AN INVESTIGATION OF THE UK MICRO- AND NANO- TECHNOLOGY GOVERNMENT INTERVENTION

by

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ABSTRACT

This study investigates a recent UK Government Intervention established to develop Micro- and Nano- Technologies (MNTs) for technology-based economic growth. While the need for such innovation policies is well recognised, there is also a need to understand the key challenges to developing effective policy interventions for the innovation process that will create sound economic leverage (Harvey, 2010).

A new method that helps us understand the innovation process at the organisational level has been developed, by working across disciplines and synthesising different methodologies. Constructs adopted from the Minnesota Innovation Research Programme (MIRP) were used to gather and analyse data. The methodological approach followed was a fusion of the Interactive Process Perspective (IPP) and Institutional Theory (IT). This method has been used to further explain the complexities of the innovation process by demonstrating the co-operation and contestation between actors from different interest groups in terms of agency and structure.

Evidence of how innovation centres exhibit different characteristics relating to their local context along with the specific actors populating them is provided. Those actors bring their own institutional logics, belief systems and associated practices to their centres. The importance which the *local context* of an MNT Centre has within the *extra-local context* of the state intervention is shown to have a major bearing on its original purpose.

For practitioners some important points have been raised: the intended purpose of the MNT government intervention was shown to evolve across MNT centres; the key influential actors of each centre demonstrably followed different institutional systems of reasoning, which in some cases resulted in internal conflicts.

As demonstrated in this study, the ingrained institutional thinking and reasoning of actors can be difficult to change for the intended purpose of an intervention, once funding has already been awarded.

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DECLARATION

This work has not been submitted in substance for any other degree or award at this or any other university or place of learning, nor is being submitted concurrently in candidature for any degree or other award.

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STATEMENT 1

This thesis is being submitted in partial fulfillment of the requirements for the degree of PhD.

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This thesis is the result of my own independent work/investigation, except where otherwise stated.
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LIST OF ABBREVIATIONS

MNT	Micro- and Nano- Technology
MIRP	The Minnesota Innovation Research Programme
DTI	Department of Trade and Industry
SME	Small and Medium Sized Enterprises
TSB	Technology Strategy Board
RDA	Regional Development Agency
NDGB	Non-Department Government Body
NSI	National System of Innovation
NIS	National Innovation Systems (alternative description for NSI)
IPP	Interactive Process Perspective
SERC	Science and Education Research Council
TCS	Teaching Company Scheme
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
CC	Clayton Christensen (scholar in the disruptive technology literature)
EDT	Emerging and Disruptive Technologies
UK	United Kingdom
NTBV	New Technology Business Venture
IP	Intellectual Property
RQ	Research Question (i.e. 1, 2 or 3)
SI	Systems of Innovation
R&D	Research and Development
IPR	Intellectual Property Rights
OMC	Open Method of Co-ordination
ITRI	Industrial Technology Research Institutes
BMEC	Biomedical Engineering Centre
KTP	Knowledge Transfer Partnership
NSSI	National Super System of Innovation
ANT	Actor Network Theory
TENS	Techno-Economic Systems
IT	Institutional Theory
RHA	Regional Health Authority
CRC	Cooperative Research Centres
PLC	Public Limited Company
CEO	Chief Executive Officer
EDM	Electrode Discharge Machining
E&Y	Ernst and Young
ROI	Return on Investment
MEMS	Micro Electro Mechanical Systems
MST	Micro Systems Technology
NDA	Non-Disclosure Agreement
KTN	Knowledge Transfer Network
RTD	Research and Technology Development

Chapter 1 - Introduction

1.1 Purpose of this Study

This thesis concerns itself with presenting an understanding of a government intervention which was designed to develop emerging technologies for commercial exploitation. The investigation's ultimate aim is to make realistic practice and policy recommendations for future effective government innovation interventions.

The contribution is in the investigation of a nascent field – that of micro-and nano-technology (MNT) – and the examination of the key factors attributed to the innovation and management of a recent government intervention. More specifically, constructs adopted by the Minnesota Innovation Research Programme (MIRP) are investigated to see how they interact in terms of agency and structure. The findings from this study will add to the existing body of knowledge in this field by enabling conceptualisation of innovation in a meaningful context and by the narration of a specific government intervention and how it shaped the innovation process.

Clarification Note on the Terminology Used in this Thesis

The MNT capital facilities programme is described using a number of definitions throughout this thesis. These include: the MNT National System of Innovation/ Intervention; the UK MNT government intervention; the MNT intervention. These terms are used interchangeably to describe the same thing.

The 24 facilities that were created are referred to as MNT centres.

This MNT network was created to provide UK businesses with access to the latest range of MNT services and capabilities within key sectors. This enabled UK industry to gain a 'step up the ladder' without the initial burden of investing in expensive capital equipment and facilities.

1.2 The UK Micro- and Nano- Technology (MNT) Capital Facilities Programme

1.2.1 Background to the Strategy

The micro- and nano-technology (MNT) Capital Facilities Programme describes an innovation intervention implemented by the UK Government to provide the UK with a network of micro- and nano- technologies. It was established to provide a:

> '*market-orientated focus for the facilities, people and organisations engaged in micro and nanotechnologies in the UK...[to help] lower entry barriers and to drive the widespread market development and exploitation of these technologies...building a prosperous, world-class MNT sector in the UK*' (DTI, 2005, p.5).

This initiative was launched as a result of findings from the UK Advisory Group on Nanotechnology. This group was appointed in June 2001 to establish a UK nanotechnology strategy, and consisted of both academic and industry experts. It was chaired by Dr John Taylor who was Director General of the Research Councils at that time. The resulting report for the Department of Trade and Industry (DTI) became known as the 'Taylor Report'.

The Report began with the stark warning that '*any industry that fails to investigate the potential of nanotechnology and to put in place its own strategy for dealing with it, is putting its business at risk'* (DTI, 2002, p.6). The strategy put forward was specifically designed *to 'support the academic research and industrial capability necessary to allow the UK to benefit from the commercial potential of nanotechnology'* (House of Commons, 2004, p.3). The advisory group was charged with:

> *'...reviewing the current state of nanotechnology applications in industry in the UK, and proposing if appropriate, actions to accelerate and support increased industrial investment in nanotechnology exploitation'* (DTI, 2002, p.7).

In July 2003 one year after the Taylor Report, Lord Sainsbury (then Minister for Science and Innovation) announced that '*a package of funding for nanotechnology worth £90 million over six years, along with the establishment of a micro and nanotechnology (MNT) network to direct the spending of this money*' was being made available (House of Commons, 2004, p.5). This funding was split into £50 million for applied research and £40 million for capital projects. This study is concerned with the latter of these, i.e. the creation of a regionally dispersed network of MNT facilities (also known as the MNT Capital Facilities Programme). Each centre is concerned with the development of new manufacturing processes, technologies and in some cases, products.

The aim was to maximise the investment wherever possible; as such, centres were expected to match-fund any grants received (i.e. generate equivalent income from customers, suppliers and host organisations), while also leveraging existing MNT facilities. For example, university centres already investigating MNTs were funded; small and medium-sized enterprises (SMEs) in the MNT area were given funding to develop aspects of their capabilities that could be used on an open-access basis by other companies; in a number of cases, large global organisations were funded to add new equipment or fund services to allow them to work with external customers, rather than internal customers alone.

1.2.2 Fields, Technology & MNT Government Intervention

The MNT government intervention is envisaged as a nascent organizational field for this research study. Scott (2001) describes an organizational field as a range of organizations that make up a recognised area of life. In terms of this government intervention, the field is based around the aforementioned MNT centres (or key suppliers), along with the other organizations involved. These include: state agencies (the Department of Trade and Industry, DTI; and the Technology Strategy Board, TSB); resource and product consumers (i.e. customers such as UK SMEs and other MNT centres); and other organizations that produce similar services or products.

This intervention involves the development of emerging technologies, which also include new manufacturing processes, technologies, and in some cases, products. All of these are a common focus of attention/or unit of analysis for innovation research. The MNT government intervention began from a national innovation system and resulted in the formation of 24 new or complimentary UK wide MNT centres. Complimentary refers to funding of existing technology centres - where possible - to stretch the funding further. In the main, these were universities and small and medium-sized enterprises (SMEs). In some cases, investment went to departments in global organisations. In a handful of cases, funding went to completely new organisations.

Twelve Regional Development Agencies (RDAs), and Devolved Administrations were also involved in setting up these centres (DTI, 2005). With this involvement, a regionally dispersed network of centres evolved. Figure 1.1 below displays the geographic location of these centres. Nearly all of these organisations were established to develop new MNT manufacturing equipment, technologies or products. There are a few exceptions, e.g. where a centre concentrates on characterisation (i.e. measurement) of micro- and nano- scale components or parts (an essential part of the development process).

A wide range of actors constitute the MNT organisational field. Initially, there were those involved in lobbying the government for the policy, which in turn led to those developing the policy and implementing it. These include individuals, as well as non-departmental government bodies (NDGBs) such as the DTI. Following the allocation of funding, centres were created, bringing new actors into the field. These actors came from a range of different professional/sector backgrounds; ranging from professional academics to exacting businessmen/women. All of these individuals brought diverse skills, motivations and organising principles to the government intervention.

Figure 1.1 - Geographic Location of the MNT Centres (Source: TSB, 2011)

1.3 MNT in the Context of a UK National Innovation Intervention

The first research question in this study asks *'how do networks such as the MNT network function?*' The second research questions asks '*how can we describe the existence of these networks and stakeholder values and understandings of the role of public interventions*?' Essential to an understanding of these questions is the need to understand how the MNT network functions at the level of individual MNT centres and on the national intervention level.

There are numerous studies in the literature concerning government intervention (also known as national systems of innovation (NSIs)). Fromhold-Eisebith (2007) describes how the concept of the NSIs established '...*a new integrated, institutional and evolutionary way of thinking about innovation support...when debating what determines successful technology-orientated economic development'* (p.217).

Balzat and Hanusch (2003) describe them as a *'...subsystem of the national economy in which various organizations and institutions interact with and influence one another in the carrying out of innovative activity*' (p.197). It is about a systematic approach to innovation in which the interaction between technology, institutions, and organizations is central.

The MNT government intervention in this study is a key example of a technological policy intervention (i.e. government intervention) at the national level (i.e. in the UK).

The MNT government intervention was built on a defined socio-economic need (i.e. to benefit the UK economy and society). **One of the key challenges for governments is in developing effective policy interventions for the innovation process that will create economic leverage** (Harvey, 2010). In order to do this, it is important to identify the appropriate conditions for intervention, which in turn requires a clear understanding of the obstacles that need to be overcome in order to make the policies effective (Fri, 2003).

One of the barriers associated with developing effective policy interventions is that many empirical studies in the literature only focus on successful examples of institutions and organizations. Denrell (2003) argues that this is due to the economic process, which means that unsuccessful firms are replaced by individuals and firms with good performance records, resulting in a limited sample of firms for research.

The main case selected for this PhD study is an example of a 'failed' MNT centre (in terms of not achieving the objectives of the MNT programme). The purpose of the MNT government intervention is detailed in later chapters. The main objectives for each centre were to be open-access, and to generate commercial revenue in order to be self-sustaining at the end of the grant funding. Coupled with this is the importance of providing help for UK manufacturers wishing to develop MNTs.

Such in-depth exploration of an unsuccessful organisation will contribute to bridging the identified literature gap. This has the potential to remove some of the under-sampling bias of the empirical data, and will add richer data to the plethora of successful examples in the literature. According to Fri (2003), public policy which is intended to promote technological innovation, should aim to achieve results by overcoming three main obstacles; firstly, where the innovation's main benefits are of ancillary value to the innovator; secondly, where technological innovation will not attract capital; thirdly, where the innovation is easy to copy.

These obstacles were highlighted by Cohen & Noll (1991, p.18-22) in their research into six major government-funded technology projects. Regarding MNT government intervention, the second of these obstacles is a clear driver for this policy. In addition, elements of the first obstacle were intended to be addressed with this intervention- i.e. by having publicly-funded centres developing MNT technologies, the flexibility to develop technologies that may not have an instant application, is facilitated. This contrasts with commercial organisations that require the technology to enter the market successfully and provide a return on investment (Fri, 2003). When customers do not buy enough of the product that produces a return on investment (ROI) for the innovator, then the innovation fails. Innovators are less likely to carry out the innovation if the rewards are insufficient (Fri, 2003, p.60).

There is also the need for policies to create a demand for innovation, i.e. 'demand creation'. Fri (2003) describes this as problematic and suggests that an alternative option for policy-makers is to develop technological options that would be useful if and when the demand finally emerges. The latter option is inherent within the UK MNT government intervention policy; i.e. that it is extremely difficult to forecast the applications of an emerging technology such as MNTs, thereby making demand creation difficult. Therefore, by opting to develop a range of MNT options through a series of MNT centres, the hope is that the infrastructure will be in place when demand emerges. Fri adds that policy intervention:

> '*must bring the costs/risks of innovation into line with the available benefits, or must attach to the public benefit a value that gives the private sector an incentive to engage in the innovation process*'(p.66).

This approach and some factors which affect its success are evaluated in this PhD study.

The discrete literature gap that was identified in the field of policy intervention was outlined above. A further opportunity for investigation arises with respect to the organizational contexts of the MNT intervention. Klein and Koslowski (2000) underline the fact that:

> '*for too long, micro-researchers have routinely neglected the effects of the organizational contexts within which individual behaviour occurs…to neglect these systems' structure in our conceptualization and research designs is to develop incomplete and mis-specified models*' (Klein and Koslowski, 2000, p.232).

This is mirrored in a case example provided by Dodgson *et al.* (2005) which highlights:

> '*the importance of considering organizational and cultural change as much as technological change innovation. Technology and organization coexist in innovation: they are two sides of the same coin*' (Dodgson *et al.* 2005, p.80).

Considering the literature gap that was identified**,** *the MNT government intervention presented itself as an ideal example of a publicly-funded NSI for investigation*. This example allowed richer insights into a nascent field of technology, whilst providing a better understanding of the barriers faced by the major case study investigated. Furthermore, following Harvey's (2010) observation that one of the key challenges for government is in developing effective innovation policies, then the findings have the potential to guide the design of future innovation policies.

1.3.1 Strengthening Comprehension of MNT Programme Using the Interactive Process Perspective (IPP): One of the most prolific UK government interventions is that of the Knowledge Transfer Partnership (KTP). These partnerships were formerly known as the Teaching Company Scheme (TCS). Both are knowledge transfer programmes and have been in operation in the UK since 1975 (Peattie, 1993; Edwards, 2001; Millward *et al.* 2004). The Teaching Company Scheme was established by the Science and Education Research Council (SERC) and the Department of Trade and Industry (DTI*)* to *'bridge the gap between industry and academia*' (Peattie, 1993, p.60). The scheme has a number of stated aims, of which one is to improve industrial methods by the effective implementation of advanced technology and new ideas (Peattie, 1993). This aim is closely aligned to the subject matter of this thesis - i.e. the investigation of a UK micro- and nano-technology government intervention (MNT intervention). In common with the TCS programme, the MNT intervention facilitates (in part) the transfer of advanced technologies from academia to industry.

Edwards (2000), also discusses existing attempts to analyse the complexities of such government interventions, using the TCS model as an example. Significantly, he highlights the need for a more explanatory theorisation of government interventions. Such a view depends on understanding the nuances between agency and structure. Edwards (2000, p. 462) introduces the Interactive Process Perspective as a way to investigate these nuances. He suggests that '*an interactive process perspective provides a framework that shows how the accomplishment of innovative activities (action) depends on the mediations constituting the contingencies of the institutional setting (structure)*'. Put simply, individuals (human agents) are both influenced by pre-existing forms of structuring (i.e. the institutional setting), yet are also empowered to interpret what should be done in the future (i.e. their action).

The adoption of an interactive process perspective evidently allows a deeper understanding of the MNT intervention in relation to the multiple structures it exhibits. Structure is important in the study of organizations, because an organization's structure shapes its flexibility, its capacity to change, and its innovations. It is patently an important issue for management (Outhwaite, 2006, p.627).

In a review of the innovation literature, Slappendel (1996) describes how contexts, in terms of different levels of analysis, are adopted in different studies of innovation. She arranges these levels into individuals (i.e. an individual person); organisations (which include innovation within and by organisations); industries; and finally, national systems. Her study concentrates on the national systems level, also described as the *extra-local context*, and organizational level, also termed the *local context* (Hallet and Ventresca, 2006). The national systems levels/extra-local context concerns the MNT government intervention which is a national programme. The organizational level/local context applies to the MNT centres. This work builds on Pierce and Delbecq's (1977) identification of three theoretical perspectives in the innovation literature. Of these, the interactive process perspective provides a way of comprehending the scope and influence of individual actors within the context of the MNT government intervention. The first of these is the *individualist* perspective. Second is the *structuralist* perspective, and third is the *interactive* process perspective (Slappendel, 1996). The links between these levels are evidently important and are also investigated in this PhD study.

1.4 Introduction to the MIRP Constructs and their Adoption in this Study

Large scale research programmes such as the Minnesota Innovation Research Programme (MIRP) were embarked upon in order to investigate the complexity of innovation processes further. The Minnesota Innovation Research Programme is introduced in this section for a number of reasons:

Firstly, as it is one of the major academic innovation research programmes in recent years, it was a natural starting point to appreciate how data can be collected to understand how organizations produce innovative products and services.

Secondly, the MIRP research programme was designed to be flexible and cover a wide range of organisations developing a diverse array of products and services. Such a flexible approach appealed to the investigation of the MNT network which comprised of organisations developing a range of products/ technologies. Examples of products/ services developed in the case studies from MIRP included: studies of technological developments (e.g. cochlear implants); administrative innovations (e.g. public policy innovations); and studies of the adoption of innovations. A thorough review of this study including the methods used and research findings was carried out and the strategies employed to frame data collection, have been applied to the investigation of the MNT government intervention.

1.4.1 Background to MIRP

The MIRP research programme was created to develop a process theory that explains innovation development (Van de Ven and Poole, 1990). These researchers wanted to carry out a longitudinal research programme which took into account the temporal order and sequence of steps that take place when an innovative idea makes the transition to a concrete reality. They refer to theory building as producing:

> '*fundamental laws of innovating... useful for explaining how a broad class of processes, sequences, and performance conditions unfold along the innovation journey. A process theory may also identify certain paths more likely to be effective under certain developmental conditions'* (Van de Ven and Poole, 1990, p.31).

They collected a common core of empirical data by using a consistent framework across a range of innovation study groups. In total, 14 studies were carried out, with different research teams. The teams comprised 34 people (15 faculty and 19 doctoral students) from eight different academic departments and five schools in Minnesota, making it a considerable piece of research work in the area of innovation. Their work increased awareness of the need to investigate a wider range of characteristics of the innovation process, rather than being preoccupied with stage models, and generalisation.

1.4.2 The MIRP framework

Poole *et al.* (2000) describe the definition of innovation used in the MIRP study as

> '*the process of innovation..[is] defined as the development of new ideas by people who engage in transactions with others within a changing environmental context and who change their behaviours based on the outcomes of their action*' (p.100).

This definition establishes the importance of a number of constructs which together constitute the MIRP framework. The investigation of these constructs allowed for a deeper understanding of the complex innovation process. These constructs provided a range of variables around which the development of the outcomes of innovations could be considered. In terms of the MIRP programme, outcomes were the result of studying a '*wide variety of product, process, and administrative innovations from concept to implementation or termination*' (Poole *et al.* 2000, p.108). This framework was also chosen because its concepts '*constitute the central factors of concern to manage in directing innovations*' (Van de Ven *et al.*, 2000, p.9). These constructs are; *ideas, people, transactions* (referred to as collaborations in this PhD), *context* and *outcomes*. It should be noted that 'transactions' later became 'collaborations' to make a distinction from MIRP's method of capturing and recording each individual transaction. The term collaboration is used to emphasise the more macro view of transactions observed in this thesis between the MNT network actors.

The original descriptions from Van de Ven and Poole (2000) are shown in Table 1.1.

Table 1.1 - Original Constructs used in Minnesota Innovation Research Programme (Source: Adapted from Van de Ven & Poole, 2000).

Construct	Description
Ideas	A coding of the substantive ideas that innovation group members use to describe the content of their innovation at a given point in time
People	A coding of the people/ groups involved in an activity, the roles and activities they perform at a given pointing time, and how they formulate problems and make decisions
Transactions [collaborations]	The informal and formal relationships among innovation group members, other firms, and groups involved in the innovation effort.
Context/ environmental	A coding of the exogenous events outside of the innovation unit in the larger organization and industry/ community that are perceived by innovation group members to affect the innovation.
Outcomes	A coding of success criteria and ratings by innovation participants of how well the innovation is progressing and accomplishing their expectations of effectiveness at a given point in time.

The MIRP programme is a good example of a framework that has been used to develop far greater comprehension of the innovation process. It '*not only sought to clarify connections between levels of analysis, but also examined these relationships over time*' (Slappendel, 1996, p.120). The constructs originally adopted by MIRP are very specific and separate in terms of the MIRP analysis. There is a previously unexploited opportunity to investigate how these constructs interact in terms of agency and structure in this study. The MNT government intervention researched in this study will be used to further understand the link between the action (collaborations/ outcomes) of the actors (people) of a government intervention with structure (context/ environmental).

However, this study addresses an opportunity to further investigate the interactions between the MIRP framework (i.e. constructs) through an interactive process perspective. By investigating the UK MNT intervention using the MIRP framework and the theorisation that IPP offers, this work offers a potential contribution to the literature in terms of further understanding this complex innovation process.

The interactive process perspective, and research methods used have been adapted from the MIRP programme as being the most suitable approach to explain how and why the MNT government intervention has transpired the way it has: '*it is the interactive process perspective that will be best able to explain how and why organizations have made .. [such] innovative transition[s]*' (Slappendel, 1996, p.124).

Furthermore, theorisation from the area of Institutional Logics has been introduced throughout this study to help explore the complexities facing different stakeholders engaged in innovation under the MNT government intervention. Such differentiation confirms the potential for greater contestation and negotiation in understanding such government interventions.

There are a number of additional advantages to adopting the IPP approach for investigating government interventions. Significantly, IPP offers an increased understanding of the duality between organizational action and structure; agents and structure are independent and not a dualism (Giddens, 1984. The implications of this are that agents are able to influence structure and structure is able to influence agents in return. Structure refers to those arrangements by which agency is exercised (Scott, 2001).

For this PhD study, one can think of ‘governance structures’ in terms of the MNT government intervention - as a public support mechanism. Secondly, government interventions have many agents, and where there are multiple agents they have the potential to choose actions deliberately, and to carry them through effectively, even in defiance of established rules and prevailing powers (Whittington, 1992). Examination of the different MNT centre contexts will highlight how different actors follow the rules of the government intervention. Finally, the IPP method takes into account the range of stakeholders and associated organizational politics, which in turn shape action and structure. Such issues are commonly omitted from governments’ assessments of their interventions.

This research study is not solely about perceiving MNTs as a network for government intervention; it is also about providing a theoretical lens to understand what is happening in that intervention. Within this research, there is an aim to evolve Edward’s (2000) proposition that the IPP is suitable for investigating innovation. This is undertaken by investigating a range of actors within the MNT government intervention to provide further evidence that IPP can be used in this way. Furthermore, this will result in offering a revised theorisation for investigating NSIs and government interventions.

1.5 Methods and Design

The overall aim of the study is to investigate a national system of innovation in order to understand how such interventions function and more specifically, how and why particular aspects of these interventions affect their initial function. In addition, a broad investigation across different bodies of literature allows for the development of a revised framework based on theory not typically associated with the investigation of emerging technologies. That is, theorisation is adopted from the area of innovation process theory (i.e. MIRP programme); the National Systems of Innovation literature; and Institutional Logics.

Three research questions drive this research study, which are informed by a comprehensive, multi-disciplinary literature review, and a number of inductive pilot cases.

Table 1.2 – Research Questions

Research Question 1 (RQ1)	How do government interventions such as the MNT network function?
Research Question 2 (RQ2)	How can we describe stakeholder values and understanding in relation to the role of a nascent government intervention?
Research Question 3 (RQ3)	How do the the following aspects of innovation management: *purpose, process, people, collaborations, context and outcomes* influence the success of emerging technologies in different organisational settings?

Research Question 1 starts the study with a general focus, following the initial pilot research study and the literature review. Saunders *et al.* (2009) describe how this approach often leads to further detailed research questions:

> ‘ *It is often a useful starting point in the writing of research questions to begin with one general focus research question that flows from your research idea. This may lead to several more detailed questions or the definition of research objectives’* (p.24).

Research Question 2 leads the way for a descriptive understanding of the MNT network.

Research Question 3 helps to focus the investigation to a number of important constructs and particular areas of interest for examining the chosen UK MNT government intervention. Construct selection is discussed in detail in Chapter 5 (the Methodology Chapter), with the associated methodological decisions and justifications.

1.5.1 Rationale for Choice of Research Method

Trott (2008, p.74) describes how '*the study of organisations and their management is a very broad subject and no single approach provides all the answers*'. This study adopts the approach most suited to the research questions, research venue, resources and access available. In addition, several authors have described the difficulties of gathering data for organisations in the early stages of technological innovation. Klofsten (2002) describes how '*…traditional business ratios are insufficient to assess newly-started fast-growing firms…in certain stages of growth, these firms have such strong dynamics that traditional business ratios do not suffice to paint a true and fair picture of the firm's current situation*'(p.76). He adds that often, such newly-started firms do not have appropriate data from such an early stage. Not all of the organisations involved in this study are 'newly-started'. However, the specific MNT centres investigated in this study are new, and evidence of 'strong organizational dynamics' was displayed in many of these centres.

The OECD[1] in their guidelines for collecting innovation data – describe how '*access to knowledge and technology can depend to a large extent on the connections between firms and organisations. This is particularly the case for the tacit knowledge that is held in the minds of people…**direct interactions with the people with tacit knowledge or with access to routines is required in order to gain access to these types of knowledge***' (OECD, 2005, p. 32). A qualitative research methodology was decided upon.

This follows the methods used by authors such as Khilji (2006) who carried out a series of interviews, describing how they '*offered the research team the flexibility to probe and highlight organizational and other contextual issues that would have remained hidden had a questionnaire survey been used*' (Khilji, 2006, p.532). Another example is that of Jones-Evans (1997, p.15) who found this method to be the most appropriate when dealing with the technical entrepreneurs and strategies of new technology-based ventures, of which the local contexts are similar.

The MNT Network has been treated as an organisational field using institutional theory. MNT centres are treated as purposive cases, with one major case study and eight comparative MNT centres. Senior actors were interviewed within these centres and, for

[1]The Oslo Manual - Guidelines for collecting and interpreting innovation data – Published by the Organisation for Economic Co-operation and Development (OECD).

triangulation purposes, a wide range of cross-field actors were also interviewed. Secondary data (where accessible) have also been used, e.g. proposal documents for the main case study, and reports/ literature in the public domain.

Initially the use of secondary financial data such as Return On Investment (ROI), turnover of the centre etc. was sought. However the release of such data was opposed by the overseeing non-departmental government body (the Technology Strategy Board, TSB).

As the data gathering process was underway it became evident that such hard financial measures might mask the realities of this MNT network, whereas the IPP process presented an in-depth understanding of the harder-to-measure aspects of a state intervention. For example, an MNT Centre may be performing well on paper (in terms of financial measures), but it is the reasoning behind this performance in terms of actors and agency in the local context of their centre that is of interest to this study.

As such, the interviewing approach proved most successful in gathering data. Interviews were structured around sensitising constructs developed from initial inductive pilot interviews, along with an existing framework from the Minnesota Innovation Research Programme (MIRP). The resulting constructs (also described as 'codes' and/or 'themes') were as follows: *purpose*, *process*, *people*, *collaborations*, *context* and *outcomes*. These interviews were transcribed and coded according to these constructs. Thematic analysis and pattern-matching of the data was used to analyse findings, develop theory and contribute to this area of research (Miles and Huberman, 1994).

The research method used enabled an example government intervention to be understood and an explanation of the key factors attributed to this intervention in a multitude of organisational and institutional venues was provided. Although generalisations should not be made from the sample size obtained, the resulting findings do offer new avenues to explore for academics, policy makers and practitioners alike.

A flow chart illustrating the methodology used in this study now follows. This process is illustrative; the actual process did not necessarily follow each step in a linear fashion.

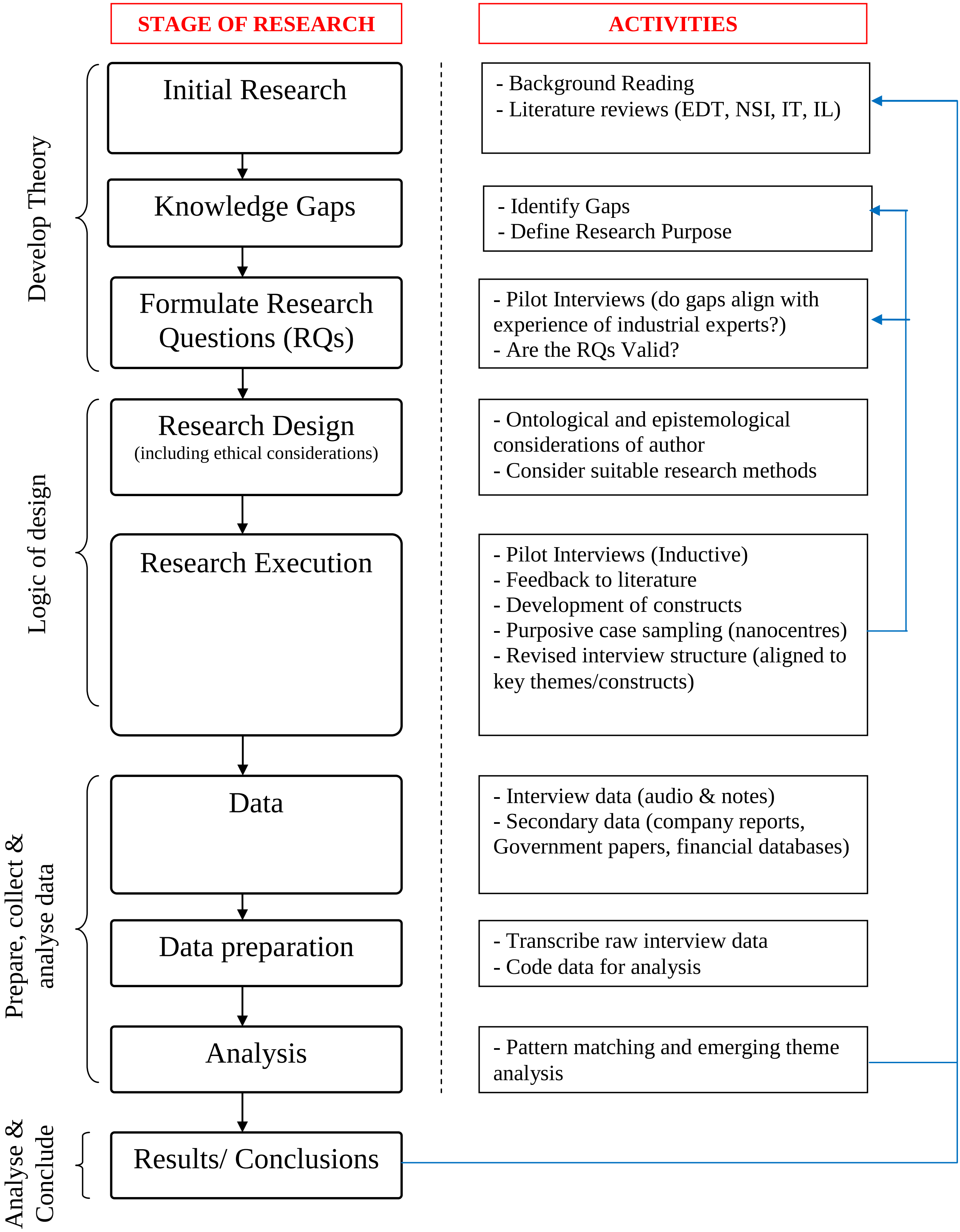

Figure 1.2 - A Flow-Chart Illustrating the Methodology followed in this Study

1.6 The Academic Contribution of this Study

A new method that helps us understand the innovation process in a recent government intervention has been developed, by working across disciplines and synthesising different methodologies. To understand innovation it is necessary to see how it is made possible in a meaningful (real world) context which is why the MNT government intervention was conceived using organisational field theorisation, with ‘local’ and ‘extra local’ contexts (Hallet and Ventresca, 2006).

In addition, the Minnesota Innovation Research Programme (MIRP) constructs have been used to gather data on a recent UK government intervention. The methodological approach adopted is that of the Interactive Process Perspective (IPP) as described by Slappendel (1996). This approach overcomes the limitations of perspectives concentrating solely on individual action or objective structures.

The method used has synthesised the Interactive Process Perspective with an Institutional Theory (IT) approach, and has been used to further explain the complexities of the innovation process by demonstrating the co-operation and contestation between actors from different interest groups. The Interactive Process Perspective pays attention to the understanding of how action and structure interrelate. The main features of the approach developed in this PhD add another viewpoint to the perspective of researchers investigating innovation at the organisational level.

1.7 Key Findings of this Study

A number of key findings in terms of practice have been made from the analysis of the MNT government intervention. Of particular importance are the following:

1. The MNT government intervention failed. Furthermore there is no evidence that the DTI considered the issues of local context and organising principles of actors when developing this technology policy. The main focus appeared to be on how much ‘leverage’ could be achieved by building on existing MNT infrastructure.

2. There was a central problem of ‘management paradox’ for this intervention. That is, within the organisational field conflicting logics were observed, along with a mixture of contested/ collaborative organising principles. The central problem in innovation management may be the management of such a paradox. For

example, Mercury provided many examples of conflicting organising principles, and in particular examples of actors reconstructing their views.

3. Successful centres were those were actors were driven by a common purpose, and had associated inherent and common business thinking, reasoning and judgement processes.

4. The notion of conflicted interpretation has been shown to be extremely important for government interventions and a significant predictor of eventual outcomes.

5. Context - The associated institutional logics of local and extra local contexts could not be avoided when trying to achieve a successful MNT technology policy.

1.8 Outline of the Thesis

This thesis is structured and presented over ten chapters: Chapter 1 introduces the topic and provides a rationale for the study. It recognises the UK MNT government intervention under investigation; provides a brief introduction to the literature; outlines the findings and contributions, and gives an overview to this study.

The Literature Review spans the next three chapters:

Chapter 2 provides an overview of the literature concerning emerging and disruptive technologies. The challenges faced by organisations developing such new technologies, and how they try to manage and organise this innovation process are identified and discussed. The outcomes of this Chapter are then compared with the findings from this study in the Discussion Chapter.

Chapter 3 introduces the literature on Systems of Innovation (SI) and its boundaries (national, regional, and sectoral systems of innovation). The use of Innovation Policy as a way of developing the innovation systems of a country is presented, and how government interventions can be enacted to stimulate this. In addition, the MNT government intervention is located within this body of literature.

Chapter 4 begins with a discussion of the theoretical lenses that were considered for this study. The chosen lens of Institutional theory is then considered; the chapter considers how key concepts from the Intuitional Logics and the wider Institutional Theory literature can be applied to study of a government intervention, and also how they can add to an understanding of actors and their actions within such a venue.

Chapter 5 presents the study's overall research approach and commences with a discussion of my ontological and epistemological views in relation to this research project. Appropriate research strategies and methods are then identified and critiqued for this study.

Chapter 6 provides a detailed background to the UK MNT Government Intervention. A timeline and key events in the evolution of this intervention are provided in order to set the context.

Chapter 7 then introduces the major case and presents the associated findings. Chapter 8 presents the data from the cross-case comparisons and wider MNT stakeholder interviews.

Chapter 9 opens up a dialogue around the study's findings in relation to the academic literature used to investigate the research questions. Furthermore, the academic contributions which result from this study are discussed.

Chapter 10 is the final chapter, and discusses how the findings from this study contribute to practice. In addition, a number of practice-orientated recommendations in the form of seven propositions are put forward. Evidence from this study is used to support each of these propositions. The chapter concludes by discussing the limitations of this study along with avenues for future research.

1.9 Summary

This initial chapter presented this study of a UK micro- and nano- technology government intervention concerned with developing emerging technologies for the benefit of the UK economy. The issue under consideration – the MNT network – was described, which illustrated a complex field with multiple actors influencing the innovation process. The interactive process perspective used in this study was identified as a lens through which such interventions could be further explored and clarified. The scope, aims, objectives and research questions of the study were also briefly introduced. The research methodology was presented, along with a rationale for using the Minnesota Innovation Research Programme framework. A number of key findings and potential contributions were also outlined.

The stage is now set to present the next chapter – Chapter 2 - which details the associated literature linked to one particular facet of this broad subject area – i.e. emerging and disruptive technologies.

Chapter 2 – Literature Review – Emerging & Disruptive Technologies

This chapter provides an overview of the growing literature concerning emerging and disruptive technologies and the difficulties and challenges faced by organisations developing, managing and organising them.

The MNT government intervention was created by the UK government to develop the emerging and disruptive technologies in the field of micro- and nano- technologies. The purpose of reviewing this body of literature is to understand how organisations manage the development of emerging and disruptive technologies, and the challenges they have faced along the way. This review includes research from a wide range of organisations, rather than those only developing technologies as part of a government intervention. This will allow comparisons to be made with the findings from the MNT case investigated in this PhD.

2.1 Disruptive Technologies

Clarification note on the terminology used in this thesis: The term 'emerging' has been used interchangeably with 'disruptive' when describing technologies throughout this thesis. Literature talks of technologies being viewed as the next *disruptive* technology. However, during the time in which they are being developed and have not shown themselves to have usurped existing technologies, they are technically still *emerging* technologies. In fact, Schumpeter said:

> '*It is hardly necessary to point out that competition of the kind we now have in mind [i.e. creative destruction/ disruptive innovation] acts not only when in being but also when it is merely an ever-present threat. It disciplines before it attacks. The businessman feels himself to be in a competitive situation even if he is alone in his field…*' (Schumpeter, 1943, p.74).

Subsequently the use of one term over the other has been considered inappropriate when describing technologies such as MNTs which are seen to be potentially disruptive technologies. Therefore both terms have been used interchangeably in this study to refer to technologies which have the potential to become disruptive and those which are already disruptive.

2.1.1 Emerging and Disruptive Technologies

Literature within this area (Foster 1986; Christensen 1997, 2004; Danneels 2004, 2006) commonly describes *disruptive* technologies. A contemporary definition of disruptive innovation follows from Christensen's work:

> *'Disruptive innovation: an innovation that cannot be used by customers in mainstream markets. It defines a new performance trajectory by introducing new dimensions of performance compared to existing innovations. Disruptive innovations either create new markets by bringing new features to nonconsumers or offer more convenience or lower prices to customers at the low end of an existing market'* (Christensen *et al.* 2004, p.11).

2.1.2 Origins of Disruptive Innovation Theory

According to Christensen the publication of the first article describing the phenomenon of disruptive innovation was in the mid-1990s (Christensen, 2004, p.vii). He did not specify the article referred to but it is premised as that of Bower and Christensen (1995). However, results of a structured systematic review of the EDT literature (carried out by the author in the early stages of this study) highlights a number of seminal works which came before this article (Dorrington and Brousseau, 2008). The review followed a structured systematic review methodology (see Cochrane 1979; Petticrew and Roberts, 2006; and Robeson, 2007). The sample papers searched as part of this review were then analysed in terms of the most frequently cited references. The resulting key citations can be seen in Figure 2.1.

A contemporary study by Hang and Yu (2010) provides further evidence that the phenomenon of disruptive innovation did indeed find its foundations in seminal work by authors such as Schumpeter (1942) and Foster (1986). Yu and Hang (2010) carried out a reflective review on the extant literature on disruptive innovation theory. As part of this review they map a timeline of the evolution of disruptive innovation theory based on a series of technological innovation studies (based on early literature of technology discontinuity as well as on the papers and books of Christensen). This is reproduced in Figure 3.2.

Figures 3.1 and 3.2 show how the true origins of disruptive innovation are found in the works of the renowned economist Schumpeter (1943) who wrote extensively on the theory of economic development (refer to Schumpeter, 1943).

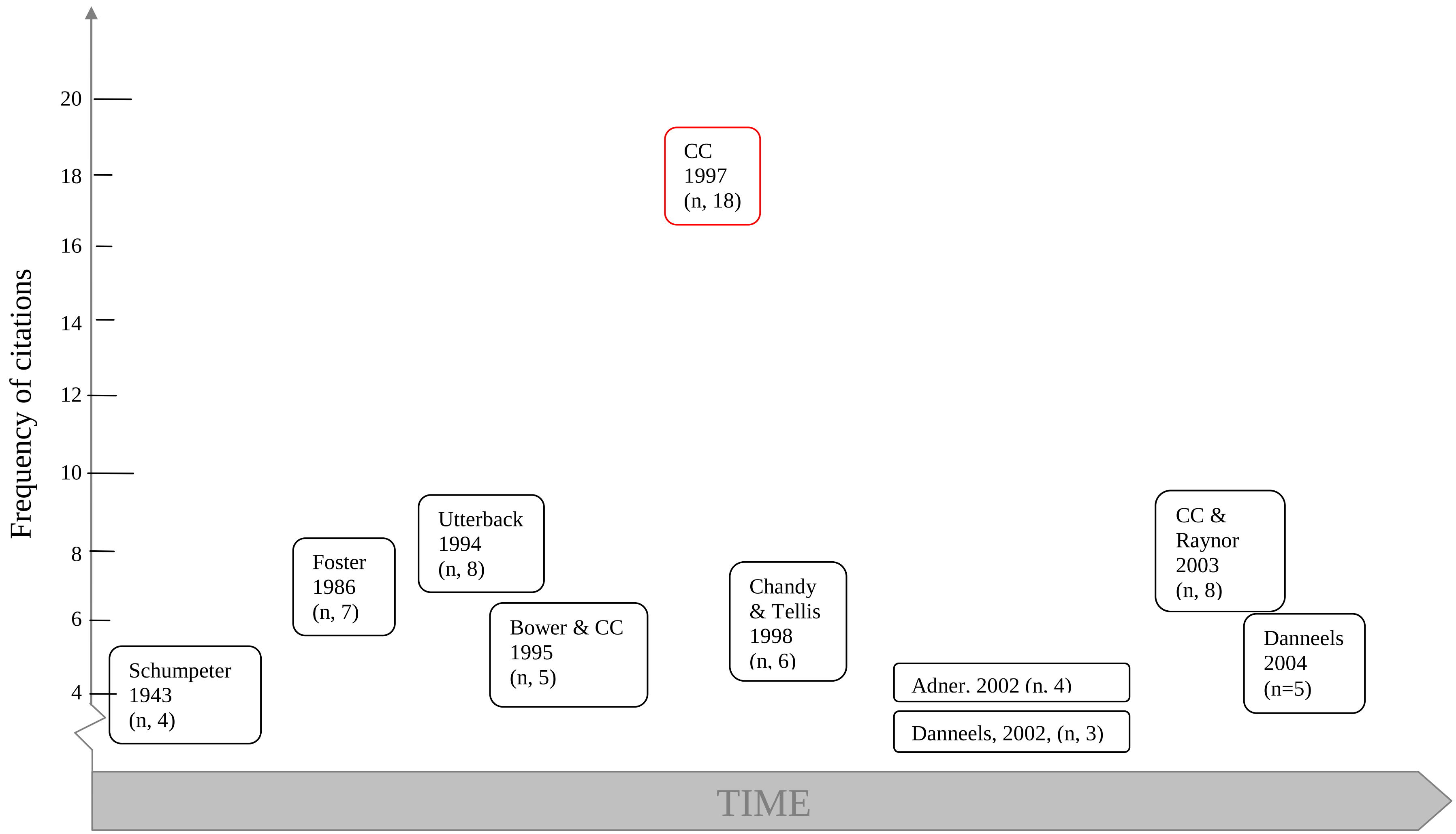

Figure 2.1 - Key Citations Over Time from the 30 Sample Texts (Source: Dorrington and Brousseau, 2008, Appendix A). Note: 1) 'CC' stands for Christensen 2) n=frequency of citations

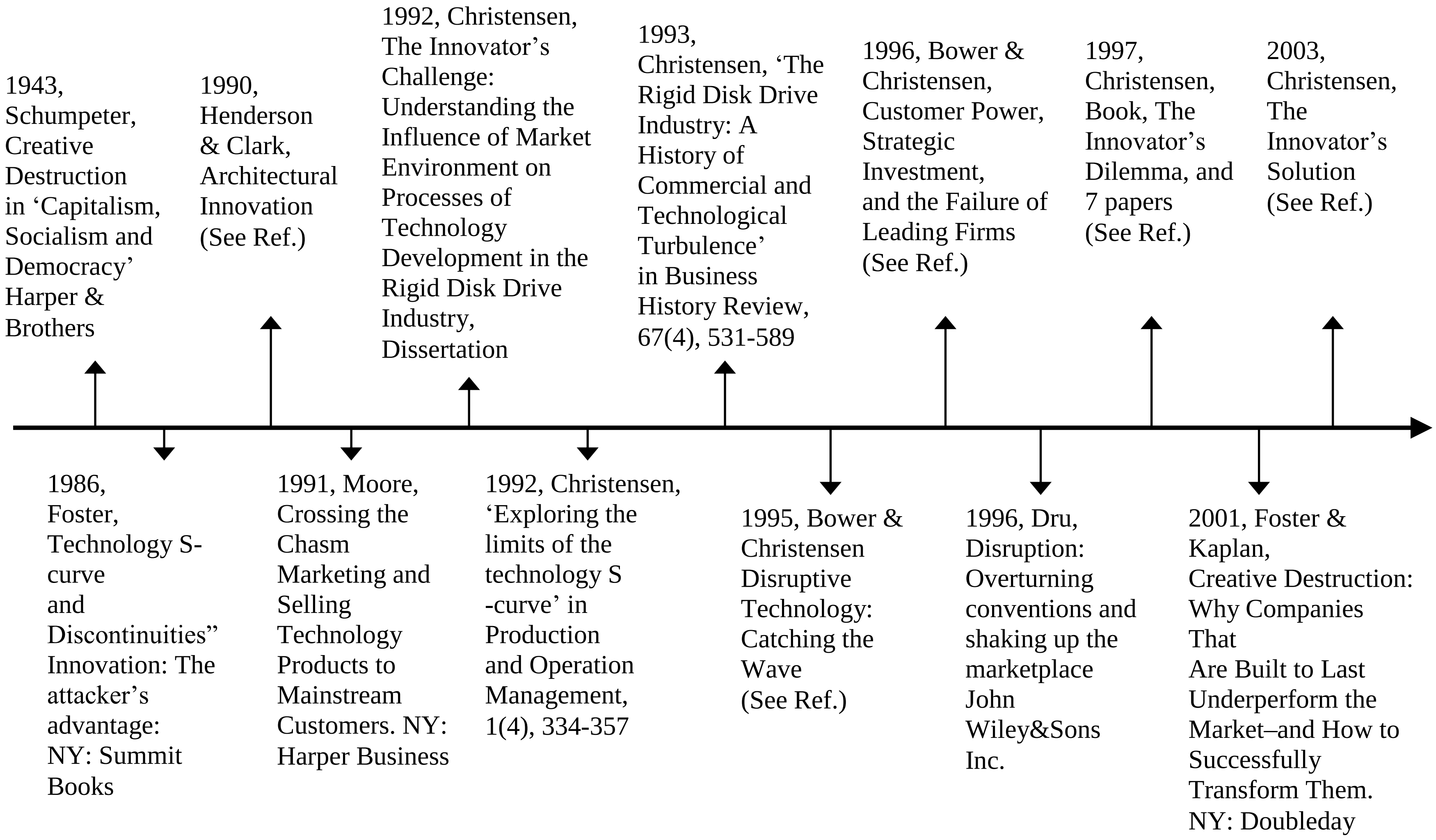

Figure 2.2 – Timeline of Evolution of Disruptive Innovation Theory (Source: Reproduced from Yu and Hang, 2010, p. 436).

2.1.3 Antecedents to Christensen's Theory of Disruptive Innovation

A number of the seminal authors - and works - highlighted in Figures 3.1 and 3.2 are now discussed to provide a foundation of the disruptive innovation theory.

2.1.3.1 Schumpeter: Process of Creative Destruction

Fagerberg *et al.* (2005) provide a useful introduction to the work of Joseph Schumpeter:

> '*Schumpeter is considered a pioneer in the economic analysis of innovation, having concentrated more effort on this topic than any other economist in the first half of the twentieth century. His insights have guided the subsequent development of the field, and helped to explicate the vital role of innovation in growth and competitiveness*' (p.87).

Schumpeter focused on the role that innovation played in economic and social change. He created one of the most original and important works of the twentieth century - in terms of its impact on disruptive innovation theory - called '*Capitalism, Socialism and Democracy*' (Schumpeter, 1943). He pioneered the concept of 'Creative Destruction' as part of capitalism and the evolutionary process it follows.

The process of creative destruction describes how the step-changes in technological understandings and major scientific breakthroughs open up new markets (foreign or domestic), resulting in a process of: '*industrial mutation…[which] incessantly revolutionises the economic structure from within, incessantly destroying the old one, incessantly creating a new one*' (Schumpeter, 1943, p.73).

Underpinning this concept is the:

> '*fundamental impulse that sets and keeps the capitalist engine in motion [and] comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organisation that capitalist enterprise creates*' (Schumpeter, 1943, p.73).

Schumpeter described how the competition which really counts in capitalism is that from the new commodity, the new source of supply, and the new type organisation, rather than the competition in terms of organisational profits and existing outputs.

That is:

> '*...competitions which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives. This kind of competition is as much more effective than the other as a bombardment is in comparison with forcing a door*' (Schumpeter, 1943, p.74).

In order for many businesses to increase the longevity of their technology base they restrict output to conserve their established position in the market, and maximise profits. Use of legislation or intellectual property provide examples of how output is potentially restricted. However, *gales of creative destruction* considerably reduce their long-run scope and practices designed to increase longevity.

2.1.3.2 Foster: S-Curves

The next evolution in the theorisation of disruptive innovation came from the work of Foster (1986). Foster developed his theory of 'S-curves' from a survey of 250 R&D Vice Presidents spanning a range of industries over a number of years. His study was part of a research exercise at a leading management consultancy (namely, McKinsey).

Where it lacked methodological rigor (i.e. there was no detailed description of the methodology in the text to reinforce the findings), it made up for in an empirically grounded discussion of how attacking organisations (attackers) can disrupt incumbent organisations (defenders) with new technologies. Moreover, a number of strategies that are deployed by both attacker and defender firms were discussed. One of the main contributions of Foster's work to the EDT literature is the concept of S-Curves as a tool for forecasting a company's technology for benchmarking purposes.

S-Curves are graphs *'...of the relationship between the effort put into improving a product or process and the results one gets back for that investment*' (Foster, 1986, p.51). Put simply, S-Curves plot the parameters of a technology over time; this allows one to see if they are in decline, or if there is s large amount of incremental innovation left. In his book he describes how:

> '*it is essential to keep an eye on the limits (and parameters) of technologies, processes and machines – i.e. which ones will become obsolete?*'… *In the world of business'* ***limits*** *determine which* ***technologies****, which* ***machines*** *and which* ***processes*** *are about to become obsolete. They are the reason why products eventually stop making money for companies*' (Foster, 1986, p.51).

This highlights the importance of tools or processes (such as S-Curves) which allow organisations to keep an eye on the technological terrain before new ‘gales of creative destruction’ take them by surprise. The S-Curve concept helps to visualise Schumpeter’s theory of creative destruction by focussing on parameters in relation to specific technologies.

It should also be noted that authors such as Benkenstein and Bloch (1993) do highlight issues with the potential simplification of S-curves, in relation to the sole focus on one technology. Benkenstein and Bloch (1993) make the point that in reality systems can be made up of a number of technologies, in which case it is important to look at the technological advances in the interrelated fields.

2.1.3.3 Abernathy and Clark: Winds of Creative Destruction

Abernathy and Clark (1985) added to the theorisation of disruptive technology through their classification of innovations according to how radical they are compared to current technology. Continuous improvements are often characterised as 'incremental' or 'marginal' innovations as opposed to 'radical' innovations (e.g. introduction of totally new type of machinery) or 'technological revolutions' (consisting of a cluster of innovation that together may have a very far-reaching impact).

Building on this scheme of classification, Abernathy and Clarke further added to the literature by producing a framework for analysing the competitive implications of innovation (1985). They based their framework on the theory of ‘transilience’; i.e. the capacity of an innovation to influence the established systems of production and marketing. This framework was used to categorise innovation into the following four types:

1. *Niche creation* – opening new market opportunities through the use of existing technologies (conserve and strengthen established designs)
2. *Architectural* – lays down the architecture of the industry
3. *Regular* – Involves change that builds on established technical and productions competences and that is applied to existing markets and customers
4. *Revolutionary* – Innovation that disrupts and renders established technical and procustion competence obsolete, yet is applied to existing markets and customers.

(Source: summarised from Abernathy and Clark, 1985).

Parallels can be seen with the contemporary literature, where the category ‘revolutionary’ grew in it importance and became known as ‘disruptive’ (see Christensen 1997, 2004; Danneels 2004, 2006). Schumpeter (1984) describes how the capitalist engine is kept in motion by ‘*a history of revolutions*’ (p.73).

Abernathy and Clark’s work further demonstrated how innovation types could be plotted on a ‘transilience map’. They used examples from the US motor industry to demonstrate this. Essentially case examples were positioned in one of four quadrants representing the above four innovation types.

Abernathy and Clark summarise one of their main contributions to the literature from this seminal paper as showing how ‘*the categories of innovation are closely linked to different patterns of evolution and to different managerial environments*’ (Abernathy and Clark, 1985, p.3). Each type of innovation imposes a different nature of change on a firm, and as such the successful pursuit of different kinds of innovation will require different kinds of organisational and managerial skills: ‘*The transilience map may thus illuminate the managerial environments required to nurture innovation and technical progress in each node*’ (Abernathy and Clark, 1985, p.20). They further describe how the climate for organisations developing such technologies must be one ‘*that encourages a sense of competitive assault*’…. [and]… ‘*management must be capable of sustaining a consensus about long-term goals through investments in new technology and innovation*’ (p.21).

2.1.3.4 Anderson and Tushman: Technological Discontinuities & Dominant Designs

Foster’s seminal text (1986) talked about the fourth era, called ‘management of discontinuities’; where organisations must be aware of the limits (technology limits), and prepare for when their technologies/ products will reach their limits, and how their products will change. Foster described how an understanding of the science and technology helps to gain the understanding of the limits.

Anderson and Tushman (1990) introduce the term ‘technological discontinuities’ in relation to industry and how it evolves through technological cycles. They draw on Schumpeter’s theory by describing how at rare and irregular intervals in every industry, innovations appear that '*command a decisive cost or quality advantage and* *that strike not at the margins of the profits and the outputs of the existing firms, but at their very foundations and their very lives*' (Schumpeter, 1942, p.84)'. Through the introduction of the term 'discontinuous' in relation to technological evolution, Anderson and Tushman added a new perspective to the evolving theory of disruptive technology. Furthermore, in their seminal paper (Anderson and Tushman, 1990) they introduced a cyclical model of technological change. This model is re-produced in figure 2.3, and describes the process following the emergence of a discontinuous technology. Anderson and Tushman (1990) introduced this model and tested it on longitudinal studies of technology across a number of industries, including the minicomputer industry, cement and glass industries.

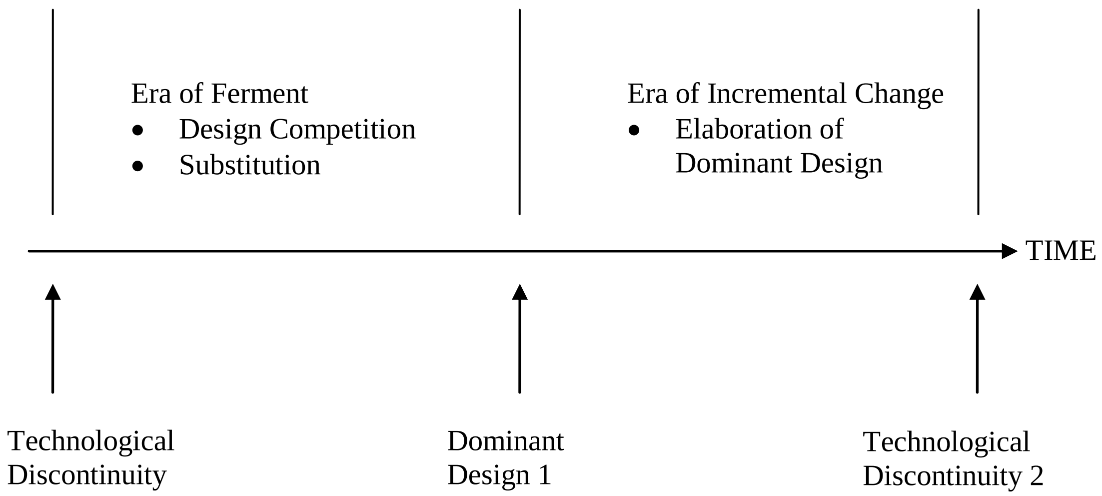

Figure 2.3 – The Technology Cycle (Source: adapted from Anderson and Tushman, 1990, p.606)

Figure 3.1 shows how a discontinuous technology first emerges in the technology cycle. This then triggers a period of change (or 'era of ferment'), as companies develop their own versions of at technology in search of market dominance. '*Several versions of the breakthrough technology appear, both because the technology is not well understood and because each pioneering firm has an incentive to differentiate its variate from rivals*' (Anderson and Tushman, 1990, p.612). They describe how a dominant design then emerges. For variation and selection to cumulate in an evolutionary process, there must be a retention mechanism: a successful variation must be preserved and propogated (Campbell, 1969). Anderson and Tushman describe how a dominant design marks the end of the era of change (or ferment), where a dominant design results as a '...*single architecture that establishes dominance in a product class*' (Anderson and Tushman, 1990, p.613). It is this single architecture which results in dominant designs as industry, manufacturers, suppliers, customers and regulatory agencies competing to decrease the uncertainty associated with variation during the era of change. lays the way for industry to reduce variation. This in turn enables competitors to introduce their own products, and an era of 'incremental change' then occurs, where the dominant designs are elaborated upon. Eventually this era is broken by as another technological discontinuity occurs, and the whole cycle begins again. This adds further detail to the evolutionary cycle introduced by Schumpeter (1943).

In addition, Tushman and Anderson's work (1986) further characterised technological discontinuities as 'competence-enhancing' or 'competence destroying'. A competence destroying discontinuity 'renders obsolete the expertise required to master the technology that it replaces. A competence-enhancing discontinuity builds on know-how embodied in the technology that it replaces. They provide sixteen examples of technological discontinuities in their study which are either competence-enhancing, or competence-destroying.

2.1.4 Contemporary Theory on Disruptive Innovations (1990s and onwards)

Christensen’s work has dominated the disruptive innovations literature since the 1990s, as highlighted particularly well in Figure 3.2 (Source: Yu and Hang, 2010).

Whilst this area has been led by Christensen, there:

> ‘*seems to be a lack of constructive criticism of the core concept of his theory, namely ‘disruptive technology,’ as well as its mechanisms and effects on firms and industries.*’ (Danneels, 2004, p. 246).

However, more recently, a number of authors have challenged this theory (Danneels, 2004; Govindarajan and Kopalle, 2006; Markides, 2006; Tellis, 2006); in particular the explanation used for a disruptive technology is described as ‘ambiguous’ (Tellis, 2006). The sampling for his empirical validation covered a wide range of product and technology types. Christensen used the scope and application of the term ‘disruptive’ to portray anything from magnetic disk drives (Christensen, 1997) through to 'Black and Decker' power tools, Honda motorcycles and Canon copiers (Christensen and Raynor, 2003). Markides (2006) elucidates how these examples are not of disruptive technologies, rather, examples of '*companies scaling up a niche market into a mass market*' (p.24).

In order to address this confusion, Danneels (2004) suggests that a disruptive technology is *'a technology that changes the basis of competition by changing the performance metrics along which firms compete'*. Tellis (2006) goes further by proposing new terms to aid clarification of disruptive technologies (i.e. those which are platform innovations, technology innovations and component innovations). Box 2.1 displays his interpretation of Christensen's theory of disruptive innovation in a more comprehensible format.

1. *A new disruptive technology initially underperforms the dominant one along the dimensions mainstream customers in major markets have historically valued.*
2. *But the disruptive technology (a) has other features a few fringe (and generally new) customers value. Products based on disruptive technologies are typically (b) cheaper, (c) simpler, (d) smaller, or (e) more convenient than those established on the dominant technology.*
3. *(a) The leading firms' most profitable customers generally do not want and indeed initially cannot use products based on disruptive technologies. So (b) disruptive technologies are first commercialized in emerging or insignificant markets. (c) Incumbents conclude that investing in disruptive technologies is not a rational financial decision for them.*
4. *The new disruptive technology (a) steadily improves in performance until (b) it meets the standards of performance demanded by the mainstream market.*
5. *At that point, (a) the new (disruptive) technology displaces the dominant one and (b) the new entrant displaces the dominant incumbent(s) in the mainstream market.*

Box 2.1 – Key Points of Christensen's Theory of Disruptive Innovation (Tellis, 2006)

The MNT government intervention is concerned with developing manufacturing and engineering technologies and as such, this review concentrates predominantly on research undertaken within these fields. Examples previously explored in this literature relevant to the MNT field include; solid-state data transfer devices and computer memory, desktop printers, integrated circuits (Markides, 2006; Hung and Chu, 2006).

2.2 Organisational Challenges

An important theme addressed in the EDT literature addresses the challenges organisations encounter when developing such emerging technologies.

In order to understand how the MNT government intervention has addressed such challenges or otherwise through its creation, it is important to firstly review existing work in this area. A number of organisational challenges/ difficulties relevant to the MNT case are discussed in the literature. These include: the need for an appropriate strategy or clear purpose; recommended strategies for EDTs; and resources, knowledge and ability to learn.

2.2.1 Need for an Appropriate Strategy or Clear Purpose

A number of authors make the point that there needs to be a continuous plan or long-term strategy in place for an organisation to successfully develop disruptive technologies (Assink, 2006; Holmes and Glass, 2004; Palumbo, 2001; Cravens *et al.* 2002). From a literature review examining the inhibitors of disruptive innovation, Assink (2006) describes how disruptive innovation should not be seen as one time effort. His review suggests that it requires a continuously developing absorptive capacity to improve the overall innovation capability of firms (Cohen and Levinthal, 1990, are key exponents of absorptive capacity). Kaplan (1999) further describes how a long-term view is needed: '*although the challenge is immense, this continuous innovation - and the ability to manage discontinuous change – is critical to the long-term growth'* (Kaplan, 1999, p.17). Holmes and Glass (2004) describe how innovation is not 'just a nice-to-do', but also a real priority. They emphasise that great technology[1] is the only thing that allows you to protect your profit margins. In the case of a National System of Innovation (NSI), the importance of technology as a driver for economic growth is also outlined (Woolley, 2008; Harvey, 2010). This focus on money and profit is echoed by Palumbo (2001) who purports that one way around this is to 'monetize the technology'. In other words, make sure that the technology alone is not the goal. In terms of the MNT government intervention, one of the ways in which

[1] 'Great' technology refers to innovations resulting from an organisation's research and development, which are successfully adopted by consumers. Examples of such successful technologies are provided by Holmes and Glass (2004) as that of Apple's iTunes Music Store, supported by their iPod music player.

they tried to monetize the technology was the clear requirement for each centre to make revenue, and become self-sustaining.

2.2.2 Recommended Strategies for Organisations Developing Disruptive Technologies

Scholars within the EDT literature provide a number of recommendations for developing organisational strategies to make disruptive technologies successful. Due to the wide ranging nature of cases investigated in this area there are many different routes for success. One highly emphasised strategy is the need to couple an organisation's technology effort with business factors early on in the new technology development process. Loutfy and Belkhir (2001) - describing the corporate innovation process at a large global OEM – maintain that the ideal point to do this is whilst the technology is in its infancy stages, and can be shaped by the emergent market needs. Such a tight coupling is almost always absent from dedicated corporate research centres and requires a strong partnership between research and business development professionals (Loutfy and Belkhir, 2001). Henderson (2006) adds to this, suggesting more emphasis should be placed on the role of market-facing competence in shaping a firm's response to disruptive innovations.

Kaplan identifies a framework to help organisations identify potential opportunities for developing discontinuous (i.e. disruptive) innovations. This framework is presented in table 2.1, and puts forwards a number of strategies; radical cannibalism; competitive displacement; market invention and industry genesis. Those of most relevance to the MNT government intervention are *radical cannibalism* and *industry genesis*.

Radical cannibalism differs depending upon the organisation's perspective. For example an organisation may choose to scale down certain technologies with a view to replace them with newer technologies. Alternatively there is *competitive radical cannibalism* which allows an organisation to offer new technologies/ offerings to customers and redefine the industry parameters. The latter is of more relevance to the MNT intervention through the creation of a number of MNT centres to develop new technologies for making the UK more competitive. *Industry genesis* is another strategy of relevance to organisations in the MNT government intervention. It describes the development of 'new to the world' technologies, which create their own markets and offerings for users. This is the umbrella under which most scholars would place disruptive technologies. Industry genesis 'is also the most challenging discontinuous innovation strategy – most are never able to do it.. remained theoretical rather than practical option for corporate strategists' (Kaplan, 1999, p.19). Problems existing with this strategy include; the unknown nature of competition (it doesn't exist yet, so one can only guess who future competitors may be); new forms of customers will emerge (those which may not value the technology currently, until it actually exists); markets are not definable. Herrmann *et al*. (2006) cast doubt over the significance of needing customer acceptance for the basis of new product design.

> '*Over the short-term, the required orientation of business actions towards the wishes of customers may be entirely correct. However, in the medium- to long-term companies in the high-tech sector, in particular, run the risk of failing to notice relevant technological changes because customers cannot assess these or reject them at first glance'* (Herrmann *et al.* 2006 p.37).

The impossibility of future prediction is also outlined by Paap and Kaatz (2004). However, they do suggest that preparing for it by focusing on the drivers of the technology is possible.

Andries (2006) describes the ambiguity of business models when developing emerging technologies – and how traditional planning is not viable '*we saw that a New Technology Business Venture (NTBV) cannot define the set of all relevant business models from the outset, owing to the presence of uncertainty and ambiguity. Changes to its original business model are thus needed as initially unavailable and unknown information becomes known*' (Andries, 2006, p.34). He suggests that adaptation in NTBVs is thus required despite environmental change. He adds that ventures have to search for their place in the environment, and sometimes even have to find the most appropriate environment.

To overcome difficulties of uncertainty Kaplan (1999) suggests two strategies: firstly to miniaturise technologies, and secondly to combine functionalities of seemingly disparate technologies. The first of which aligns with the development of 'micro' and 'nano' technologies – i.e. technologies enabling the creation of smaller devices. A very recent example is that of solid-state memory sticks (Universal Serial Bus – USBs). The second strategy - to combine functionalities of disparate technologies – refers to the creation of new methods of meeting combinations of customer needs, which when satisfied together result in new business opportunities (Kaplan, 1999, p.20). A recent example is the development of Smart Phones, e.g. the Apple iPhone, or Google Nexus. An older example is that of the first scientific calculator combining integrated circuits and light emitting diodes.

An alternative strategy is that suggested by Holmes and Glass (2004) which is to manage a portfolio of opportunities. Managing a portfolio of opportunities refers to the management of risk in order to optimize profits. In terms of emerging technologies, Holmes and Glass suggest that this relates to the considering of three dimensions: markets, time and source (2004, p.8). Market refers to the target customers; time defines the period over which the emerging innovations must be completed; and source refers to the need for investing in resources which add value to the market over a given time. The government can be viewed as having done this with the MNT intervention; market being the micro- and nano- technologies; time referring to the grant periods; and source in relation to the need for providing a route for UK companies to access MNT resources to add value to this market.

Drew (2006) describes the use of scenario planning in order to identify disruptive technologies and map them out, building the appropriate paths and organisational capabilities for them. Other scholars such as Phaal *et al.* (2006) have described technology roadmapping tools to help develop new technology strategies successfully. Whether the MNT centres have used such tools as part of their innovation process, or strategy development will shed further light on this debated area, where one school of thought clearly believes forecasting is impossible (Paap and Kaatz, 2004), and others that it is manageable (Drew, 2006; Phaal *et al.* 2006). This disagreement in the literature further adds to the difficulties faced by policy makers when developing national systems of innovation based on disruptive technologies.

Table 2.1 highlights a number of strategies described by Kaplan (1999) for developing disruptive innovations. The *Industry Genesis* category can be seen as particularly relevant to the need for the development of micro- and nano- technologies (referred to in DTI, 2002a).

Table 2.1 - Strategies for Developing Disruptive Innovations (Source: Kaplan, 1999, p.19).

Strategy	**Approach**	**Focus**
Radical Cannibalism	Hypothesize obsolescence	What forces could lead to the demise of the business?
	Scan startups	What emerging technologies could displace the current value you provide to the market?
Competitive Displacement	Elevate business charter	What is the root end-user need that your business satisfies?
	Explore tangential industries	How does the fundamental value you provide get satisfied within industries outside of your own?
Market invention	Expand customer boundaries	If the entire world represented your customer base, how would you segment your markets and what needs could you satisfy within each segment?
	Identify systems	What larger systems do your products operate within, and how might you incorporate a larger value set into your offering?
Industry Genesis	**Miniaturize**	What value would your technology provide if it were 10-20 times smaller than it is today?
	Combine functionality	What unique combinations of technology or functionality might provide a new form of value?

2.2.3 Resources, Knowledge and the Ability to Learn

The way resources are used in organisations and how organisations and its staff can learn new knowledge (known as absorptive capacity) is an important consideration for those developing EDTs (Assink, 2006; Herrmann *et al.* 2006). A thorough investigation into the effect that resource-based views have on the development of radical product innovations was carried out by Herrmann *et al.* in 2006. The term resource-based refers to the challenges which occur when actors are forced to use old-technology investments when new technologies exist to develop radical product offerings. It is also tied in with the ability of an organisation and actors to discard old knowledge and develop their learning capability toward newer technological offerings (Herrmann *et al.*, 2006). In their paper they use pilot research to prepare surveys to senior managers from 53 companies, across a range of technologies (from software to image processing). 87 of the 109 managers surveyed responded. Their findings were subsequently considered more robust than a number of other research papers investigated in this sample of papers used for the EDT literature review[2] (for example, papers by Hughes and Cosier, 2001; and Foster, 2000). Their results show that the willingness of those responsible to abandon existing knowledge (unlearn), collective experience and actual investments strongly determines radical product innovations. One of the main limitations they found was the focus of an organisation to abandon an investment – reiterated by the work of Assink (2006), and Tellis (2006). Assink suggests further barriers to innovation: organisational rigidity and the existence of dominant designs; the inability of organisations to unlearn; the attitude organisations take to risk (i.e. risk averse); and the management of the innovation process and a lack of infrastructure to push it through in time.

In order to overcome barriers to radical product innovations, Herrmann *et al.* (2006) recommend that:

> '*a company should concentrate on power and technical promoters who, because of their technical and personal authority, are able to bring new product-ideas to fruition. Hence, it is necessary for top managers to allow corresponding personalities in the company, and to give necessary power to individual innovation managers*' (Herrmann *et al.*, 2006, p.39).

Loutfy and Belkhir describe how one global OEM used the equivalent of innovation managers for upfront selection (2001). Lee and Park (2006) further emphasised the need to look at stakeholders when investigating research and development linkages in a national innovation system: '*the performance of an innovation system increasingly depends on the intensity and effectiveness of the interactions between the main actors involved in the generation and diffusion of knowledge*' (Lee and Park, 2006, p.1048). These observations introduce the notion of actors and roles into the EDT literature. The importance of actors and their role in the development of emerging technologies highlights a gap in the EDT literature. This gap is explored in this study, with the addition of theorisation from institutional theory. The Bridging Chapter describes how

[2] They were considered more robust because they had clear and justified research methods; unambiguous presentation of results based on a structured literature review; objective analysis of results; aware of limitations; and published in high impact factor journals.

the organisations developing emerging technologies are further understood (in the MNT intervention) through an institutional theory lens. This gap presented an important opportunity to further understand the roles of actors in the MNT case organisations, and how the aforementioned promoters are able to develop EDTs (or not).

Lifelong learning of actors (employers and managers) is put forward as an important, but difficult to obtain requisite for innovation (Herrmann *et al.* 2006). Assink builds on this notion by describing disruptive innovation as more than just a one time effort that requires continuous development, and the need to develop absorptive capacity to improve the overall innovation capability of firms (Assink, 2006).

Authors also describe the difficulties actors face when trying to gain access to physical resources (e.g. machines, equipment). Resources often have to be prioritised away from innovation to address short term gains; or business which trades the organisation's future against more immediate but clearly needed gains (Loutfy & Belkhir, 2001; Dorrington, 2005). In order to make better use of capabilities, Cravens *et al. (2002)* suggest that management must make changes to the organisational structure, processes, and culture in order to maximise their long-run innovation success and overall business performance. This study investigates a wide range of contexts, and it is premised that use of resources may have an effect upon development of MNTs. For example, a commercial organisation may prioritise use of their emerging technologies differently from universities.

2.3 Structured Responses to Challenges Faced when Developing EDTs

A number of the challenges/ barriers faced when organisations develop disruptive technologies have been discussed above. This section will describe some of the ways in which organisations structure for and overcome these issues.

2.3.1 Use of Key Gatekeepers

Herrmann *et al.* (2006) through their analysis of senior managers across a range of innovation sectors, makes the case that the use of product champions led to a fundamental change in the organizations of nearly all of the companies he examined

(53 companies across six high technology sectors). He describes product champions as actors who are able to overcome barriers to disruptive technology development. He argues that they consist of two types; power promoters and technical promoters. The former are hierarchically positioned in an organisation to influence the organisation to apply sanctions against actors resisting innovation, whilst protecting those who are in favour of it. The latter actor – i.e. technical promoter – is able to drive forward an innovation process using their specific technical knowledge. For example, in the case of 'SAP' a global software specialist, a clear and sustained upgrading of the product management function was observed, i.e. the product management organisational unit was given greater significance, allowing the linking of research and development roles with responsibility (Herrmann *et al.*, 2006). Other descriptions of such key roles include the term 'gatekeepers'. Collins (2004) describes the use of gatekeepers to diffuse/ show the technologies from a large organisation's laboratories as and when appropriate. He adds that improved disruptive innovation results from an increased amount of contact that R&D people are given, through mechanisms such as increased customer visits.

2.3.2 Collaboration and Cross-linking of Departments

Many authors refer to the need for collaborating both internally and externally when organising for emerging and disruptive technologies. A common finding is the importance of cross-linking departments in large global organisations from senior levels and below. Collins (2004) found that actors within a leading global company (Hewlett-Packard) use such a form of cross-linking of departments to ensure a high level of engagement with the technology teams throughout the business. Herrmann *et al.* (2006) go further by recommending that there should be organizational units such as product management which act *at and across* the business functions.

Again focussing on the larger organisations[3], researchers such as Kash and Rycroft (2003) talk of how '*managing the innovation of complex technologies today is more about identifying and co-ordinating shifting bundles of resources held by multiple organisations, not always firms*' (Kash and Rycroft, 2003, p.29). They give examples of the need for cross-disciplinary actors to work together in a collaborative network. '*Managers of the innovation of complex technologies who do not appreciate that they*

[3] A large number of the authors within the literature sampled used global organisations as their object of inquiry.

are managing networks not just their own organisation, operate at a great disadvantage' (Ibidum, p. 30). Furthermore they suggest that systems are too complex for one person to understand/ master nowadays, therefore collaboration is needed.

External collaborations are also discussed in the literature; Hemais *et al*. (2005) describe the case of foreign company joint ventures as one such way of structuring business. In their description of Brazilian polymer firms they describe how they form tripartite relationships to develop emerging technologies. However, they also report that this also means that the companies are dependent upon the decision-making of the international firms.

2.3.3 Incumbents and the Need to Work with New Entrants

Fagerberg *et al.* (2005) describe how '*ever since Schumpeter associated the advent of revolutionary technologies with 'waves of creative destruction', there has been debate about the relative role of incumbent large firms and the new entrants in exploiting them*' (p.104); a number of these debates are now discussed.

Linked to the notion of collaboration is the need expressed in the literature for incumbent firms to make links with smaller, entrant firms. Incumbent firms have the resources to serve their current markets; e.g. customer knowledge, sales and distribution changes, and brand and reputation. However they lack the ability to build the resources necessary to serve new markets (Danneels, 2006). Markides recommends that incumbent firms should not enter markets initially served by new technologies themselves, and rather they need to monitor these remote markets first, to assess how they might impact them. Incumbents should '*create, sustain and nurture a network of feeder firms'* in order to achieve this (Markides, 2006, p.24). The premise is that the young entrepreneurial feeder firms are busy colonising new niches. The converse argument is also applied: that in order to carry out systematic innovation there is the need for new entrants to work in tandem with incumbents to gain entry. Entrants and incumbents can then create joint ventures which have the potential to reap major benefits (Dyerson and Pilkington, 2005). All of which leads to the question of 'why do such emergent technologies represent such difficulties for incumbent firms with such bureaucratic structures?'

Libaers *et al.* (2006) study the extent and intensity of the linkages between firms and university spin outs in the case of nano- technologies. The aim of their research was to further explore the process of technology transfer from Universities. A university spin-out describes the process when a parent university transfers *university-invented technology* and *expertise* to another entity or to the market (Roberts, 1991). That is, they have been 'spun-out' from a university. This paper is particularly relevant to this study as a number of the venues selected for MNT centres are essentially spin-out organisations, in the sense that centres were created from existing research centres which were then developed into Limited companies.

A number of findings of particular relevance to this investigation were reported by Libaers *et al.* (2006). Firstly, university spin-outs play an important *but not* dominant role in the development of nano-technology in the UK. In addition, their work describes how multinational companies and new technology-based firms are as, or even more important than spin-outs in the development of the nano- technology industry in the UK. Through the investigation of MNT centres from a range of venues, this study has the potential to add further to these findings. Particularly, considering that the UK state purposely established a number of centres on existing university facilities in order to 'leverage' existing facilities. The term 'leverage' is used to describe the idea that building on existing infrastructure will provide more economic gains than having to start from scratch.

Through their qualitative examination of USO cases they discovered that a major disadvantage of developing emerging technologies in small firms was the added difficulty and resources they had to protect their intellectual property (IP). In fact, more often than not the firms under investigation revealed that secrecy and the development of tacit knowledge within the firm were seen as an alternative way to protect the IP that they created (Libaers *et al*. 2006).

2.3.4 Incumbent Firms and Bureaucratic Structures

Incumbent firms are large firms which have the resources to serve their current markets; e.g. customer knowledge, sales and distribution changes, and brand and reputation (Danneels, 2006). One might conclude that having access to more resources (including finance, manpower, etc.) provides a number of advantages to incumbents over small entrant firms for developing disruptive technologies. For example; greater staying power; better equipped to develop complex, high quality and reliable products and services; relatively free from the distracting and exhausting funding game that new firms must deal with (Loutfy and Belkhir, 2001).

In contrast to these views, other scholars describe how incumbent firms often lack the ability to build the resources necessary to serve new markets (Tellis, 2006; Assink 2006; Danneels, 2006). Furthermore there is an argument that as a larger organisation they have to deal with the increased level of bureaucracy that comes with size. From his in-depth literature review, Assink (2006) suggests that this makes it difficult to challenge, provoke and engage in innovative activities. The MNT network has the potential to cast further results on this variation of views in the literature.

2.3.5 Overcoming Bureaucratic Structures - Decoupling

Corporate bureaucracy is one of the most frequent barriers to successful disruptive technologies within this literature review. Holmes and Glass (2004) provide examples of companies such as 3M, IBM and GE who understand that *'new technologies often require creative business models'* which enable them to *'empower their business units with autonomy and profit/loss responsibility'* similar to the way a start-up firm would. Therefore the natural approach appears to be disconnecting them from the bureaucratic structure of the parent organisation, so that they can adopt a more innovative/ entrepreneurial culture and reward structure. In the institutional theory literature this is called 'decoupling'. It refers to the way in which organisations adapt to demands which are inconsistent or harmful to the organization, essentially to enhance their prospect of survival (Boxenbaum and Jonsson, 2010). In terms of the EDT literature scholars describe the physical creation of separate organisational units from larger host incumbents, in order to foster the development of disruptive innovations (Holmes and Glass, 2004; Govindarajan and Kopalle, 2006; Danneels, 2006). The development of disruptive innovations often requires new business models to unlock their value to the firm; '*disconnecting innovation efforts from the corporate bureaucracy allows them to flourish and to adapt a more entrepreneurial spirit and reward structure*' (Holmes and Glass, 2004, p.10). In addition, the development of disruptive innovations may require new processes and routines, along with the creation of autonomous units which aid in breaking from current routines and processes (Govindarajan and Kopalle, 2006).

In contrast, the realities of decoupling disruptive technology attempts from the larger bureaucratic firm environment does lead to other issues. Loutfy and Belkhir (2001) discuss some of the realities of developing independent companies in their analysis of 12 cases within the *Xerox Technology Enterprise* (a corporate innovation process to commercialise new technologies). When venture capitalists were involved they discounted the technology greatly when calculating Xerox's equity position and placed enormous premiums on the existence of a committed team that could deliver. Some of the new technologies described were incredibly promising, but there were issues of access to expensive infrastructure to overcome. Often equipment owned by other companies couldn't be accessed, and to buy the equipment alone was not feasible. As such these technologies ended up being licensed out to the owners of such equipment. In other cases projects that were picked up internally often began well but then failed because of having to compete with larger projects for funding. For those technologies that were taken into independent organisations successfully, *'unless a self-driven and passionate team is ready to dedicate itself completely to the project, the entire undertaking grows to nothing more than a stillborn entity. Creating a new business takes an inordinate amount of energy, dedication and personal sacrifice'* (Loutfy and Belkhir, 2001, p.16). In addition, they describe that teams who are just allocated to a project and may see it as their day job will not succeed. Libaers *et al*. (2006) add that small firms often find it expensive to file, defend, and monitor patents. Instead they often use secrecy or tacit knowledge (or first mover advantage) when developing disruptive innovations.

2.3.6 Ways Incumbents can Overcome Issues of Bureaucracy and Structure

Considering the large call from scholars for incumbents to decouple departments developing disruptive technologies, there still remain those who believe that '*if they [incumbents] are able to create the kind of environment that will stimulate and nurture this wealth creating activity*' then success with emergent technologies in new markets is possible (Loutfy and Belkhir, 2001, p.27). Holmes and Glass (2004) ask the question 'why do some incumbents succeed where others fail? They provide a list of potential reasons for this, the most relevant to this discussion being:

- Disconnecting innovation efforts from the corporate bureaucracy allows them to flourish and to adapt a more entrepreneurial spirit and reward structure. New technologies often require creative business models to unlock their value to the firm.

- Interdisciplinary expertise required.
- Strive for revolutionary inventions.
- Consider IP as currency.
- Innovation is not just a nice-to-do, but also a real priority. Great technology is the only thing that allows you to protect profit margins.
- Internal profit sharing can help spark creativity in firms.

Tellis (2006) proposes 'leadership' as the reason why some incumbents thrive and some fail. They agree that '*new technologies can come from large incumbents championing new technologies*'. Assink (2006) suggests that there are often infrastructure barriers, i.e. a lack of a means of pushing the innovation through in time. Hemais *et al.* (2005) found that the best companies within their sample that maintained their technological competitiveness were those who knew how to align their R&D processes with their current processes, and measure such alignment.

2.4 Technology Origins of the Sample Literature

The range of technologies observed within this literature sample suggests that the theory of disruptive technologies is considered by authors to be wide-ranging. This provides evidence for the argument presented by authors such as Danneels (2004) and Tellis (2006) who suggest that the theory is over-used, and sub-categories need to be defined.

'The term disruptive technology has been used disparately to apply to things such as; department stores, airlines, power tools, online businesses, and travel agents. A distinction needs to be made between 'business model innovations' and 'technological innovations'. The similarities between the two have led some researchers to treat two types as one and the same' Markides (2006). In fact, Danneels attempted to clarify this definition a few years earlier; *'the core of the definition of a disruptive technology is this; a disruptive technology is a technology that changes the basis of competition by changing the performance metrics along which firms compete'* (Danneels, 2004).

Christensen provided a response to a number of challenges to his original theory of disruptive innovation in his recent paper (Christensen, 2006). In this paper he asserts that his theory has been applied to – and worked in- the following industries: *'hydraulic excavators, department stores, steel, computers, motorcycles, diabetes care, accounting software, motor controls, electric vehicles, education, and financial services'* (Christensen, 2006). However, he does provide the caveat that his theory can only be tested on a case by case basis. The literature within this study's sample indicates that disruption theory would benefit from further categorisation; however, Christensen's point is also noted that the extent to which they replace or add to the disruption theory, cannot yet be judged until deductive research is carried out. To be precise, Christensen is offering a challenge for any author to validate their claims with empirical research.

Christensen's original focus on low-cost, initially inferior products that attack an incumbent's products from below has also been challenged by Utterback and Acee (2005), who make the point that not all disruptive innovations are *'bottom up'* in their approach; many, for example calculators, are *'top-down'*. They purport that there should be a distinction between low-end (simple) disruptive technologies and high-end ones (technologically more advanced). The addition of high-end technologies includes products such as calculators that were more expensive and complex than alternatives (i.e. slide rules) when they were first introduced; however, they were disruptive (reference to Utterback & Acee 2005, Table 1, p.8). Christensen has since acknowledged this in his paper of 2006. *'For example, in about 2000 I realized that the phenomenon I previously had characterized simply as disruptive technology actually was comprised of two fundamentally different phenomena, which I characterized as low-end and new-market disruptions*' (described in Christensen and Raynor, 2003).

Taking the above discussion of technology focus into account provides a useful platform on which to develop our understanding of technology in relation to the MNT government intervention under investigation. In order to understand how the MNT government intervention functions, and describe the existence of stakeholder values and the role of public interventions (i.e. RQ1), technology needs to be conceptualised in a way that it can be linked to the MNT organizations under investigation. The EDT literature described above generally follows the premise that technology is deterministic (Orlikowski, 1992); that is, it is objective and can independently influence human behaviour or organizational properties. While providing insight into the often determining aspects of technology, this body of research largely ignores the action of humans in developing, appropriating, and changing technology. '*As a consequence, this perspective furnishes an incomplete account of technology and its interactions with organizations'* Orlikowski, 1992, p. 400). This reinforces the need that this study addresses in terms of understanding the development of emerging technologies through an interactive process perspective.

2.5 Summary

This chapter reviewed the literature concerning emerging and disruptive technologies (EDTs). The varied understanding of disruptive technologies in the literature has been discussed, along with the need to be more specific when selecting the products and/ or technologies under investigation.

The main purpose of this review has been to understand the mechanisms used by organisations to manage the development of emerging technologies, and the challenges they have faced along the way.

A gap has been highlighted for the investigation of organisations developing emerging technologies in relation to their specific contexts and in terms of the actors inhabiting them.

Chapter 3 - Systems of Innovation

This chapter provides an overview of the systems of innovation (SI) approach, along with its relevance to this thesis. The concept of systems of innovation in general is introduced, along with the ways in which the boundaries of systems of innovation are addressed. This helps to locate the government intervention under investigation in the wider body of literature. The chapter begins with the SI concept in general terms, and then focuses on boundaries of SIs; including geographically (spatially), sectorally and in terms of activities.

The chapter also discusses the way in which innovation systems are enacted through innovation policies, which of particular importance to this study, can lead to government interventions.

3.1 Systems of Innovation

Fagerberg (2005) highlights the systemic nature of innovation processes, and how firms do not normally innovate in isolation, but in collaboration and interdependence with other organisations. In other words they innovate as part of a wider 'system of innovation'.

'Organisations' may be other firms such as suppliers, customers and competitors. Alternatively, they may be organisations in the public sector such as universities, schools, and government ministries (Edquist, 2005, p.182). He describes how the behaviour of such organisations is shaped by institutions. He clarifies the terms 'organisations' and 'institutions' as follows:

- Organisations are seen as '*formal structures that are consciously created and have an explicit purpose. They are players or actors*';
- Institutions are '*sets of common habits, norms, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups, and organisations. They are the rules of the game*'.

(Edquist, 2005, p.182).

A system of innovation describes the determinants of innovation processes, that is:

> '*The important economic, social, political, organisational, institutional, and other factors that influence the development, diffusion, and use of innovations*' (Edquist, 1997, p.14).

Innovations refer to both product and process innovations within the SI theorisation. Products can be new or better material goods; process innovations are new ways of producing goods and services. Either may be technological or organisational.

The SI approach has diffused broadly amongst the academic literature (see: Freeman, 1987; Lundvall, 1992; Nelson, 1993; Edquist, 1997; and Balzat and Hanusch, 2004). This approach has also been applied to policy frameworks used by regional authorities and national governments, as well as international organisations such as the European Union and the Organisation for Economic Co-operation and Development (OECD) (Edquist, 2005).

3.2 Boundaries of Systems of Innovation

The interactions which take place between organisations in system of innovation are bound at certain levels. For example, when they are within the borders of the nation state, then the term 'national systems of innovation' is used.

Conway and Steward (2009) describe how the systems of innovation concept was originally adopted to analyse and understand systems of innovation at the national level, however '*it has been increasingly employed in research and policymaking focused at the regional and sectoral levels*' (Conway and Steward, 2009, p.413).

These boundaries are also referred to as *spatial scales* by researchers such as Fromhold-Eisbith (2006). Identified levels within the extant literature include international, national, regional and sector levels. For example, Phelps and Tewdwr-Jones (2001) examine state firms and practices at a regional level, to understand how certain types of interest and activities are privileged. His focus in on the regional policies and how they have encouraged foreign direct investment (FDI).

Another example is that of Woolley and Rottner (2008) who examine the implementation of policies at the state level related to nanotechnology, including a focus on entrepreneurs. His work tracks policy initiatives from 1985 to 2005 for nanotechnology.

3.2.1 National Systems of Innovation

A national system of innovation (NSI) is a subsystem of the national economy where various organisations and institutions interact and influence each other during the process of innovative activity (Groenewegen and Steen, 2006). This is an important level to focus research on as most public policies influencing innovation processes or the economy as a whole are still designed and implemented at the national level (Edquist, 2005, p.199).

It is about a systemic approach to innovation in which the interaction between technology, institutions, and organisations is central. '*NIS thinking led to a structurally different view of how governments can stimulate the innovation performance of a country*' (Groenewegen and Steen, 2006, p.278). It moved away from the traditional linear way of thinking about innovation (i.e. thinking about the innovation process as a sequence of events), and emphasised a more holistic view on innovations. This view took into account the interactions and dependencies amongst the variety of actors; i.e. agents, organisations and institutions.

3.2.2 Background of National Systems of Innovation

In the early 1990s the NSI concept diffused more rapidly with the introduction of a number of seminal texts: firstly, '*National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*' by Lundvall (1992); secondly, '*National Innovation Systems: A Comparative Analysis*' by Nelson (1993). Both authors adopted different approaches to their investigations of NSIs; Lundvall's (1992) book followed a more theoretical orientation than Nelson's (1993) book, and was developed around themes, placing interactive learning, user-producer interaction and innovation at the centre of the analysis. On the other hand Nelson's (1993) book focused on a 'national' approach rather than themes, and emphasised empirical case studies. His study spanned fifteen different nations and their associated innovation systems. The studies were selected in order to investigate different structures and focus. As such in comparison to Lundvall's work, Nelson '*advanced a more narrow approach, focusing on national R&D systems and organizations supporting R&D as the main source of innovation*' (Edquist and Hommen, 2008, p.5).

More recently, authors such as Sharif (2006) have analysed the development and dissemination of the NSI concept through interviews with key advocates of the NSI concept, in order to understand how and why it has become so widespread in academic and policymaking circles. He describes the way in which the concept of NSI has come to mean different things to different people:

‘*The practical application of the (National) Innovation Systems concept is embedded in social choices and negotiations about what counts as an innovation system, what should count as the delimiting criterion (whether on a national or some other scale), and how to draw borders. These social choices and negotiations are made each time the Innovation Systems concept is used, or developed further, by any individual or group depending on their location on the ‘map’ of the larger field*’ (Sharif, 2006, p.762).

Considering Sharif’s observation that the NSI concept evolves, Niosi (2002) - on the other hand - does highlight how there is still a semantic core appearing in most of the definitions used. Conway and Steward reveal this semantic core (and variety) when they highlight a selection of definitions from key proponents of the NSI approach (Conway and Steward, 2009, p.418). Of these, one of the most resonant for this study is that of Niosi *et al.*:

‘*A national system of innovation is the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal, social, and financial, in as much as the goals of the interaction is the development, protection, financing or regulation of new science and technology*’ (Niosi *et al.* 1993, p.207).

3.2.3 Benchmark National Systems of Innovation Models

Groenewegen and Steen (2006) explain how many policy studies have tried to describe, understand and compare innovation processes of a country. One way in which they do this is to develop models of the innovation process. Figure 3.1 shows such a model developed by Bremer *et al.* (2001), cited in Groenewegen and Steen (2006, p. 279) which provides a useful conception of how a national system of innovation is made up. Polt *et al.* (2001) describe how this model is one of the dominant designs for comparative studies of national innovation systems.

Figure 3.1 highlights the major building blocks of an NSI (in terms of creating practical policy). The key building blocks of this model include firms, universities, and other public research organisations. Together these organisations constitute the science and technology capabilities and knowledge fund of a country.

The arrows in the diagram refer to the interactive learning and diffusion of knowledge amongst organisations. An essential building block shown at the top of figure 3.1 is that of ‘demand’, which refers to the level and quality of demand as an instigating factor for a firm to innovation. By their very nature, national systems of innovation often come into existence to address some form of demand, or ‘need’.

Institutions are shown by the building blocks of ‘framework conditions’ and ‘infrastructure’. These include: laws, policies, and regulations linked to science, technology and entrepreneurship. A broad range of policy issues are included in these, such as Intellectual Property Rights (IPR), and economic instruments to stimulate mobility of labour between universities and firms.

Groenewegen and Steen (2006) describe how benchmarking exercises of NSIs typically compare the indicators from such a dominant framework. They also explain that the figure demonstrates ‘…*that in order to improve the innovation performance of a country, the NIS as a whole should be conducive for innovative activities in a country*’ (Groenewegen and Steen, 2006, p.278).

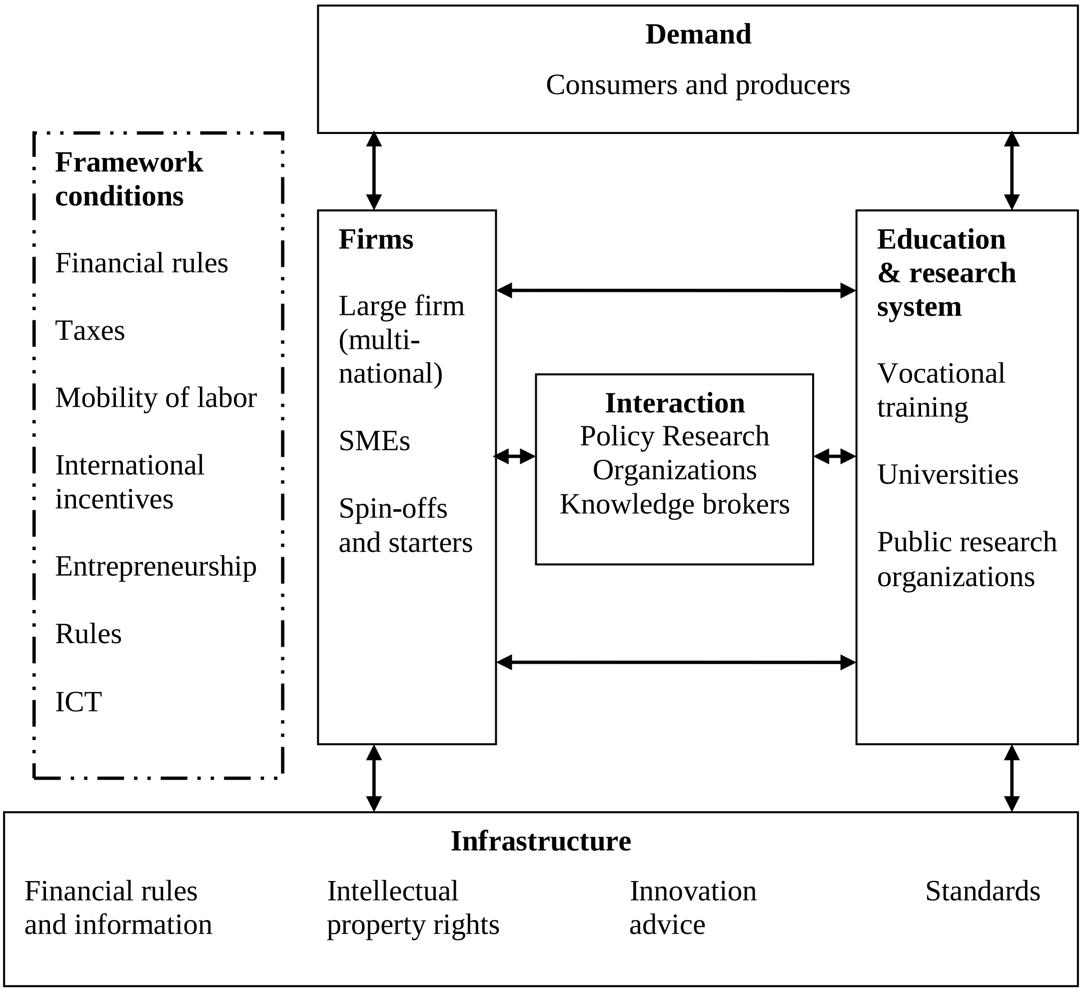

Figure 3.1 – The Benchmark NIS Model (Source: Bremer *et al.* 2001, p.8).

3.2.4 Layered National Systems of Innovation Models

Groenewegen and Steen (2006) draw attention to the need for a framework which allows for comparisons of NSIs along with their idiosyncrasies. They suggest connecting the levels which constitute the NSI model, and seeing it as an inter-connected system of institutions and innovation patterns driven by the learning process of economic agents. They suggest conceptualising institutions first in hierarchical layers and then analysing the interactions between them. There are a number of advantages of adopting such a multi-level view in this research area. Fromhold-Eisbith builds on this in her 2006 paper, describing how systems at different spatial scales could be linked and co-ordinated for positive benefits.

Fromhold-Eisbith (2006) further theorises the links between the international, national and regional levels, claiming that the three levels do not function independently of one another. They rely on each others' strengths and specific system qualities in order to productively interact. This represents an important gap in the NSI literature; i.e. the need to investigate the different layers. Groenewegen and Steen (2006) explain how papers typically only look at the technology and firm level, and the national category is seen as a 'leftover'. They suggest separating the layers that make up the NSI to see it as an inter-connected system of institutions and innovation patterns driven by the learning process of economic agents.

Their research results in a potentially new framework for NSI policies to follow. Groenewegen and Steen (2006) propose the importance of viewing NSIs as a layered system and the need to investigate between layers. They suggest that existing theoretical contributions to NSI do not sufficiently conceptualise institutions or the dynamics of NSI over time. Therefore they propose the need to view NSIs as a layered system, with logics based on habits and routines. This is introduced as the 'Layered Institutional model', shown in figure 3.2. Groenewegen and Steen (2006) propose that this model overcomes the limits of copying other benchmark models such as Figure 3.1, which many policies do. They suggest that the dynamics of an NSI can be captured by analysing the interaction between levels/ layers, to provide more effective policy recommendations. The fields of activity in this model are of differing importance to different countries, but all are useful to achieve systemic integration.

Groenewegen and Steen (2006) describe how there is a need for more precise theoretical analysis of how these innovation systems actually function and how they evolve over time. Using a number of observations from the literature they develop a layered institutional model, which is reproduced in Figure 3.2. In order for policies to be effective they suggest that there is a need to understand the layers and dynamics of an NSI, for future policy learning.

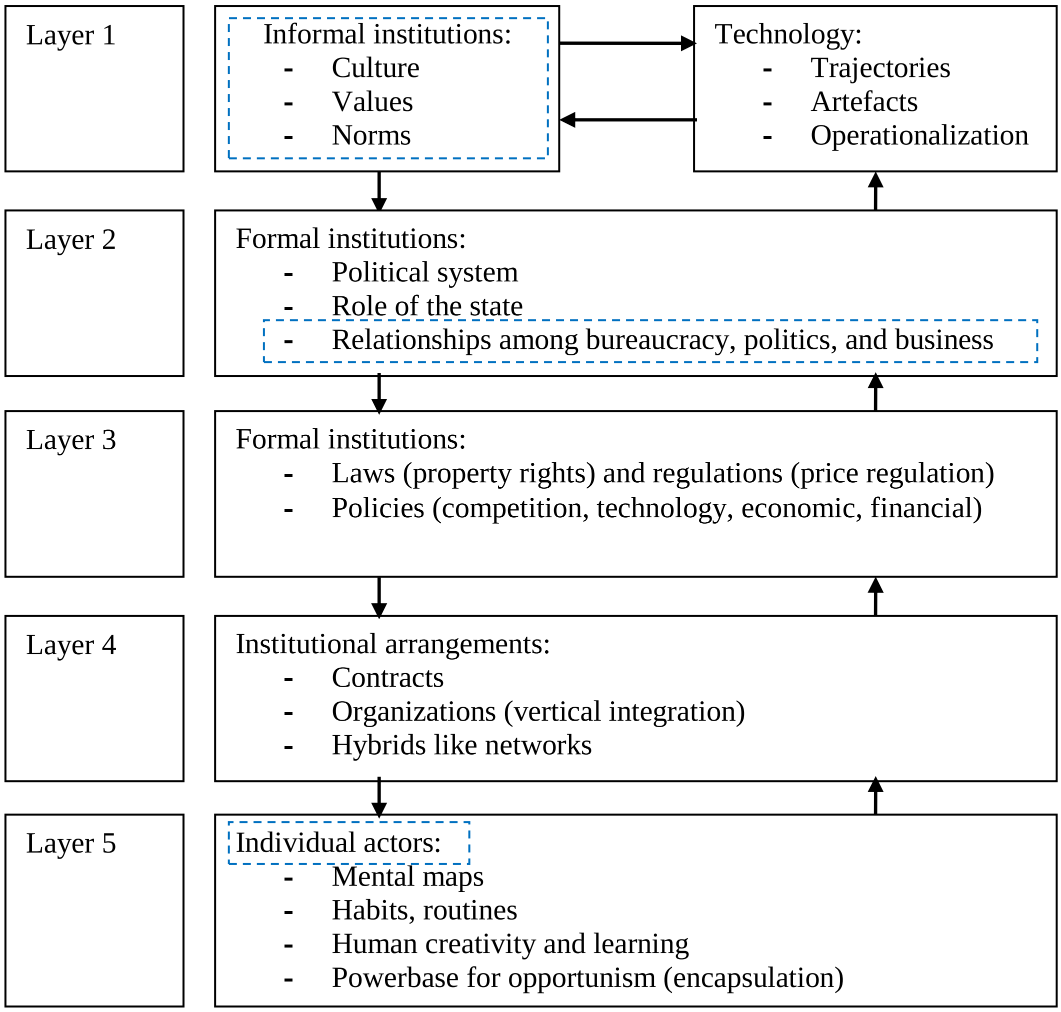

Figure 3.2 – Layered Institutional Model (Source: Groenewegen and Steen, 2006, p.279. Note: the dashed rectangles highlight a number of characteristics from this model which are also studied within this PhD).

This framework consists of five layers which make up the institutional environment. Through layering, this approach helps to view an NSI as an inter-connected system of institutions and innovation patterns. These are driven by the learning process of economic agents. By separating these layers from the traditional benchmark NSI models, the institutional diversity in a system of innovation can be further understood.

The first three layers make up the institutional environment. Layer 1 describes the informal institution (i.e. culture: values and norms) and technology.

Layer 2 deals with the political system. Layer 3 refers to the formal rules of the game (laws, regulations, and policies). These can act to constrain or facilitate the development of innovation; e.g. regulations might come into force in one nation that require all new cars to be fitted with a new type of restraint for children using an emerging technology. This may lead to an increase in the development of restraint technology within one nation.

Layer 4 shows the institutional arrangements (public and private organizations, contracts, and hybrids like networks). Layer 5 displays creative, innovative learning that is embedded in habits and routines, which include strategic behaviour and the power base of actors, which can block innovative development, according to their existing interests or motivations.

The arrows connecting the layers indicate how the higher layers not only constrain the lower ones but that lower layers within a certain range can influence higher ones. As such changes at one layer can reinforce one another, but also be conflicting. For example the culture, values and norms of an informal institution at layer 1 may influence/ shape the actions of an individual actor at layer 5. This is important because: '*These interdependencies are not universal but specific to national and sectoral systems*' (Groenewegen and Steen, 2006, p.284), and the benchmark models do not consider such interdependencies.

To summarise, layered institutional models highlight the need for researchers and policy makers understand the institutional aspects of a system of innovation.

3.2.5 Regional Systems of Innovation

Scholars in this area of research believe it is important to define systems of innovation by pre-defined spatial/ geographical regions (see: Cooke *et al.* 1997; Oughton *et al.* 2002; and Fleming *et al.* 2007). Conway and Steward (2009) describe how this research has built on work concerning the importance of 'industrial districts' and 'regional clusters' (for example: Piore and Sable, 1984; and Rogers and Larson, 1984; respectively). They explain how such districts/ clusters are geographical concentrations of interconnected companies and associated institutions focused around a specialised area of economic activity. These include: end producers; universities; research laboratories; service providers; and a pool of highly skilled labour.

Authors such as Asheim and Gertler describe how '*the regional innovation system can be thought of as the institutional infrastructure supporting innovation within the production structure of a region'* (Asheim and Gertler, 2005, p. 299). They suggest that innovative activity is not a uniformly spread activity across the geographical landscape. Their research claims that the more knowledge-intensive the economic activity is, then the more geographically clustered it tends to be. For example, Silicon Valley in the USA (in terms of information technology) and Motor Sport Valley in the UK (for racing car production). Authors such as Feldman conclude that the acquisition and transfer of knowledge from organisations in such close proximity adds to this geographic clustering:

> '…*knowledge spillovers from science-based activities are localised and contribute to higher rates of innovation, increased entrepreneurial activity and increased productivity within geographically bounded areas*' (Feldman, 1999, p.20).

Conway and Steward (2009) describe how such processes are self-reinforcing, which in turn promotes the local accumulation of knowledge and expertise.

However, Edquist points out that one of the drawbacks of using this type of boundary system is the question of which criteria should be used when identifying a 'region':

> '*For a regional SI, the specification of the boundaries should not only be a question of choosing or using administrative boundaries between regions in a mechanical manner (although this might be useful from the point of view of availability of data). IT should also be a mattter of choosing geographical areas for which the degree of 'coherence' or 'inward orientation' is high with regard to innovation processes*' (Edquist, 2005, p.199).

The next section looks at bounding innovation systems from a sectoral perspective.

3.2.6 Sectoral and Technological Innovation Systems

Whereas levels of systems of innovation may be bound to regions or nations, sectoral and/or technological systems of innovation can navigate across geographical areas.

3.2.6.1 Sectoral Systems of Innovation

This area of research looks at factors which affect innovation in 'sectors'. One of the key advocates of the sectoral systems of innovation approach is Franco Malerba (2002). He defines a sectoral system of innovation as:

> '*a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production, and sale of those products…[it] has a knowledge base, technologies, inputs… The agents composing the sectoral system are organizations and individuals… characterized by specific learning processes, competencies, beliefs, objectives, organizational structures and behaviours. They interact through processes of communication, exchange, cooperation, competition, and command, and their interactions are shaped by institutions (rules and regulations)*'. (Malerba, 2002, p.250).

Scholars in this area are interested in examining systems of innovation in sectoral areas (for example: Breschi and Malerba, 1997; Fri, 2003; Tether and Metcalfe, 2004; Malerba, 2005; Storz, 2008). They describe how innovation takes place in quite different sectoral environments, relating to different sources, actors and institutions. They recommend the investigation of systems at the sectoral level in order to understand and address 'system failures' of policies aimed at the innovation of specific sectors. In particular:

> '*Sectoral analyses should focus on systemic features in relation to knowledge and boundaries, heterogeneity of actors and networks, institutions and transformation through coevolutionary processes. As a consequence, the understanding of these dimensions becomes a prerequisite for any policy addressed to a specific sector*' (Malerba, 2005, p.79-80).

Major differences occur between different sectoral systems, and the affect that policies have may drastically differ across them. For example, the importance that networks have in relation to non-firm organisations (e.g. transfer agencies) varies from sector to sector. '*Importantly, these sectoral differences imply that different policies are required to support and stimulate different sectors*' (Conway and Steward, 2009, p421).

3.2.6.2 Technological Systems of Innovation

This area of research is closely related to that of sectoral systems of innovation. Rather than looking at industrial innovation as a single national system, scholars in this area believe it is more useful to examine systems of innovation in several areas of technology (for example: Hughes, 1983; Carlsson and Jacobsson, 1994; Carlsson, 1995). They describe how causal connections between technological change and economic growth are poorly understood. They recommend a more dynamic approach in which technological change is viewed as taking place *within* the economic system, forming a base for industrial development and economic growth. That base is referred to here as the *technological system*.

Researchers in the NSI field investigate innovation processes and the circumstances surrounding them, with a focus on institutions and actors (primarily in science and technology), as well as the role of technology policy at a national level. They are confined to a nation and its entities, and consider one system only.

The *technological system of innovation* research is interested in what characteristics of an environment are making it conducive to technological innovation. As characteristics of technology systems vary considerably among various areas of technology (e.g. electronics, biotechnology, and nanotechnology), more than one system of innovation may be considered, and technological systems typically span multiple sectors

Carlsson (1995) defines technological systems of innovation as:

> '*…consist[ing] of network(s) of agents interacting in a specific technology area under a particular institutional infrastructure for the purpose of generating, diffusing, and utilizing technology. Technological systems are defined in terms of knowledge or competence flows rather than flows of ordinary goods and services*' (Carlsson, 1995, p.7).

In an earlier paper, Carlsson and Jacobsson describe how the main components of the technological system are: 1) the institutional infrastructure; 2) clustering of resources in the form of networks; 3) the economic competence of various agents (1994, p.236).

Their study of technological systems and the diffusion of factory automation in Sweden led them to propose a number of conditions which would enable a functioning technology system (with rapid and extensive diffusion). These were:

> *(1) a speedy and wide diffusion of basic engineering competence to all the components of the production system (large and small companies) which sets strict demands on the functioning of the educational system;*
>
> *(2) a mechanism for monitoring the technological development globally where the emerging features of new production systems are identified at a very early stage;*

(3) a well functioning communication system in industry (large and small companies) ... In this communication system, we have underlined the role of well-functioning bridging agents in the form of both collective research institutes… industry associations…and government agencies;

(4) centres of excellence for the integration of the various technologies. These can be located in both supplier ... and user companies ... or even outside industry .. but the know-how produced in these centres must be accessible to the other actors in the industrial network.

(Carllson and Jacobsson, 1994, pp.245-246)

3.3 Innovation Policies

Innovation systems are often enacted through innovation policies. This section discusses how innovation policies can be arranged into a number of initiatives which helps to make a distinction between types. The three types that are of relevance to this Thesis are 'science policy', 'technology policy' and 'innovation policy'. These are discussed in depth by Lundvall and Borras (2005), and are outlined below.

3.3.1 Science Policy

The emphasis of science policy is to allocate adequate resources to science, such that there is an effective spread of these resources between a range of suitable activities which contribute to social welfare. As such, science policies often focus on the quantity and quality of students and researchers. Scientific policies aim to achieve a mix of objectives, including national prestige and cultural values besides social, national security and economic objectives.

Science policies are different from technology policies in that they need to cater for university scholars – who argue the importance of 'freedom' and 'autonomy' of academic research, i.e. that it is 'value-free'. Weber (1948) describes how scientific communities have developed a certain outlook on the world which gives priority to 'scientific rationalities' seeking value neutral, law-regulated knowledge often presented in the form of mathematical formulae or statistics (Weber, 1948).

This argument is founded on the need to allow basic research to evolve, leading to new avenues for applied research and technical solutions. Lundvall and Burrás (2005) argue the importance that critical – impartial - science plays in modern democracy. That is, independent scientific knowledge allows important political decisions to be made in an open, transparent and representative way. As such the economic impact of research flowing from such policies is likely to be less important than other types of policies (for example technology policies).

The mechanisms used for science policy are generally based on budgetary decisions; i.e. the allocation of funds by governments to public research organizations, such as universities. In addition to this is the offering of subsidies for companies or tax relief (Lundvall and Burrás, 2005).

3.3.2 Technology Policy

The objectives of technology policy are not very different from those of science policy but – at least to begin with – it represented a shift from broader philosophical considerations to a more instrumental focus on national prestige and economic objectives.

Technology policy typically emphasises science-based technologies as being the very core of economic growth. This can be seen in a number of recent UK government white papers, which innovation policies are built on: DTI, 2000a; DTI, 2000b; DTI, 2001; DTI, 2002; and Lambert, 2003. These are outlined further in table 5.1, chapter 5. Such policies are perceived to open up new commercial opportunities and typified by a high rate of innovation addressing rapidly growing markets.

It is important to note that technology policies will differ depending upon whether a country is already an established 'high-income' country, or is a developing 'catching up' country.

Technology policies typically define 'strategic technologies' and sometimes even the sectors producing them. Lundvall and Burrás (2005) state that one needs to be aware of a number of fundamental questions when developing technology policies, some of which are touched upon within this Thesis.

- *Is it legitimate and effective for the state to intervene for commercial reasons in promoting specific sectors or technologies?*
- *What technologies should be supported?*
- *At what stage should the support be given?*
- *What limits should be set for public sector competence?*
- *How can promoting a technology or sector best be combined with competition?* (Lundvall and Burrás, 2005, p.609)

Similar to science policies, technology policies focus on organisations such as universities, research institutions, technological institutes, and R&D laboratories. However, the departure from science policy is the progression from universities toward engineering (in terms of application); and from the internal organization of universities toward how they link to industry.

3.3.3 Innovation Policy

Innovation policy describes the broader policies which take into account the complexities of the real world and advanced capital economies. The main focus of innovation policy is on the creation of economic wealth and international competition. Lundvall and Borras (2005) present the relationship between science, technology and innovation policy in Figure 3.2. This figure indicates the elements of the innovation system still include universities, research institutions, technological institutes, and R&D laboratories.

The main difference between innovation policy and science/ technology policy is that the focus of innovation policy shifts from the 'micro' university and technology sector view to the 'macro' focus of all parts of the economy that impact upon the innovation processes. Furthermore, innovation policy pays special attention to the institutional and organisational aspects of innovation systems; '*Innovation policy calls for 'opening the black box' of the innovation process, understanding it as a social and complex process*' (Lundvall and Borrás, 2005, p.615).

There are a number of recent UK innovation policies which link universities to companies in order to transfer technological knowledge and skills. Jones (2000) provides examples of recent policies: Firstly, the DTI's Teaching Company Scheme (now 'Knowledge Transfer Partnerships'); secondly 'business links'; and lastly, the Carrier Technology Programme. All of which encouraged SMEs to improve their innovation capability. Typically these policies focus on the need to improve the competitiveness of rims operating in mature manufacturing sectors such as metal working, auto-components, and chemicals. As such they are unsurprisingly focused on technological innovation.

Science policy

Focus: Production of scientific knowledge
Instruments:
- Public research funds granted in competition
- (Semi-) Public research institutions (i.e: laboratories, universities, Research centres..)
- Tax incentives to firms
- High education
- Intellectual Property Rights

Technology policy

Focus: Advancement and commercialization of sectoral technical knowledge.

Instruments:
- Public procurement
- Public aid to strategic sectors
- Bridging institutions (between research world and industry)
- Labour force training and improvement of technical skills
- Standardisation
- Technology forecasting
- Benchmarking industrial sectors

Innovation policy

Focus: Overall innovative performance of the economy

Instruments:
- Improving individual skills and learning abilities (through general education system and labour training)
- Improving organizational performance and learning (i.e. ISO 9000 standards, quality control etc.)
- Improving access to information: information society
- Environmental regulation
- Bioethical regulation
- Corporate law
- Competition regulations
- Consumer protection
- Improving social capital for regional development: Clusters and industrial districts
- Intelligent benchmarking
- Intelligent, reflexive and democratic forecasting

Figure 3.3 – Relationship between Science, Technology, and Innovation Policy (Lundvall and Borrás, 2005, p.615).

3.4 Government Interventions

A national system of innovation '*provides the framework within which governments form and implement policies to influence the innovation process*' (Metcalfe, 1997, p.289). Furthermore, '*...we are increasingly seeing* **policy interventions** *aimed at directing, shaping, and influencing the configuration and activities of various systems of innovation, at the supranational, national, sectoral, and regional levels*' (Conway and Steward, 2009, p.415, emphasis added). These extracts emphasise how government (and policymakers) have the potential to intervene in a number of ways in terms of influencing the innovative capacity of organizations, regions, sectors, and the nation as a whole.

Carllson and Jacobsson describe how the conventional prescription for dealing with market failure is government intervention (1994, p.242).

Table 3.1 provides additional examples of how innovation policies address the 'need for intervention'. Some relate particularly to government intervention, whereas others do not. A number of which are further illustrated.

Table 3.1 – Examples of Different Types of Interventions

Need for Intervention	**Example /level**
Develop economic competitiveness, using economic initiatives (i.e. programmes develop innovation or technology to improve economic status of area/ state)	Harvey, 2010 Analysis of how competition state plays out in stem cell science in Australia. /state Woolley and Rottner, 2008 Empirically tests the relationship between innovation policy and new founded ventures in the US nanotechnology area /state
Development of a specific sector of a nation	Fri, 2003 Survey of what has been learned from US government interventions for the energy systems sector /nation
Develop a nation's global competitiveness	Casper, 2000 Examination of the relative importance of national institutional frameworks as opposed to sector-specific policies common in Germany. Fri, 2003 (as above)

Need for Intervention	Example /level
High-technology based economic growth (stimulate new industries from emerging technologies)	Hung and Chu, 2004 Investigation of Taiwanese examples of how policymakers can shape the development of emerging technologies in new industries. /nation
Open method of co-ordination (OMC) For joined up thinking of policies across the EU nations (& to define targets).	Kaiser and Prange, 2004 Explains why the OMC method of co-ordination has not gone very far in innovation policies across the EU. /international
Regional development using Universities	Charles, 2006 Examines the ways in which universities engage with processes of regional development with a particular focus on innovation. Universities are labelled 'civic institutions'. /regional
Development of networks to achieve common innovation goals	Rampersad *et al.*, 2010 Investigates the key factors leading to the effective management of innovation networks from a diverse perspective of actors. /network

In her theoretical analysis of how the competition state plays out in stem cell science in Australia, Harvey (2010) describes the 'competition state'. This refers to managing the innovation system such that opportunities for knowledge generation and commercialisation are maximised. She explains how states are – in theory at least – in a position to actively develop economic competitiveness. The inclusion of the term 'competition' into this level description helps to clarify the reasoning behind this system of innovation.

It is this reasoning of why systems of intervention are borne from policy which helps us as researchers to understand the interventions in more detail. Examples of how interventions are used for differing needs are shown in table 3.1. A number of these are now discussed in more detail.

Of particular relevance to this PhD study are those interventions relating to high technology based economic growth policy interventions. One example from table 3.1 is that of Hung and Chu (2006). They describe the need in Taiwan to stimulate new industries from emerging technologies in order to stimulate successful high-tech based economic growth. They investigated how policymakers are able to shape the development of emerging technologies, using examples from two case study industries; biochips and nanotechnology.

Both sectors were developed through initiatives stemming from the Taiwan government's Industrial Technology Research Institutes (ITRI). This institute was founded in 1973 as a non-profit R&D institute for national research. Its mission was to develop applied research with the aim '*of accelerating industrial technology development in Taiwan to promote industrial growth and social well-being*' (Hung *and Chu,* 2006, p.106). In particular, ITRI provides services and technology transfer to small and medium sized companies. In 1999, the Biomedical Engineering Centre was created (BMEC) which concentrated on the Biochip area, helping early stage commercial research develop with teams made up of IP, marketing and legal experts.

For the nanotechnology sector, the ITRI established the NanoTechnology Research Centre in 2002. This carried out R&D planning for scientific foundation, platform technology and applied technology research. As part of the nanotechnology development, the 'Nano Train' was set up along with the 'NanoTechnology Labs'. Nano Train carried out symposia throughout Taiwan to discuss business opportunities. The Joint NanoTechnology Labs provided resources for domestic, industrial and academic research. Further collaborations were developed as part of the nanotechnology initiative.

Drawing conclusions from these sector cases, they put forward three mechanisms to stimulate new industries from emerging technologies: firstly to encourage partnerships in the commercialization process; secondly to foster entrepreneurship and venture initiatives in the innovation system, and thirdly to sustain the commercialisation and new firm creation. They provide 'open labs' as space for joint technology-based activities between industry and researchers. It is worth noting that the 6 year plan in Taiwan was 21.5 Billion US dollars in comparison to the UK intervention of 90 Million UK Pounds. This clearly illustrates a large difference in terms of funding allocation to the MNT sector between different nations.

This difference may provide additional barriers to the resources available to the commercialisation of such technologies.

> '*Technology and innovation related policies can be thought of as a specific set of policies that aim to improve the ability of firms to compete by promoting technological improvements through the generation, diffusion and adoption or process, product and organizational technological changes*' (Bartzokas, 2001, p.13).

Woolley and Rottner (2008) aim to provide an empirical test of the relationship between innovation policy and new ventures created at the US state level. They discuss economic initiatives, i.e. programmes to develop innovation or technology to improve economic status of area/ state. They discuss nanotechnology at the state-level, and his findings support the positive link between new firm formation and science and technology and economic initiatives. States with science, technology and economic initiatives had six times as many firms founded than those without.

Furthermore ventures were seen to form earlier and more frequently when the state they are in had aligned innovation technology policies. Woolley and Rottner (2008) do however talk about the study being generalisable, but they have only looked at a number of variables, and issues of cultural differences and context are not referred to.

Furthermore, the way they have used policy as a standard unit of analysis is questionable, as each policy is likely to differ vastly in each state. He also states that the relationship between innovation/ policy and entrepreneurship was overlooked until the 1990s, which is clearly incorrect, as evidenced by examples in the literature discussed in the previous section. Therefore his findings are interpreted with caution.

The notion of demand creation related to the technology and innovation policies is described by Fri (2003) as the only strategy that actually drives new technology into commercial use while providing the appropriate public good. However, he continues by saying that policies to create this demand are hard to achieve. He provides an alternative option for policy-makers: the development of technological options that would be useful if and when the demand finally emerges (Fri, 2003). The latter option is displayed in the UK MNT government intervention policy; i.e. it is extremely difficult to forecast the applications of an emerging technology such as MNTs, making demand creation difficult. Therefore by opting to develop a range of MNT options through a series of

MNT centres, then the hope is that the infrastructure is there when demand emerges. He adds:

> '*Policy intervention must either bring the costs/ risks of innovation into line with the available benefits, or must attach to the public benefit a value that gives the private sector an incentive to engage in the innovation process*' (Fri, 2003, p.66).

It should be noted that although Fri's paper provides some useful discussion points concerning demand creation and ways of overcoming the associated difficulties of such policies, it draws mainly from his personal experience and a number of historical examples. Further empirical evidence to reinforce his views (in terms of presenting the additional data that he has based his findings on) would benefit his work.

The last example in table 3.1 highlights the development of networks to achieve common innovation goals; namely *innovation networks*. '*Innovation networks are defined as a relatively loosely tied group of organizations that may comprise of members from government, university and industry continuously collaborating to achieve common intervention goals*' (Rampersad *et al.*, 2010, p.794). The UK MNT government intervention was initially envisaged as an innovation network, to form a supply-chain for micro- and nano- technology development. This was overseen by the MNT Network, an organization led by Professor Hertz, which acted as a linking agent for the centres and potential customers alike. This facility was lost with the morphing of the DTI into the TSB. leaving a more loosely tied group of MNT centres, overseen by the TSB.

However not everyone accepts the concept of NSI fully. According to Quere (2004), because there is no agreement on the role and frontiers of the institutional infrastructure supporting firms' innovative behaviours at a country level, the NSI concept:

> '*appears very unclear and allows for a huge range of topics from the simplest requirements to firms' innovation support, to the analysis of macro-*institutions in *their ability to provide suited incentives or resources to firms' innovative behaviours*' (p.81).

An important distinction is made by Quere (2004) who identifies the narrow versus broad definitions of NSI in the literature; that is, Nelson (1993) versus Lundvall (1992). He explains that NSI in a narrow sense refers to organizations and institutions involved in interactive learning at the firm level, e.g. R&D units or technology institutes with academic actors. This is counter to the broad view where all components of the macro-economic infrastructure influencing firms behaviours are considered.

3.5 Inhabited Institutions in relation to National Systems of Innovation

Taking a step back from the multiple views and categorisation of systems of innovation, the concept of inhabited institutions is useful to analyse a national system of innovation in either its *local context* or *extra local context*.

Historically, organisational sociologists have not considered the local context of organisations, tending to consider the macro cultural logics of an institution instead (Hallet and Ventresca, 2006, p.213). The importance of how institutions are inhabited and how people do things together is discussed by Hallet and Ventresca (2006), with a need to develop research in this area. Their paper which discusses inhabited institutions describes – amongst other things – patterns of industrial bureaucracy; i.e. intellectual context, purpose and relevance. They describe how:

> ‘*Institutions are not inert categories of meaning; rather they are populated with people whose social interactions suffuse institutions with local force and significance*’ (Hallet and Ventresca, 2006, p.213).

By this, they are making reference to the importance of bringing people and their interactions into view. The work of Gouldner, in his book entitled *Patterns of Industrial Bureaucracy* (1954) is discussed in detail. Of particular relevance to this study is the way in which this book captures how life is recognised as being embedded in obstinate social relations and contexts: Gouldner through the description of his case study, recognises the ‘local context’ that made up how the workers in the Gypsum Company viewed their work, and on the other had, the location of the Gypsum plant in the existing community relations, at what Gouldner termed the ‘extra local context’. (Gouldner, 1954). This theorisation is used during this PhD study; the MNT centres constitute the *local context* within the MNT organisational field; and the wider MNT field (including state actors and cross-field actors) can be viewed as the *extra local context.* Through recognising the local negotiated orders that situate and define how the individuals within the MNT field view the world, it is presupposed that a deeper understanding of the UK intervention can be acquired.

3.6 Key Themes in the Systems of Innovation Literature

On reading the systems of innovation literature, a number of key themes begin to emerge. Those most relevant to the topic of this thesis are now discussed. They provide a foundation to the question of *what is it that the National Systems of Innovation theory can add to the investigation of a government intervention?*

3.6.1 Universities as Important Contexts for Systems of Innovation

The focus of researchers on different levels of systems of innovations has already been discussed. In addition to this, there are a variety of organizational contexts which are also commonly investigated. One of the most common is that of universities, and how knowledge is transferred to and from local industry for the benefit of the economy.

For example Charles (2006) examines some of the ways in which universities engage with regional development agencies focusing on innovation across Europe. In particular he looks at how regional systems of innovation engage universities, and how regulation and policy govern these engagements. Through the observation of a range of university systems of innovation across a number of European countries, he draws a number of findings. The system of innovation adopted is shown to be highly dependant upon the different national and regional contexts of each intervention. They are further affected by the different approaches to governance and innovation contexts within each university system. The central message he presents is that the university role needs to evolve out of these contexts and co-evolve with the regional innovation system itself. It is not just about the overall intervention programme – there are issues of regional fit too. This is an interesting conclusion, and perhaps brings into question the original focus of the UK MNT intervention which looked to create two or three main MNT centres (DTI, 2002).

Whilst discussing university technology transfer and NSI, Feldman *et al.* (2006) describe how:

> '*many countries around the world are experimenting with new initiatives to promote technology transfer from universities, with varying results. The effectiveness of these initiatives and the degree to which these economies adapt is determined by the specific local context*' (Feldman *et al.*, 2006, p.359).

The importance of transferring technological knowledge from universities to industry has been emphasised in UK government white papers over the last decade. Lambert's review of business-university collaborations is a good example of such a paper (Lambert, 2003). Lambert explains that the main challenge for the UK in 2003 was not how to increase the supply of commercial ideas into business, but how to raise the overall level of demand by business for research from all sources. It proposed that new networks should be created among research-intensive businesses; along with suggestions that the government should look at ways of investing its support for business R&D to SMEs. Both of these proposals fit with the way the UK MNT government intervention moved from an initial conception of two large centres to the distributed model which aligns more with these proposals. One of the issues Lambert raised was the lack of clarity of intellectual property ownership (IP) in research collaborations. This problem was still an issue for the MNT centres created as part of the intervention investigated in this thesis. Problems with state-aid and use of equipment provided by the state for revenue generating activities appeared to be a hurdle for the model.

Furthermore the Lambert review describes how '*business is critical of what it sees as the slow-moving, bureaucratic and risk-averse style of university management.. [it] suggests ..the sector .. [should adopt] a voluntary code of governance.. to represent best practice across the sector*'.

The Lambert review provided support for the Knowledge Transfer Partnership (KTP), which is an example of a government intervention intended to shape part of the UK NIS. The purpose of the KTP programme is:

> '*to strengthen the competitiveness, wealth creation and economic performance of the UK by the enhancement of knowledge and skills and the* ***stimulation of innovation*** *through collaborative projects between business and the knowledge base*' (Regeneris Consulting, 2010, p.1, emphasis added).

This is an example of how the UK government has developed a mechanism to increase competitiveness. Like the MNT government intervention, it is also overseen by the TSB.

Academics have written extensively about KTPs which are '*an important tool to help academics engage with business and a key vehicle to develop their understanding of* *industry*' (Regeneris Consulting, 2010). Access is key to research, and the KTP structure is ideal for providing access to industrial data for academics.

A recently commissioned government review of KTP states how '*KTP has generated high levels of satisfaction amongst businesses, academics and associates. The impacts on business performance are significant. Although fairly diffuse, they appear to align reasonably well with firms' motivations*' (Regeneris Consulting, 2010, p.ii). Furthermore the benefits from KTPs are not solely economic; feedback into academic teaching follows from knowledge gained during programmes, and new research themes emerge.

3.6.2 Challenges to Systems of Innovation

Of course not all systems of innovation run smoothly, and a number of authors have described some of the challenges faced. Harvey (2010) in her review of the emerging stem cell industry in Australia outlines some of the problems faced when a government tries to utilise innovation as a key to economic success:

1. Innovation is a contested concept; the route to commercialisation is not clear-cut. That is, hoping that the market will do the rest once a feasible idea has been developed.
2. Successful innovation is not necessarily uniform across all industries, or indeed, all regions. A problem therefore arises with how to tailor policies for specific industries and regions.
3. Evaluating the effectiveness of an innovation policy is by nature a complex process – innovation is flexible, adaptable and future-based. If the general philosophy behind the concept of innovation is the production of new and novel products and ideas, then in effect, a certain amount of unknowability exists in the innovation process itself. In other words, <u>there are no guarantees</u> that any new idea, product or process will have the desired market success.

(Adapted from Harvey, 2010, p.76-77).

The points that Harvey raises for the equally emerging stem cell industry in comparison to the micro- and nano- technology industry raise questions of how manageable such government intervention processes are?

3.6.3 Foresight Activities

Another prevalent theme which links to the systems of innovation literature is that of foresight tools, or roadmapping activities. Georghiou and Keenan (2006) describe foresight activities as the expert workshops/ forecasting events which help to set priorities for future funding and technology and/or strategies. In their 2006 paper, they investigate what constitutes an appropriate evaluation strategy for national foresight activities, claiming that there is 'no one-size-fits-all' approach for evaluation. These are important activities which often include a range of field experts from academia, industry and public sector bodies. Phaal *et al.* (2006) describe how:

> '*a large number of approaches ('tools') have been developed by managers, consultants and academics to understand the practical and conceptual issues associated with the management of technology (see, for example, Gaynor, 1986; Twiss, 1992; Cotec, 1998). Such tools can take many forms, including matrices, grids, tables, graphs, checklists, taxonomies, lists and software, together with combinations of these forms*' (Phaal *et al.* 2006, p.336).

Foresight activities are one way to involve experts from different fields in order to develop more effective policies. This is an interesting area in terms of planning for technology policies and/or strategies, however to maintain the focus of the Research Questions investigated in this PhD, it was decided not to pursue this. However such foresight activities clearly are of importance in setting up national systems of innovation that have potential to make a difference to the economy of the nation concerned.

3.7 Gaps in the Systems of Innovation Literature

Whilst carrying out the literature review for national systems of innovation, a number of important gaps and themes became apparent. A number of these have influenced this PhD research, and are now introduced.

3.7.1 Importance of Effective Policy Initiatives

The importance of policy initiatives in shaping the economy through innovation activities is outlined by Bartzokas (2001) in the following quotes:

> '*Policy initiatives have had a central role in the evolution of national science and technology capabilities, both in the development of underlying knowledge bases, and in the provision of the physical and knowledge infrastructures on which technological progress depends*' (Bartzokas, 2001, p.12).

> '*In a world increasingly characterized by high uncertainty, change, and innovation, stimulating new industries from emerging technologies is central to successful economic growth, employment, competition and sustainability*' (Hung *and Chu,* 2004, p.104).

However, even though this role is well understood, one of the key challenges for governments is in developing effective policy interventions for the innovation process that will create economic leverages (Harvey, 2010). In order to do this it is important to identify the appropriate conditions for intervention, which in turn requires a clear understanding of the obstacles that need to be overcome in order to make the policies effective (Fri, 2003).

3.7.2 Limited Sample of Field Studies

An important gap in the literature is the lack of *detailed* field studies of national systems of innovation. Many authors discuss NSI at a theoretical level, (Fromhold-Eisebith, 2006; Quere, 2004; Groenewegen and Steen, 2006); others use historical cases (Consoli, 2008; Hung and Chu, 2004); contemporary cases (Clarysse *et al*. 2007; Harvey, 2010; Phelps and Tewdwr-Jones, 2001; Kaiser, 2004); some present a narrative (Charles, 2006; Fri, 2003); and others literature reviews (Casper, 2000).

Of the contemporary extant literature reviewed for this chapter there appeared to be a gap for further detailed field study research. Only a handful used empirical methods (e.g. Rampersad *et al.* 2010; and Bartzokas, 2001).

Furthermore, Quere describes the importance of the need for empirical field studies, due to the unavoidable differences which are apparent between SIs in different nations:

> '*The diversity of national systems of innovation largely results from the various types of interactions existing between national institutions and firms located in one specific country, which are an unavoidable inheritance from historical patterns. Consequently, learning from empirical observation is essential in assessing the adequacy of national institutional infrastructures in order to provide firms with appropriate incentives to favour innovation and economic growth*' (Quere, 2004, p.81).

This PhD will therefore add to the NSI literature by investigating a contemporary UK government initiative in detail. The aim being a deeper understanding of the actual workings of such interventions, and the learning opportunities for the future.

3.7.3 Evaluating Policies

Authors such as Georghiou *and Keenan (2006)* highlight the need to evaluate policy instruments. A fundamental element is '*asking why government needs to be taking action in an area. In the traditional framework of innovation policy an intervention* *should be seen to be correcting a market failure such as asymmetric information, high uncertainty or inability to appropriate the benefits*' (Georghiou and Keenan, 2006, p.763). This is clearly an important area, however for the purposes of this thesis, the ongoing NSI is investigated, rather than the ex ante preparation work.

3.7.4 Understanding the Levels of Systems of Innovation in more Detail

The layered institutional model illustrated in figure 3.2 was developed by Groenewegen and Steen (2006) to further comprehend the layers and dynamics of systems of innovation for future policy learning. As well as differentiating between the institutional layers in this model, they described the *NSI* as '*a socially embedded system ... [which was]...perceived as an interconnected system of institutions, and innovation patterns are driven by (interactive) learning processes of economic agents*' (p.280). The consideration of government interventions within a range of organisational contexts has the potential to provide fresh insights which consider the specific environments of organisations involved therein.

Casper (2000) describes how:

> '*Static descriptions of existing institutional environments must be combined with micro-level accounts, tracing how firms, governments, and other actors within the economy experiment with, and at times re-configure, the institutional tool-kits at their disposal*' (Casper, 2000, p.911).

3.8 Links to Institutional Theory

> '*National competitiveness requires the transformation of technological capabilities into actual economic profitability that largely depends on the socio-institutional context into which those technological capabilities are embedded. As a consequence, economic growth also depends on institutional characteristics and not exclusively on access to scientific resources and technological capabilities*' (Quere, 2004, p.78).

As per Quere's above quotation, the success of a national system of innovation is not solely reliant upon having the correct access to scientific and technical resources and capabilities. An essential part of a NSI should consider the institutional characteristics associated with the intervention. A nation could have the most advanced technologies within a sector, but without the appropriate infrastructure and actors, they are highly unlikely to achieve their potential.

Findings such as Quere's begin to highlight the importance of institutions for intervention policies, and starts to form a natural bridge to the institutional theory literature.

3.8.1 Actors and Agents

Further reading of the extant NSI literature also links national systems of innovation to the various actors in a nation who follow types of behaviours and relationships; or in institutional theory terms this describes logics. The actors are acted upon by institutions and policies within their nation that influence the generation, production, absorption, diffusion and use of innovation enhancing know-how. Feldman *et al.* describes how the systems of innovation approach:

> '*..shifts the focus away from single factors such as investments in basic research or commercialisation towards the degree of integration, or institutional fit, among the social and economic actors who comprise the knowledge and innovation system*' (Feldman *et al.*, 2006, p.360).

Consoli and Patrucco (2008) describe how their work links up with empirical studies identifying that '*innovation is a distributed process generated through interactions among heterogeneous agents*' (p.701). In their historical analysis of a coordinated innovation effort for the automotive industry in Italy, versus a public-sector coordinated health product intervention in the UK, they argue a number of points. Firstly they discover that '*technological change is a collective process generated by the coordination of dispersed capabilities across a variety of agents*'. This connects well with the literature on institutional logics, and in particular agency, embeddedness, and collective identities and identification, which will add more depth to this study.

3.8.2 Institutional Levels

Groenewegen and Steen (2006) introduce the idea of the NSI as a layered system with a specific logic based on habits and routines. Their reasoning for this is to move away from the notion that a nation can simply copy a successful example (benchmark) and implement it themselves. Their multi-layer perspective is adopted to capture the dynamics of an NSI by analysing the interaction between the different institutional levels, with an aim to make more effective policies.

Conversely authors such as Fromhold-Eisebith (2007) do put forward a model for NSIs which they call the National Super System of Innovation (NSSI). This model argues that the three main levels of systems of innovation, i.e. regional, national and international, need to be considered in a general model like the NSSI. However, they do ponder as to how the question of an NSSI oriented strategy could actually be implemented.

In both of these cases there is a recognition that there are various levels in an NSI, and this fits well with the idea of institutional levels, discussed in the institutional theory chapter, which will be adopted in this research.

3.8.3 Context

The most commonly described context when reading about national systems of innovation appears to be that of the University. Following the logic that many NSIs are built from existing university expertise, or look to transfer knowledge from universities to industry, then this is not surprising. Charles (2006) examines some of the ways in which universities engage with processes or regional development with a particular focus on innovation. He concludes that there are no standard recipes or packages that universities can follow in their individual regional innovation systems: '*Different universities in different national and regional contexts with different governances and different innovation contexts will need to adopt different combinations*' (Charles, 2006, p.128). He continues by emphasising the role of a university in a region needs to evolve out of its own context and evolve in partnership with the regional innovation system itself.

This is an interesting idea, particularly when many national systems of innovation appear to be developed with the 'nation' in mind, rather than specific regions, and the reality of developing nuances for each region might be too complex. His work does focus on regional interventions though, so the findings should be taken in that context.

By linking NSI theory with institutional theory the organizational contexts within NSIs can be viewed using a new theoretical lens. This will add to the systems of innovation theory literature.

3.9 Locating the MNT Government Intervention in relation to the Systems of Innovation and Innovation Policy Literature

The MNT government intervention in this study is a key example of a technological policy intervention (i.e. government intervention) at the national level (i.e. in the UK).

It is part of the wider Technology Strategy Board's UK systemic innovation policy instrument (described by Conway and Steward, 2009, p. 423). As such this intervention is seen to result from a wider national system of innovation, but is itself not representative of a national system of innovation. *It is understood as a government intervention resulting from a technological system of innovation approach, and technological policy*.

This definition follows the notion of technology policies as being focused on establishing capabilities and capacity to produce contemporary science-based technologies, as well applying them (Lundvall and Burrás, 2005).

3.10 Summary

This chapter has provided an introduction to the 'systems of innovation' (SI) approach theorised in research and employed in policymaking (Edquist, 1997; Feldman *et al.*, 2006). Additional ways in which the SI literature is bounded has been discussed; for example national, regional, sectoral and technological. Particular relevance to this study is the work on sectoral and technological systems of innovation (Malerba, 2002; Carlsson and Stankiewicz, 1995, respectively). The ways in which innovation systems are enacted through innovation policies which in turn lead to government interventions has been introduced, and the location of the study topic within this body of literature has been clarified.

Chapter 4 – Bridging Literature

This chapter begins with a brief discussion of the theoretical perspectives considered for this PhD study. It then moves on to introduce the key theoretical lens – institutional theory – selected for this thesis. A number of more specific literatures are also included at the end of the chapter for completeness.

4.1 Theoretical Perspectives

A number of possible theoretical perspectives were considered for this PhD study, with the key theoretical lens being selected as that of institutional theory. Poole *et al.* (2000) describe the importance of deciding upon a good theory: '… *because it provides a systematic way to understand complex phenomena in the real world*' (Poole *et al.* 2000, p.65). Before presenting institutional theory in detail as the theoretical perspective underpinning this research, it is important to introduce those theories which were not selected but can be linked to this research topic, along with those which influenced the theoretical perspective adopted. Those theories were process (innovation) theory and actor network theory (ANT).

4.1.1 Process Theory

Poole *et al.* (2000) describe how process theory can be used to gather data that indicates how a process unfolds over time:

> '*Some of this data could be in the form of quantitative measurements of key variables but other data would consist of detailed descriptions of the events that constituted change and development of the entity under study*' (Poole *et al.* 2000, p.12).

Van de Ven and Poole (1995) describe how process theory uses the concept of process in a number of ways in organisational research:

1. As a logic that explains a causal relationship between independent and dependent variables;
2. As a category of concepts or variables that refer to actions of individuals or organizations;
3. As a sequence of events that describe how things change over time;

(Van de Ven and Poole, 1995)

One of the main advantages of considering a process theory approach to research is how it acknowledges the role of actors in development and change. Elements of process theory influenced the methodology of this thesis, particularly with regard to understanding the role actors play as part of the change process of the intervention, and how their '*plans and choices are premised on goals or visions of what the final product will be*' Poole *et al.* 2000, p.32). Process theory, in terms of 'processual analysis' contributes a further facet to this research; i.e. '*to explore the dynamic qualities of human conduct and organisational life and to embed such dynamics over time in the various layers of context in which streams of activity occur*' (Pettigrew, 1997, p.347).

However, the use of event sequences, coding of events, and longitudinal elements of process theory were not adopted. The implications of following such a prescriptive process theory approach would have meant that a large amount of access to organisations would have been required in order to gather the data on critical events and conjunctions of events required to explain change as part of the causality requirement of process theory. This would have incurred time and resources beyond the scope of PhD study. Furthermore, the author wanted to gain a deeper understanding of the organising principles driving the actors in a government intervention, which process theory is less equipped to deal with. The MIRP programme is an example of how process theory has been used to track the development of a wide variety of products and process innovation from concept to completion.

4.1.2 Actor Network Theory (ANT)

Actor network theory (ANT) is another theoretical perspective that can be linked to the topic investigated in this thesis. It relates to scientific and technological networks and examines how particular definitions or configurations of science and technology succeed over alternative conceptions. Actor network theory incorporates the concept of 'techno-economic systems' (TENS) and the 'social construction of technology'. Conway and Steward (2010) describe how this helps to provide useful insights into the way in which power and influence may shape the innovation process.

Callon (1991) describes techno-economic systems theory as grouped around three main poles:

- the 'scientific' pole (where empirical knowledge is produced; comprising of universities and other independent research centres);
- the 'technical' pole (where this empirical knowledge is used for prototyping, model-making and testing; comprising of technical laboratories, development engineers, scientists);
- the 'market' pole (where users or consumers generate, express or seek to satisfy demands or needs).

Callon (1992) further describes how different poles have different membership goals and procedures; i.e. '*which may be mutually exclusive… however, arrangements and links are made between the members of different poles, so that the outputs of various activities are exchanged with the members of other poles*' (p.74).

As such, actor network theory is built on the idea that:

> '*various actors participate collectively in the conception, development, production, distribution and diffusion of procedures for producing goods and services*' (Edwards, 2001, p.226).

The primary contribution of ANT to the relationship between networks and innovation is to show that not only can networks facilitate innovation, but they also constrain it by determining the kind of innovations produced, their subsequent interpretation, and their final use (Callon, 2002).

The more traditional network approaches try to understand actors (which includes organisations) and the relationships between them (for example: Ahuja, 2000; Alasoini, 2001; Arndt, 2000; Birley, 1987). In contrast, ANT adds further emphasis on a 'contextual' understanding in relation to actors and their relationships, rather than a 'structural' one (Conway and Steward, 2010, p.80). Its focus is on '*the way in which they [individuals] define and distribute roles, and mobilize or invent others to play these roles. Such roles may be social, political, technical, or bureaucratic*' (Law and Callon, 1988, p.225). As such, ANT highlights the dynamic and political nature of interactions between actors.

Actor network theory as a theoretical perspective was not considered for use in this thesis, but has some links to the findings of the thesis. That is, the importance of the interplay between agency and structure described by ANT has also been highlighted using institutional theory.

A key factor in the decision not to pursue ANT as a theoretical lens for this study was the way in which it affords equivalent status to both 'human' and 'non-human' actors. It is unique in the sense that it treats artefacts and technologies, as well as people and organisations as members of a network (Callon 1998; Latour, 1987). For example, computers and other technological artefacts are considered as 'intermediaries' in the interactions between human actors (Conway and Steward, 2010).

Callon (1991) purports that '*artefacts are not the enigmatic and remote objects to which they are often reduced…*' (p.137). He continues by inferring that they provide links between the user and the roles that the user plays. For example a human might observe a screen and then click a computer mouse.

This theorisation of artefacts as '*ordering human beings around by playing with their bodies, their feelings or their moral reflexes*' (Callon, 1991, p.137) does not align with the author's ontological and epistemological position, and as such was not adopted.

4.2 Institutional Theory – an Overview

This section presents a brief overview of the key ideas and themes within the institutional theory literature (IT). The selection and justification of institutional theory as the key theoretical lens for understanding and describing the MNT government intervention is provided.

This remainder of the chapter also synthesises the different bodies of literature discussed in this thesis and how they relate to the MNT case discussed.

Figure 4.1 has been created in an attempt to synthesise a number of the complex theoretical ideas from the IT literature into one diagram.

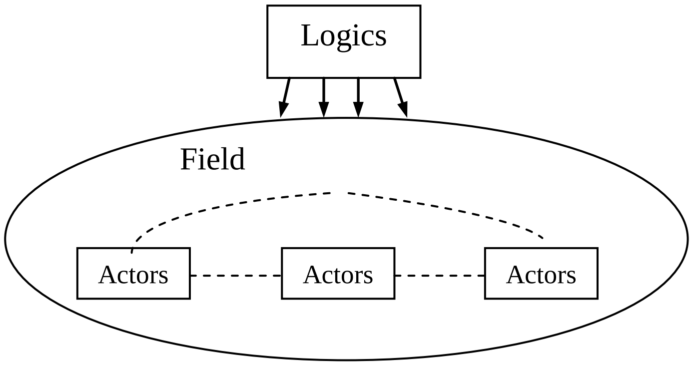

Figure 4.1 – Representation of Key Concepts within the Institutional Theory Literature

This figure demonstrates how an organizational field is made up of a range of actors. These actors can be individuals, organizations or institutions. Actors follow a number of logics within the organizational field, called field logics. However, Greenwood *et al.* (2010) make an important point that institutional logics do not come from the organizational field: the organizational field is the level of analysis, it is a place where institutional logics are played out. Through a number of mechanisms such as embeddedness, or collective identities, institutional logics may be reshaped and customized in the organisational field. Institutional logics stem from the institutional orders of the inter-institutional system. Fields vary in the shapes they take; Reay and Hinings (2005) demonstrate major changes in the Alberta Healthcare Organizational Field after a government intervention.

Contested and collaborative logics are enacted within an organizational field, as illustrated in Reay and Hinings (2005). For example they describe how the *Physician actors* collaborated with hospitals, peers, other health professionals, pharmaceutical companies and so on, in the original Alberta Healthcare Field, to organise patient care. As part of the new Alberta healthcare intervention, the key *government* actor attempted to move the organisational field from dominance of the *medical professionalism* logic to a new institutional logic, that of *business-like* healthcare (Reay and Hinings, 2005). This resulted in contested logics between the newly created Regional Health Authority (RHA) actors focussed on business-like measures such as quality, efficiency, and the redefining of 'patients' as 'consumers'. Such measures were contested with the medical professional logics of the Consultants.

Scott introduced one of the main models in institutional theory called the 'three institutional pillars'. He describes how he created this model to help progress theorisation in this area '*by distinguishing among the several component elements and identifying their different underlying assumptions, mechanisms, and indicators'* (Scott, 2001, p.51). He argued that this increased analysis helps '*identify important underlying theoretical fault lines that transect the domain*' (Scott, 2001, p.51). The three pillars constitute: regulatory, normative and cultural-cognitive.

Furthermore the comprehension of decoupling and legitimisation will add deeper insights into this PhD research.

4.3 Viewing the MNT Government Intervention through an Institutional Theory Lens

This section relates important concepts from institutional theory to my PhD research, and addresses how the MNT government intervention can be viewed through an institutional theory lens. In turn, this theorisation is intended to answer the higher level questions posed in Research Questions 1 and 2:

Research Question 1

- How do networks such as MNT function?

Research Question 2

- How can we describe stakeholder values and understanding in relation to the role of a nascent government intervention?

This research is not just about seeing MNTs as a network for government intervention, it is about providing a theoretical lens to understand what is going on in that intervention. One of the aims of my research is to evolve Edwards (2000) proposition that the interactive process perspective is suitable for investigating innovation, and more importantly government interventions. The aim is to move closer to a common theorisation for government intervention.

4.3.1 Introduction to the Institutional Theory Literature

Institutional theory offers insights into the continuity and conformity of organizational practices. It is essentially the dominant approach to understanding organizations

(Greenwood *et al.* 2010). The importance of understanding previous literature is outlined by Scott:

> '.. *knowledge of what has gone before is vital to information. The ideas and insights of our predecessors provide the context for current efforts and the platform on which we necessarily craft our own contributions*' (Scott, 2001, p.47).

The foundations of institutional theory are found in the late 1970s to early 1980s. The building blocks of IT include the following concepts: *institution, institutional context, institutionalization*, and *isomorphism*. Influential works from this time include: Meyer and Rowan (1977); Zucker (1977); Meyer and Rowan (1983); DiMaggio and Powell (1983), Tolbert and Zucker (1983), and Meyer and Scott (1983).

During the 1980s to early 1990s researchers favoured four main areas of study: *processual*, *cross-category*, *cross-national* and *means of transmission.* In terms of understanding the MNT government intervention, the latter two categories are of relevance.

Cross-category research relates to the MNT centres as it compares the state or non-profit agencies and commercial organizations. In the early 1980s the majority of studies stayed true to Meyer and Rowan's definition of 'institutionalized organizations' as those with weak market forces (Meyer and Rowan, 1977), and subsequently only researched non-profit organisations and governmental organizations. A recent example was the paper by Tracey *et al.* 2010, in which the authors address the question of how new organizational forms are created. They investigate the creation of a non-profit homeless organisation. One of their observations is that researching across categories remains an unsolved problem within IT; as such, this presents an opportunity for comparing state agencies and commercial organizations through the use of the MNT case. That is not to say that researchers did not include commercial organisations as institutions, they did toward the end of the 1980s. However, authors such as Zucker (1977) and Powell (1991) were among the first authors to call for examination of *all* types of organizations.

Although this PhD is not researching across different countries there is the potential that due to the different organizational types involved in the government interventions, then there are likely to be a range of cultural values and beliefs. *Cross-national* refers to the approach whereby researchers hypothesised the difference in social values between different countries and their associated use of organizational practices. Studies such as those carried out by Lincoln *et al.* (1981) investigated attitudes of United States and Japanese workers in 28 Japanese-owned organizations based in the US. Their results rejected the old myth:

> '*of classical theory that what happens within organizations or between them and their environments is always linked to performance goals..*'. Instead they suggest an emerging view that '*organizational phenomena are shaped by the cultural values and beliefs, as well as the institutional arrangements, of the populations in which they are embedded*' (Lincoln *et al*, 1981, p. 114).

The different MNT centre environments are linked to the original DTI goal; how they are shaped by organizational practices will be comparable to the aforementioned works. One criticism of the study carried out by Lincoln et al. is that they compared Japanese companies 'within' the US, rather than in their native environment. This is recognised by Lincoln et al. who suggest that by doing so would have made it '*extremely difficult to separate differences due to national origin from differences in the firms themselves*' (Lincoln *et al.* 1981, p.97). An advantage of the reviewing the MNT centres is that they are only based within the United Kingdom, however due to the different organizational types involved it will be interesting to see whether cultural values and beliefs vary.

4.3.2 Institutional Isomorphism

Isomorphism is an important concept in the area of institutional theory[1]. This concept was originally introduced by Meyer and Rowan who argued that many post industrial organizations do not reflect the actual demands of their work activities, rather they still reflect the *myths* of their institutional environments (Meyer and Rowan, 1977, p.341). Put simply, this suggests that isomorphism was understood as the relationship between an organization and its institutional context. Nevertheless, isomorphism continues to be used to describe the tendency for all organizations to respond in the same way.

[1] Boxenbaum and Jonsson (2010) provide a detailed review of isomorphism along with diffusion and decoupling. They describe a central idea of isomorphism which is '*that organizations conform to 'rationalized myths' in society about what constitutes a proper organization*' (Boxenbaum and Jonsson, 2010, p.78). These *myths* appear as solutions to the problem of organizing, and later become rationalized (i.e. justified actions when they are believed to make up the proper solutions to these problems). With the increased conformance of organizations to these myths, they become more entrenched leading to *institutional isomorphism*.

DiMaggio and Powell (1983) proposed that this is partly due to institutionalized ideas which put pressure on organizations to adopt similar structures and forms, hence resulting in them becoming increasingly similar. The concept that organizations in a similar environment over time come to share their appearance was not new; Weber (1952) already talked of the 'iron cage of rationality' and how competitive forces in society put pressure on organizations to become similar in structure and action. The very nature of the MNT centres belonging to a range of institutions and variety of contexts brings in to question whether isomorphism is possible with such an intervention. However the ways in which the mechanisms of institutional isomorphic change can occur might shed some light on the differences between centres. These mechanisms were outlined by DiMaggio and Powell (1983), and suggest ways in which change can occur to bring isomorphism about.

1) *coercive isomorphism* - stems from political influence and the **problem of legitimacy** [i.e. demands of the state or other large actors to adopt specific structures or practices, or else face sanctions. They are not only by official order, but can result from resource dependences, e.g. demands to adopt specific practices to be eligible for state grants, e.g. requirements of ISO certification to become a supplier];
2) *mimetic isomorphism* - results from standard responses to uncertainty [this often leads organizations to imitate peers that are perceived as successful or influential];
3) *normative isomorphism* – is associated with professionalization [pertain to what is widely considered a proper course of action or moral duty, e.g. when there are signals from the organizational environment that the adoption of a particular practice or structure is a correct moral choice]'.

(Source: DiMaggio and Powell, 1983, p.150. Additional comments from Boxenbaum and Jonsson, 2010, p.80, in square brackets).

DiMaggio and Powell (1983) make the point that the above typology is analytic, i.e. the types, like Scott's three pillars, are not always distinct. They give the example of how:

> 'E*xternal actors may induce an organization to conform to its peers by requiring it to perform a particular task and specifying the profession responsible for its performance…Yet, while the three types intermingle in empirical setting, they tend to derive from different conditions and may lead to different outcomes'* (p.150).

It is premised that the external state/ public body actors of the MNT field are likely to try and induce conformance of actors as per DiMaggio and Powell's example. However, in the case of the MNT government intervention, the way the technology centres *derive from different conditions and lead to different outcomes* (as per above quote) is very important. The effect of all three levels of the government intervention network researched will add to this discussion of 'intermingling'.

The three mechanisms of change can also be used when considering an organizational field; i.e. they can show where isomorphic pressures emanate from in the field. Regulative pressures – such as the state – may come from above, whereas mimetic and normative pressures often come from horizontally positioned peer organizations or groupings.

4.3.3 Criticisms of Isomorphism

Having introduced isomorphism it is important to also discuss the reality that organizations might not respond in the same way, i.e. heterogeneous behaviour. A number of studies during the 1980s showed that organizations were <u>not</u> in fact responding in a similar fashion to institutional processes. This complexity was further observed during the 1990s, often consisting of competing institutional demands; '*there was this growing interest in why and how organizations interpret and respond differently to their contexts*' (Greenwood *et al*., 2010, p15). Research Question 3 of this PhD asks:

> '*How (& why) do the following aspects of an innovation process: purpose, process, people, collaborations, context and outcomes influence the function/purpose of a public innovation intervention?*' (Source: Author).

Aspects of this research question will investigate the notion of whether isomorphism is applicable to the framing of the MNT centres. Prior to the analysis stage, the fact that there are numerous settings for each centre in differing institutions suggests that isomorphism is unlikely to prevail. This is in line with Fombrun's observation that '*If isomorphism obtains, how then are we to explain the apparent variety of organizations that nonetheless co-exist within industries?*' (Fombrun, 1989, p.439). Moreover, when considering institutional contexts, Meyer and Rowan (1977) recognised that organizations meet institutional contexts containing multiple and inconsistent myths that allow for multiple yet equally legitimate responses. Fligstein's work also reinforces this.

Fligstein showed that complex organizations constitute arenas of struggle where groups compete for power and selectively appeal to institutional pressures to legitimate their claims (Fligstein, 1985). The notion that organizations would become aligned with their institutional contexts thus becomes contested. However, having presented both views there is the opportunity to see which holds true for MNT centres.

4.3.4 Decoupling

The concept of 'decoupling' is also linked to the research on institutional isomorphism. This concept can be seen as:

> '*a rational response to demands for organizational adaptation that are inconsistent or harmful to the organization; by decoupling, organizations achieve legitimacy through espoused action but remain efficient or consistent through actual action, which enhances their survival prospects*' (Boxenbaum and Jonsson, 2010, p.81).

A number of the institutions hosting the MNT centres can be viewed as having 'decoupled' their MNT centres from the host institution/ organisation. For example a number of universities created separate research centres; one SME created a new decoupled business; and a number of centres established themselves on science parks. Meyer and Rowan (1977) proposed that formal structure can be, and often is, decoupled from production activities. A number of examples of large organizations using 'decoupling' to develop new and emerging technologies have been presented in the literature review of emerging technologies. Govindarajan and Kopalle (2006) argued for the creation of separate organisational units that can foster disruptive innovations. They reinforce the idea that in order to develop disruptive innovations, new processes and routines may be required, and by creating autonomous units existing processes and routines can be broken. Assink (2006) describes how a traditional *'command and control'* management style *'makes it difficult to 'challenge, provoke and engage in innovative activities'*. Such management styles are typically associated with large organisations, hence the need for autonomous units (sometimes called 'start-ups'). Markides asserts that incumbent firms should create, sustain and nurture a network of feeder firms, which are kept busy innovating and colonising new niches. Palumbo (2001) provides the example of how Kodak spend $100 million per year on image related start-up firms.

The above examples from the emerging technology literature provide a link into the institutional theory literature in terms of the decoupling argument. They add weight to the theoretical discussion within the IT literature, by providing empirical case examples.

4.3.5 Institutions

Similar to the comprehension of 'isomorphism', the understanding of 'institutions' has been problematic amongst IT scholars in recent years. Researchers took the term to represent cultural models, the state (or its policies). Some authors even avoided the term and referred to presumed institutional effects (Greenwood *et al*. 2010, p.14). Scott illustrates this describing how 'institution' had acquired new meanings '*much like barnacles on a ship's hull*' (Scott, 1995, p. xiv). In order to reduce the ambiguity in our understanding of institutions Scott introduced elements to underpin institutions, called 'Scott's institutional pillars'.

4.3.6 Scott's Institutional Pillars

Scott's pillars were an extremely important development during the mid-1990s to develop our understanding of institutions further. They '*have become one of the most-cited contributions in the institutional literature*' (Greenwood *et al*., 2010, p.15). These elements or 'pillars' were identified and seen to compose institutions. The analogy of a pillar is used because social scientists see institutions as resting on these 'pillars'. Each of these pillars is seen as a vital ingredient of institutions. Scott explains that '*one possible approach would be to view all of these facets as contributing, in interdependent and mutually reinforcing ways, to a powerful social framework, one that encapsulates and exhibits the celebrated strength and resilience of these structures*' (Scott, 2001, p.51). The MNT field is made up of a number of institutions including; state institutions (e.g. non-departmental government bodies-NDGBs, universities, RDAs); private global organisations (e.g. OEMs); and SMEs.

Scott describes his belief that more progress can be made '*by distinguishing among the several component elements and identifying their different underlying assumptions, mechanisms, and indicators. By employing a more analytical approach to these arguments, we can identify important underlying theoretical fault lines that transect the domain*' (Scott, 2001, p.51). Table 4.1 displays a summary of the three pillars of institutions:

Table 4.1 – Scott's Three Pillars of Institutions (Source: Scott, 2001, p.52)

	Pillar		
	Regulative	**Normative**	**Cultural-Cognitive**
Basis of compliance	Expedience	Social obligation	Taken-for-grantedness Shared understanding
Basis of order	Regulative rules	Binding expectation	Constitutive schema
Mechanisms	Coercive	Normative	Mimetic
Logic	Instrumentality	Appropriateness	Orthodoxy
Indicators	Rules Laws Sanctions	Certification Accreditation	Common beliefs Shared logics of action
Basis of legitimacy	Legally sanctioned	Morally governed	Comprehensible Recognizable Culturally supported

The first pillar is the *regulative pillar*; the second pillar is the *normative pillar*, and the third pillar is the *cultural-cognitive pillar*.

The regulative pillar describes how '*institutions constrain and regularize behaviour*' (Scott, 2001, p.51). The NDGBs overseeing the MNT government intervention (DTI initially, then TSB) fit within this regulative pillar. Those theorists who subscribe to this pillar give prominence to explicit regulatory processes: rule setting, monitoring, and sanctioning activities.

> '*In this conception, regulatory processes involve the capacity to establish rules, inspect others' conformity to them, and, as necessary, manipulate sanctions – rewards or punishments – in an attempt to influence future behaviour… may operate informally.. [e.g.] shaming or shunning activities, or .. highly formalized and assigned to specialized actors, such as the police and the courts*' (Scott, 2001, p.52).

Specialized actors are seen as the TSB monitors and third-party consultants for the MNT intervention.

Those seeing institutions as resting on the *normative pillar* place emphasis on normative rules. Normative rules are those:

> '*..that introduce a prescriptive, evaluative, and obligatory dimension into social life. Normative systems include both values and norms. Values are conceptions of the preferred or the desirable, together with the construction of standards to which existing structures or behaviour can be compared and assessed. Norms specify how things should be done*' (p54-55).

Goals and objectives are defined for normative systems, along with appropriate ways to pursue them. The overall purpose (goals and objectives) of the MNT case are outlined in this thesis. Considering the range of institutions (contexts/structures) hosting the centres, it is conceivable that the normative rules will vary. Not all values and norms apply to all members of the institution; some apply only to certain actors or positions. Those which apply only to certain positions connote the idea of 'roles':

> '*conceptions of appropriate goals and activities for particular individuals or specified social positions… these.. are .. normative expectations.. of how the .. actors are supposed to behave.. the expectations are held by other salient actors in the situation and so are experienced by the focal actor as external pressures.*' (p.55).

Roles align with and build upon the 'people' construct used in the MIRP programme; it adds an *understanding* of actors' actions and agency rather than just taking a more *descriptive* look at the roles and activities they perform during the innovation process. Furthermore the MNT case offers an opportunity to investigate actors with backgrounds from a number of institutional settings. The unique nature of the MNT intervention brings together actors from different traditional institutions in a way that other government technology creation actions do not.

The *cultural-cognitive pillar* stresses the '*centrality of cultural-cognitive elements of institutions: the shared conceptions that constitute the nature of social reality and the frames through which meaning is made*' (p.57). Those viewing institutions through this pillar place importance on the mental processes of perception, memory, judgement and reasoning of human existence. Generally speaking this pillar postulates that what an actor does is influenced by their internal representation of their environment.

Scott's pillars have generally been used in a selective manner by researchers in this area, as displayed in Mizruchi and Fein's (1999) review of types of isomorphism. This review examined the fate of DiMaggio and Powell's key essay on institutional isomorphism within the preceding literature (refer to DiMaggio and Powell, 1983). The authors coded up 26 sample papers citing DiMaggio and Powell's paper according to the type of institutional isomorphism followed by the author, and discussed the significance of each. Although this paper does not refer directly to Scott's institutional pillars, it nicely displays the focus on individual elements of institutions adopted by authors, and presents an opportunity to frame the MNT intervention using a number of the pillars. In particular, the regulative and normative pillars are likely to be of relevance considering the varied institutions involved in the MNT field.

Not all institutional theorists agreed with Scott's presentation of the three institutional pillars. Hirsch (1997) interpreted Scott's initial presentation of the three pillars (Scott, 1995), by stating that:

> '*Scott .. clearly rejects the counterstrategy of seeking ways to 'view each of these facets as contributing, in interdependent and mutually reinforcing ways, to a powerful social framework'. This decision to look for, focus on, and so emphasize the differences between perspectives is unfortunate…Each vertical institutional pillar, self-contained and isomorphic, is set up by Scott to address, account for, and explain actions and behavior [in or at a range of levels of analysis]*' Hirsch (1997, p.1709). Scott answers this criticism as follows: '*Far from wishing to 'rule-out' or 'discourage inter-pillar communication' or to make the 'cross-fertilization of ideas unusual and unlikely', .. my intent in constructing this analytic scheme is to encourage and inform such efforts*' (Scott, 2001, p.70).

The point we can take away from this debate is that Scott's pillars are analytical, not finite. They are a way of understanding common types of institutions.

4.3.7 Legitimacy (as agency)

A more recent subject of examination within the area of institutional theory is that of *legitimacy*[2]. According to Greenwood *et al*. (2010) this approach is often accompanied with a more agentic approach; that is, a focus on individuals and their actions. An agentic approach fits well with the IPP approach; more importantly the IPP approach also recognises the link of agency with structure. As with many terms in the IT literature, there are many interpretations of legitimacy by theorists.

One useful definition for the purpose of this PhD thesis is that of Meyer and Scott (1983):

> '*…organizational legitimacy refers to the degree of cultural support for an organization – the extent to which the array of established cultural accounts provide explanations for its existence, functioning, and jurisdiction, and lack or deny alternatives … <u>A completely legitimate organization would be one about which no question could be raised. [Every goal, mean, resource, and control system is necessary, specified, complete, and without alternative].</u> Perfect legitimation is perfect theory, complete (i.e., without uncertainty) and confronted by no alternatives*' (Meyer and Scott, 1983, p. 201, underlining added).

[2] Studies from authors such as Deephouse and Suchman (2010) provide a thorough review of legitimacy in organizational institutionalism.

The complexity of the relationship between legitimacy and performance has been demonstrated by authors such as Zimmerman and Zeitz (2002). The perceived legitimacy of each MNT centre by their actors and other field stakeholders is likely to have a bearing on how successful they are in developing micro- and nano- technologies to benefit the UK economy. Zimmerman and Zeitz (2002) carried out a review of the impact of legitimacy on new ventures as well as sources of legitimacy for new ventures. They describe how the literature had previously focused on maintaining and repairing legitimacy in established organizations. Through the discussion of new ventures they describe how the complexity of the relationship between legitimacy and performance was demonstrated. Furthermore, they argue a number of points: (1) legitimacy is an important resource for gaining other resources; (2) such resources are crucial for new venture growth; and (3) legitimacy can be enhanced by the strategic actions of new ventures.

4.3.8 Role of Legitimacy

Scott's institutional pillars framework is also considered by Zimmerman and Zeitz as a similar framework from which legitimacy can be derived. They offer an additional element to the framework, i.e. industry as a source of legitimacy. They purport that a new venture can use the industry's standards, norms, practices, and technology; the past actions of industry members, and so forth to acquire legitimacy. When considering a very new *industry*, they describe the difficulties associated with it gaining legitimacy:

> '*A very new industry, however, may provide its component organizations little legitimacy, because the industry has little history, no established standards, strange or unacceptable norms, and novel practices… The new venture in a new industry must work even harder to establish its own legitimacy, for there is little knowledge about the industry, there are few recognized industry members, and there may be uncertainty as to the industry's survival*' (Zimmerman and Zeitz, 2002, p.421).

The MNT centres examined in this study are typically small in nature, with a few exceptions. The above quote from Zimmerman and Zeitz is particularly relevant when we consider how they are part of the new micro- and nano- technology industry, which has no established standards/ norms, and follow novel practices. The paradox is that the government intervention was created in order to develop this industry in the UK, however one of the barriers is the newness of this industry, and the expense associated with capital equipment and developing novel practices. Furthermore the legitimacy of each host will have a bearing on how well the centres establish themselves. Legitimacy is therefore an important component of the individual MNT centres researched in this study, along with the overall government intervention. In terms of the individual centres, legitimacy will be important for potential customers wishing to use the new technologies. The question of setting up open access MNT centres in a range of contexts will be investigated. Are there particular settings that add legitimacy for potential customers, and potential uptake of technologies, increasing the view of the new sector?

The MNT case offers an opportunity to add to Zimmerman and Zeitz's literature on legitimacy in smaller/ new ventures.

Zimmerman and Zeitz put forward four strategies for acquiring legitimacy: firstly, *conformance* as strategy; secondly *selection*; thirdly *manipulation* and lastly *creation*. More detail of these legitimation strategies are presented in Table 4.2.

Underpinning Table 4.2 is Zimmerman and Zeitz's proposition that '*A new venture can take purposive action to increase visible consistency with the environment by conforming to, selecting, manipulating, and/or creating the environment in which it exists*' (p.426). Zimmerman and Zeitz present some very interesting propositions, however they do not back these up with empirical findings or data. This thesis presents the prospect of building on their theoretical take on legitimacy in newer ventures/ smaller organizations using the MNT case.

Denrell (2003) adds to the legitimacy debate by suggesting that many empirical studies in the area only focus on successful examples of institutions and organisations. Basically Denrell (2003) argues that this is due to the economic process which means that unsuccessful firms are replaced by individuals and firms with good performance; resulting in a limited sample of firms for research, leading to an undersampling of failure. When carrying out my case selection for this study, I included where possible, those organisations which are suggestive of failure, or appear to be unsuccessful. This has the potential to remove some of the undersampling bias of the empirical data, and will add richer data to the plethora of successful examples in the literature. Denrell provides the following example:

‘*Consider, for example, the advantages of outsiders and newcomers in the development of radical innovations. Suppose that newcomers and outsiders are, on average, less informed about the potential of alternative technologies. This implies that newcomers and outsiders will make less informed choices about the allocation of their R&D resources. Such uninformed choices usually lead to false starts. However, they may also lead the firms to do research in areas that few informed firms are investigating because these areas are correctly evaluated as having very low potential, and thus low expected returns. If such areas turn out to be promising, however, they may produce radical innovations. As a result of this mechanism, a large proportion of the most radical innovations may be developed by outsiders and newcomers. Thus, if most of the false starts produced by newcomers and outsiders cannot be observed, it is easy to come to the conclusion that newcomers and outsiders have an advantage in producing radical innovations*’ (Denrell, 2003, p.236).

Table 4.2 – Legitimation Strategies (Source: Zimmerman and Zeitz, 2002, p.423)

Strategy	Definition	Example
Conformance	Conformance involves ‘following the rules’. A new venture that conforms does not question, change, or violate the social structure. There is little room for strategic choice. Conformance is the least strategic of the four strategies and is often used by new ventures.	Addressing regulations. A new venture conforms to the government regulations to which it is subject, such as when it registers with the SEC, as is required to publicly sell stock.
Selection	Selection involves locating in a favourable environment (Scott, 1995). Selection is more strategic than conformance.	Selecting where to locate a new venture. If the technology is new and/or unfamiliar, the new venture may seek to locate near ventures using related technology or engaging in related activities, such as software ventures locating in Silicon Valley.
Manipulation	Manipulation involves innovation and/or a substantial departure from prior practice. The innovator ‘must often intervene pre-emptively in the cultural environment in order to develop bases of support specifically tailored to the distinctive needs’ of the organization. Manipulation is more strategic than selection and is difficult for new ventures.	Manipulating norms and values of society, such as changing the vale that a company publicly offering its stock should generate a profit at the time of initial offering.
Creation	Creation involves the creation of the social context – rules, norms, values, beliefs, models, etc. Creation is especially evident in the introductory stage of new industries. It is the most strategic of the four strategies.	Creating new operating practices, models, and ideas, such as Amazon’s introduction of retailing books online to the mass market.

4.4 Institutional Logics and the MNT Government Intervention

This section builds on a particular area of institutional theory called *institutional logics*[3]. Some of the fundamental concepts of institutional theory that allow the framing of the MNT government intervention originate from the area of institutional logics. These include: *logics* (at different levels)*; actors, action and agency; embedded agency; collective identities; classification and categorisation; field logics; and dominant field participants*. They will allow us to understand, describe, and consider what is going on in this national system of innovation at a number of levels (individual, organizational, and field level).

4.4.1 Introduction to Institutional Logics

Institutional logics provide categories, beliefs and motives – i.e. *organizing principles* – that inform members of how to conduct themselves in the field (Delbridge and Edwards, 2007; Reay and Hinings, 2005). Institutional logics provide a way of understanding the MNT case which brings together a range of very different people. It allows conceptualisation of people in terms of actors, with different demands, relating to the actions of others. *Different actors will follow multiple logics that allude to different organising principles, which in turn shape field-level behaviour* (which also links to the aforementioned idea of legitimacy, but at an individual level).

In order to comprehend individual and organizational behaviour Sage *et al.* (2010) suggest it must be located in a social and institutional context, and this institutional context both regularizes behaviour and provides opportunity for agency and change (pp.101-102). *An institutional logic is why a particular social world works*. Institutional logics include the socially constructed historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material substance, and organize time and space, and provide meaning to their

[3] Alford and Friedland originally introduced the notion of institutional logics (Alford and Friedland, 1985) to describe contradictory practices and beliefs, which are an essential part of modern western societies. They identified three institutional orders, with different practices and beliefs: *capitalism*; *bureaucracy* and *political democracy*. In 1991 they developed these further (Friedland and Alford, 1991) to five institutional orders: *capitalist market*; *bureaucratic state*; *families*; *democracy*; and *religion*. Each has a central logic, which constrains both the means and ends of individual behaviour. These institutional orders are made up of three levels*: individuals*, *organisations* and *society*. They can constrain action, but also enable agency and change.

social reality (Thornton & Ocasio, 1991).

4.4.2 Logics at Different Levels

Institutional logics may develop at a variety of different levels (e.g. organization, markets, organizational fields, geographic communities). Society can be conceived as being made up of three levels: institutions (in contradictory and interdependency with one another); organisations (in conflict and co-ordination with one another); and individuals (in conflict and co-ordination with one another). Berger and Luckmann (1967) explain that rather than privileging one level over another, the institutional logics view suggests while individual action is embedded within institutions, institutions are socially constructed and therefore made up by the actions of individuals and organizations. In other words, this illustrates the importance of researchers adopting a cross level view within their research. This is critical in order to identify effects of mechanisms *across levels of analysis* which makes the theory more precise as well as more general. However, there is a need to be clear at which level the analysis occurs: societal, organizations, markets/ industries, inter-organizational networks, and/or organizational fields. Actors from a range of levels constituting the MNT field are investigated for this research. The adoption of such a cross-network approach aims to add to empirical examples of cross-network research.

4.4.3 Actors, Action and Agency

Actors - The convention in social science publications is to refer to 'actors' rather than people and groups (Meyer, 2010). He adds how '*in every social science field except anthropology.. 'new' institutionalist theorizing appeared, with models again envisioning people and groups as embedded in larger structures and cultures of one sort or another*' (Meyer, 2010, p.792).

Actors interact continuously within a field, sometimes in antagonistic ways (Reay and Hinings, 2005, p.345). '*Actors can hold different orientations although it is also likely that a given orientation will predominate in certain structural contexts'* (Delbridge and Edwards, 2007, p.200). Following the concept of actors allows us to ask questions such as 'how might the key actors conceive the MNT government intervention?' Actors conform to rules and resources, which are used to bring about action in everyday interactions. As established earlier, rules introduce a prescriptive, evaluative, and obligatory dimension into social life. Resources on the other hand are the facilities drawn upon by agents, organized as properties of social systems. The concept of actors is also referred to as 'agents' (i.e. actors who possess agency, or can bring about action).

A number of additional agents discussed in the literature and of particular relevance to the MNT field include: government agencies, management consultants (Ghoshal, 1988) and senior executives (Harrison, 1987[4]) in transmitting or communicating institutional values and beliefs. Harrison recommends the increased use of boards to develop a firm's strategic interests. He argues that boards can help maintain legitimacy, and links the director to accountability in the increasing global environment. The use of committees in MNT centres will be observed in the research. They are likely to be of the monitoring type, and called 'steering groups'. The role they play in strategy can add to this research in terms of smaller organizations.

Meyer's aforementioned definition of actors referring to people and groups embedded in larger structures and cultures of one sort or another will be used in this thesis to describe the individuals that constitute the MNT network. This includes a number of organizations and state institutions. In the main the term actors will be used to describe individuals, and organization for the MNT centres, or public-sector agencies.

Action **-** Action reaffirms rules and resources. Someone performs an action when what s/he does can be described as intentional. '*Actions are practical conclusions drawn from intentions and beliefs; 'action' and 'rationality' are interrelated… Social actions are always part of larger systems and of processes of intersubjective understanding, and this raises the question of the role of the acting subject ('human agency') in the processes by which actions are coordinated*' (Outhwaite, 2006, p.1).

Agency - All actors possess some degree of agency. According to Scott (2001), agency is an actor's ability to affect the social world. The level of agency varies among actors and among the types of social structure. Agency is carried out by altering *rules* or distribution of *resources*. According to Giddens, agency presumes a non-determinant,

[4] Whilst investigating senior executives, Harrison (1987) discusses the different types of board committees and their strategic use (or non-use). He introduces two types of committee: firstly the *monitoring* or *oversight* committee. This protects shareholders by providing an objective, independent review of corporate affairs. Secondly, he describes the *management support* or *operating committee*, which advised management and the board on major business decisions (e.g. executive committees and finance committees).

voluntaristic theory of action (Giddens 1979). This means actors are able *to intervene* in the world *or refrain* from such interventions (with the effect of influencing specific process of affairs). Actors (also known as ‘agents’) have the ‘potential to choose actions deliberately and to carry them through effectively – even in defiance of established rules and prevailing powers’.

4.4.4 Embedded Agency

The concept of embedded agency arises from the difficulty of trying to isolate the impact of agency from other factors. Holm asks ‘*How can actors change institutions if their actions, intentions, and rationality are all conditioned by the very institution they wish to change?*’ (Holm, 1995, p.398). Through conceptualizing society as an inter-institutional system (i.e. as existing between institutions) DiMaggio (1988) outlines three ways that this question can be addressed; firstly via *institutional entrepreneurs*; secondly through *structural overlap*; and lastly the idea of *competing logics*. Due to the heterogeneity of organisations in the MNT field and emerging nature of the MNT sector it is premised that actors running such centres will display embedded agency to a lesser or greater extent.

Institutional entrepreneurs - these are agents that can create new and modify old institutions because they have access to resources that support their self-interests (DiMaggio, 1988). *Institutional entrepreneur-ship* may also refer to the role that an organization plays in institutional change *(Battilana, 2006).*

Structural overlap - occurs when individual roles and organizational structure and functions that were previously distinct are forced into association. Greenwood and Suddaby (2006) carried out research which found that elite organizations are more likely to come into contact with competing and contradictory logics because they bridge different organizational fields. The area of micro- and nano- technology is a specialist, ‘elite’ area, that covers a wide-ranging area of technological applications. As such the emerging MNT field is likely to attract actors from a wide range of backgrounds. This fits with Greenwood and Suddaby’s (2006) argument that contact with institutional logics in multiple and different organizational fields increases the awareness of and experiences with contradictions in logics, which lowers constraints and embeddedness of actors and enables central actors to become institutional entrepreneurs. A number of MNT cases investigated are a hybrid of different institutional logics, and a certain amount of structural overlap is presumed to exist.

Competing institutional logics – '*Competing logics are not, by themselves, an explanation for change in institutional logics, but an antecedent or a consequence… moreover competing logics can facilitate resistance to institutional change*' (Sage *et al.* 2010, p117). They include mechanisms such as *environmental selection*, *pressures*, *political contestation* and *social movements*. Considering political contestation as one example, when the MNT government intervention was taken over by the TSB (from the DTI) a number of competing logics appear to have ensued. During pilot discussions concerning the use of the MNT intervention as the object of enquiry for this PhD, it was clear that new political contestations were already becoming apparent. The MNT Operations Manager described how many of the MNT centres were 'pushing back' at the increased levels of auditing.

Dominant logics – Reay and Hinings describe how:

> '*studies of organizational field change that highlight institutional logics tend to associate a dominant or prevailing logic for the field with identifiable eras or equilibrium points over time'* (Reay and Hingings, 2005, p.354).

They illustrate this during their study of institutional change within the Alberta healthcare system. They show that although the Alberta state try to enforce a business-like logic as part of a radical government-led health reform, in reality the existing logic of medical professionalism continues to be an important logic in the field[5]. In addition, their research shows that although new dominant logics may arise as part of a change process, the previously dominant logic will continue to be an important factor in the field.

4.4.5 Collective Identities and Identification

This section asks the question of 'how do logics shape individual and organizational action?' Institutional logics can affect individuals and organizations through the idea of collective identities. In essence this describes the way that individuals can identify with collective identities of a group/ organization, industry or population[6]. As individuals

[5] Reay and Hinings (2005) could have used the term market logics rather than business-like logics in their paper, because essentially they are talking about the same type of logic, but introducing a new term that may add confusion. The market logic is already well defined in the institutional literature.

[6] Although Zilber (2006) draws our attention to the point that not all participants subscribe to one of these

identify with the collective identity of the social groups they belong to, they are likely to co-operate with the social group, by its norms and its prescriptions. As social groups they seek to protect the interests of the collective and its members against contending identities (Tajfel and Turner, 1979). As collective identities become institutionalized, they develop their own distinct institutional logic, and these logics prevail within the social group (Jackall, 1988). Examples include distinct logics such as ‘market’ logics and ‘professional’ logics. Through investigating actors from different societies with collective identities - e.g. emerging groups from the MNT field (professional academics, market-focused groups, and state-focused groups) – the findings from this work will add to a deeper level of understanding of each category. Ideologically, each collective identity would be striving to achieve the same purpose that the government intervention was set up to address. However, in reality this is not the case, and the institutional logics theorization will help to uncover this.

This is particularly relevant for the MNT intervention, as in theory all of the MNT centres involved were set up for a common activity, along with the associated individual actors. This is not to say that they all follow a common activity, or purpose though.

4.4.6 Classification and Categorisation

Institutional logics help agents in organizations to classify social actors, organizational forms, products and organisational agendas. Changes in institutional logics lead to the creation of new categories (Sage *et al.*, 2010, p.113) and to changes in meaning of existing categories. Categories are seen as a basic unit of cognition and are a necessary component of mindful, agentive behaviour. Put simply, categories show how actors mentally acquire knowledge through their thoughts, experience and senses. Unlike the terms ‘schemas’ and ‘scripts’ which imply mindless cognition of actors, ‘categories’ present thoughtful cognition. The actions of individuals cannot be divorced either from the activity of different individuals or from organizational structure from within which they operate; i.e., the structural, normative, and symbolic as necessary and complimentary dimensions of institutions.

The institutional logic approach views any context as potentially influenced by

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categories alone, which can reveal different organising principles around a common activity.

contending logics of different societal sectors, e.g. in the Reay & Hinings (2005) study, the healthcare field in Alberta is shaped by institutional logics of the market, logics of the democratic state, and professional logics of medical care. Institutional logics are different depending upon whether you are looking at individuals and organizations, and which contexts are being observed, which markets / industries they belong to, and the population of these. For this PhD a common market is looked at: *the emerging MNT network*. Organisations and actors have been selected from this common market to add to the comparability of the findings.

4.4.7 Institutional Logics and Field Logics

Field level logics refer to the consideration of logics at the organizational field level, and are very useful for us in terms of understanding the MNT government intervention.

> '*An important distinction is [made] between those, such as Thornton, who retain the idea that logics at the field level are nested within higher-order societal institutional logics, i.e. the 'institutional logics' of Alford and Freidland, and others (the majority) who identify logics within a field without referencing their societal patronage'* (Greenwood *et al.* 2010, p.21).

Essentially they describe the same thing, i.e. the organising principles that inform members of how to conduct themselves in the observed level of analysis. The link between the intersocietal logics and field logics has not been clearly defined in the literature, hence the aforementioned ambiguity by Thornton.

The following section will describe logics in relation to the organizational field level, however the understanding is that the definitions may also apply at the higher level as well. However, Thornton and Ocasio (2010) also point out that a clear implication of the logic construct is that there will be variation across sectors, fields and historical periods.

4.4.8 Types of Field Logics

A number of types of field logics have been outlined in the literature, and some of the main ones are now listed.

- **Content –** describes when logics are challenged as actors interpret beliefs from different perspectives. Reay and Hinings (2005) provide an excellent example of this when they discuss how actors with a medical logic challenge the introduction of a business-like health logic. They describe how this leads to a field with co-existing logics, leading to ‘pragmatic collaboration’.

- **Penetration** - the degree to which logics permeate fields.
- **Linkage** – the extent to which logics connect laterally and vertically.
- **Exclusiveness** - when fields are dominated by one or more logics. In mature fields actors aware of their involvement in a common enterprise are defined by a clear set of rules and values. Hasse and Krucken (cited in Greenwood *et al.* 2010, p554) reinforce this when discussing how academic entrepreneurship is perceived and processed according to the distinct logics of different societal systems and their organizations.

It has been suggested that in emerging fields like the MNT government intervention, social relations and logics are more likely to be weakly formed and established (Delbridge and Edwards, 2007). As a follow on to this, the logics within MNT centres/ field actors based in developed institutional contexts may be more exclusive (borrowing from the already existing institutional logics). This remains to be seen with the MNT intervention investigated herein.

The ‘exclusiveness’ logic is considered to be important in the MNT government intervention as the MNT centres have been created in a wide range of institutional contexts, e.g. from large global private companies, to small SMEs and universities. *Exclusive* logics are likely to be seen by actors in the large institutions such as universities

There is of course an alternative to the exclusive type of logic which is the ‘not exclusive’ type. *Not exclusive* logics may contain secondary logics competing for adherence to or of multiple belief systems. Again, with the range of actors and different settings for the MNT centres in the government intervention, it is perceived that this logic is more apt. In the MNT field there are likely to be more pluralistic systems, that is, more contentious. Within them there the existence or toleration of a diversity of ethnic groups or cultures and views in the society is to be expected.

4.4.9 Dominant Field Participants

The concept of dominant field participants describes the strength and unity of the most dominant field participants. They have the ability to affect the organizational field logics. Examples include groups of *professionals* or *trade associations*. Professionals are groups who lay claim to formal knowledge and exercise control by defining the following characteristics:

- Cultural-cognitive and normative (relating to standards, norms) frameworks (Scott, 2001, p.129).
- They propose distinctions/ fabricate principles/ guidelines for action that define arenas within which they claim jurisdiction and exercise control.
- 'Ideas are their weapons'
- Governance structures must be created and jurisdictional claims defended – often with the aid of the state – if professional power is to be realised (Scott, p.129).

These can also be seen as a group of collective identities.

4.5 Differences in Actor Perceptions

The differences between the perceptions of objectives an actor has in an organisation, and how they define success has also been studied by a number of authors in the innovation literature, and are of relevance to this thesis.

Mass and Testa (2008) investigated the different perspectives held by actors within a sample of Italian SMEs. They identified the three main innovation stakeholders as: entrepreneurs, academics and policy makers. Through interviews with these stakeholders their results showed the existence of very deeply ingrained and different perspectives in relation to innovation. The perceptions of different actor groups varied from the simple definition of innovation, right though to how effective innovation policies are, and the role of intermediary institutions. '*Sometimes, these views show diverging goals among the stakeholders and consequently, contrasting opinions on effective supporting policies*' (Mass and Testa, 2008, p.393).

Garrett-Jones *et al.* (2005) carried out research into the common purpose and divided loyalties observed for academic and government researchers involved in an Australian government intervention which set up collaborative research centres. The researchers draw upon 30 in-depth interviews with actors across these Australian Cooperative Research Centres (CRC). The CRC centres were set up with cross-sectoral (government, academic and business) and cross-disciplinary teams for a '…*well-defined national social, economic or environmental objectives in view*' (Garrett-Jones *et al.* 2005, p.535). Their research concluded that:

‘*…CRCs appear to be hybrid organisations, drawing upon the practices and cultures of all their participants.. [developing into] .. organisational styles, perspectives, approaches and mechanisms that are substantially different from the sum of their constituent parts… This CRC ‘culture’ reflects, first … the need for a consensual approach to marshalling the resources of the CRC towards common objectives. Second, concurrently, it requires the CRC to somehow accommodate the disparate ‘cultures’ of the participants, comprising the individual researchers, their research units or scientific disciplines and their ‘host’ organisations*’ (p.543-544).

4.6 Micro-Politics and Contestation in Innovation

For completeness, it is important to recognise that there is a wide body of academic literature concerning micro-politics and contestation also in existence. A number of pertinent works from this area are now discussed, which may have a bearing on the investigation of a nascent government intervention.

Edwards (2007) investigates micro politics in an organisation undergoing a crisis event; the event concerned was that of the change of ownership in a Knowledge Transfer Partnership (KTP) organisation. He investigates the creation and sharing of knowledge in this context, and how the ability of an actor to adopt knowledge is linked with how they cope with the uncertainties that emerge from crisis events. During these times ‘*actors can transform their social context in ways that allow them to overcome the politicisation of tasks*’ (Edwards, 2007, p.391). Put simply, this study proposes that the ability (individual and collective) to introduce new meaning is not only related to knowledge acquisition through the introduction of new practices or systems, but also relies upon the socially embedded nature of knowledge, i.e. legitimisation in the local context. It should be noted however, that the findings of this study are only based on a single case, which reflects one context. A review of additional contexts would have added strength to the findings.

Hislop *et al.* (2000) investigated the role of knowledge in networks and networking for two companies implementing computer-based systems. Through the examination of the decision-making processes during the early search and evaluation phases, the political nature of networking and knowledge utilisation practices became apparent amongst the various interest groups.

Their study shows:

> *'how power and politics shaped a wide range of issues such as the framework within which the scope of change was discussed, issues of agenda formation, the type of people involved in (and excluded from) decision-making processes, the value that was attached to particular bodies of knowledge, and the way meaning was managed to justify the decisions made'* (Hislop *et al.* 2000, p.400).

The paper concludes that the development and utilisation of networking and knowledge resources has a dual character, in providing access to (often embodied and tacit) knowledge and artefacts necessary for the implementation of change, and as political tools in support of particular interests.

Swan and Scarbrough (2005) investigated three cases of networked innovation, each of which involved the development of new technologies. Their paper discusses the political dynamics that shape networked innovation, with an aim to understand networked innovation processes by identifying and relating the characteristics of networked innovation to the productive, or constraining effects of different dimensions of power (power of resource, meaning and process).

Additional authors in the area of innovation politics describe the importance of elite actors within organisations who are able to facilitate the journey of innovations through an organisation. Smith (2007) describes the importance of senior gatekeeper roles within organisations that 'champion' the products through, and ensure that they overcome any hurdles. Kelley (1976) introduced the notion of 'organisational elites' who are 'those actors within the organisation or organisational network who are qualified by 'the rules of the game' and their positions of power, to oversee the activities of the organisation' (p.66). They may not have the power to control the decision-making completely, but they are never excluded from any major decision.

4.7 Summary

Dodgson *et al.* (2005) stated that *'Technology and innovation can only properly be understood in the context of the particular social and cultural environments in which they are developed and used'* (p.19). This chapter has introduced and explored institutional theory as a lens through which the development of emerging micro- and nano- technologies can be understood in relation to the UK MNT government intervention. Greenwood *et al.* (2010, p.28) describe how the institutional theory literature has gained from a combination with, or incorporation of, other theories. This PhD will add the perspective from process innovation research (i.e. the MIRP studies), along with findings from the disruptive technology literature to institutional theory.

One of the main points that comes across when reviewing literature on institutional theory, is that there are many contested definitions within the field, and during its evolution. Greenwood *et al.* (2010) describe this in the following: '*Institutionalism's proliferation, however, comes at the expense of linguistic specificity. Even the term 'institutional' defies precise definition, leaving it open to alternative conceptual constructions that are adapted to the topic at hand*' (2010, p.31). Because of this, the last few sections of this chapter have attempted to clarify the aspects of institutional theory of relevance to the cases being studied.

Furthermore this thesis uses a 'failed' example as its major case. This looks to add further empirical evidence to the institutional theory literature, and address the 'undersampling' bias outlined by Dunrell (2003).

The following chapter describes the methodological considerations and decisions made in order to answer the Research Questions for this PhD.

Chapter 5 – Methodology

This chapter begins with an outline of social science research perspectives which are an important foundation for a researcher when considering the way the design and carry out their investigations. The importance that a researcher's world view has on the type of research data they collect and how they analyse it is discussed.

The chapter then introduces the research gaps identified during the literature review, along with an exploration of the research questions which were developed as a result.

Through consideration of the author's research perspective, a suitable methodology is selected to answer the research questions. This includes a discussion relating to the research venue investigated, along with the research design, strategies and methods chosen to study this venue.

5.1 Social Science Research Perspectives

A researcher's ontological and epistemological viewpoints are crucial in terms of how he or she views the world; this in turn, will affect the way the researcher designs and carry out the research work and the theoretical frameworks that are adopted (Morse, 2008). This is explained by Saunders *et al.* (2009) in the following:

> *'...the philosophy you adopt will be influenced by practical considerations. However, the main influence is likely to be your particular view of the relationship between knowledge and the process by which it is developed'* (p.34)

By outlining the main research perspectives along with that chosen by this researcher, the reader is enabled to further understand the way the data was collected and analysed within this study.

5.1.1 Ontology

Ontology, put simply, is how each individual pictures reality. It is concerned with the nature of existence. The main point concerning ontology is:

> '*whether social entities can and should be considered objective entities that have a reality external to social actors, or whether they can and should be considered social constructions built up from the perceptions and actions of social actors'* (Bryman and Bell, 2003, p.19).

There are two main ontological positions: that of *objectivism* and *constructionism*.

5.1.1.1 Objectivism - social phenomena and their meanings exist independently of social actors, e.g. 'the thesis you are reading now really exists, and one can see it and feel it'.

5.1.1.2 Constructionism – social phenomena and their meanings are a direct result of social actors. Constructionism implies that social phenomena and categories are not only produced through interaction, but that they are also constantly being altered, e.g. 'is this table really here? Or has it been created by my perception of my surroundings, and what I understand to constitute a table'? In summary, ontological assumptions are the foundations for theories about what exists (i.e. 'what is reality?') (Sayer, 2000).

In terms of my ontological position, I adopted elements from both of the above: I believed that physical artefacts do indeed exist, such as this physical thesis that you are now reading. However, I also believed that individuals (actors) bring their own meaning to an environment and this meaning can be affected by that environment. The bridging literature chapter has discussed this in terms of the interaction between actors and structure.

5.1.2 Epistemology

Epistemology concerns the question of what is regarded as acceptable knowledge in a discipline (Johnson and Duberley, 2009). It is the theory of knowledge; moreover, it is used to refer to the methods of scientific procedure which lead to the acquisition of knowledge (how we come to have knowledge of the external world). An important issue within this context is the question of whether the social world '*can and should be studied according to the same principles, procedures, and ethos as the natural sciences'* (Bryman and Bell, 2003, p.13).

Within social science business research, there are a number of important epistemologies that need to be considered. Saunders *et al.* (2009), list these as follows: *positivism* - working in the tradition of the natural scientist; *realism* - which asks whether objects exist independently of our knowledge of their existence; *interpretivism* - understanding differences between humans as social actors; and *axiology* - what roles do our values play in our research? Rather than describe all of these in detail, those most relevant to this PhD study were now introduced. Some reflection on the influence each position has on my PhD research, and my epistemological agreement (or otherwise) with these categories, was also presented.

5.1.2.1 Positivism - is '*objectivity, prediction, researcher detachment, the production of true and wide ranging laws, [allowing] generalisation from a sample to make universal claims'* (Gurney, 2006, p.1707). Within positivism, human behaviour is described in terms of cause and effect (*Ibid*). The positivist researcher undertakes research in (as far as possible) a 'value-free' way (Saunders *et al.* 2009). Research tends to be of a deductive nature - i.e. theories are first made (using existing theories to develop hypotheses) and these are then tested. They are tested to confirm or refute and lead to further theory development.

Typical methods used in positivism include self-completion questionnaires, structured interviews, simulation, experiments, and the use of secondary data. Positivists are concerned with sample size- i.e. the larger the sample, the better the generalisability of the results. As such, they are keen on statistical methods to apply their results to the wider populations and to validate their data sets. Johnson & Duberley (2009), suggest that for positivists, quantitative methods involving highly-structured measurement and large samples (e.g. surveys), are deemed far more important than qualitative methods.

This study is based on the author's understanding of positivism which agrees with Saunders *et al.* (2009), who pose the question of '***...whether data presented in statistical form, are any more deserving of authority than those presented in a narrative…'*** (Saunders *et al.* 2009, p113). Having carried out the aforementioned pilot interviews in organisations developing emerging technologies, it became clear that the use of qualitative methods in the local nature of the venues and actors involved was more than sufficient to provide the detailed understanding required.

I was interested in finding out the details of a government innovation intervention. More quantitative methods (such as surveys) would be limited to determining the political or emotional perspectives of the MNT government intervention under investigation (i.e. reflexivity - who you are, your culture and your expectations - all of which are important when investigating such a government intervention. Saunders *et al.* (2006, p.116), state that '*insights into the complex world are lost if such complexity is reduced entirely to a series of law-like generalisations'*. This is important in this study which adopts an interactive process perspective to consider the action of actors in relation to a state government intervention. This statement reaffirms the aim of understanding and explaining the range of MNT centres within the MNT government intervention, an understanding that would negate sweeping generalisations.

5.1.2.2 Realism: Like positivism, realism frames that the social science world can and should apply the same approach as the natural sciences to data collection and explanation (Bryman and Bell, 2003). The philosophy of realism is that there is a reality quite independent of the mind (Saunders *et al.* 2009) - i.e. reality exists separately from how we describe it. For example, ‘rocks exist and are there, regardless of how we describe them’. There are two forms of realism; empirical realism (or direct realism) and critical realism.

5.1.2.3 Empirical Realism (or ‘direct realism’): Direct or empirical realism says that ‘*what you see is what you get: what we experience through our senses portrays the world accurately’* (Saunders *et al.* 2009, p.114). Empirical realists assume that through the use of scientific research methods, we can understand and explain reality. Consequently, empirical realists do not entertain the belief that there are underlying structures and generative mechanisms that can produce observable events. Generally speaking, empirical realists can only have a conversation about something they can actually see and point to.

The pragmatic approach of this epistemological stance appealed to the researcher. However, following the belief that the way people see the world and subsequently act, was considered an important issue for organisations trying to achieve a set business purpose. Through examination of the MNT government intervention within this PhD study, there was a need to conceptualise underlying structures and mechanisms that had a role in driving the behaviour of individuals. A direct realist perspective would reject this and suggest that the world is relatively unchanging; that it operates in the business context and at one level only (the individual, the group or the organisation) (Saunders *et al.* 2009). The other type of realism – critical realism – was therefore more appropriate to my understanding of research.

5.1.2.4 Critical Realism: Critical realists start from the assumption that there is a clear distinction between the objects that exist independently and the scientists who study them. In addition, critical realists are perfectly content to admit into their explanations theoretical terms that are not directly amenable to observation (Bhaskar 1998: Bryman

& Bell, 2003). Critical realists reject the view that the world is created by the minds of human observers. They attempt to explain observable phenomena and their relations by identifying underlying structures. However, such structures are often unobservable, e.g. labour markets.

5.1.2.5 Interpretivism: Interpretivism is at the extreme end of the spectrum to positivism. Interpretivists *'share a view that the subject matter of the social sciences – people and their institutions- is fundamentally different from that of the natural sciences. The study of the social world therefore requires a different logic of research procedure, one that reflects the distinctiveness of humans as against the natural order'* (Bryman and Bell, 2003, p.15). Social reality has a meaning for people and their behaviour alters relative to their actions and those of others. The interpretivist researcher is interested in *getting into the head of the people* to interpret their actions and their view of the world in which they live.

Interpretivism uses small research sample sizes, in-depth investigations, and is on the whole qualitative. Authors typically adopt an empathetic stance toward those being investigated. The challenge is to understand their world from their point of view (Saunders *et al.* 2009, p.116). This is very important for complex business environments. Interpretivism is highly suited to the research environment chosen for this study, as it enables the viewing of innovation as a function of particular contexts, motivations and people coming together at a point in time.

5.1.3 Ontological and Epistemological Assumptions for this Study

This study adopts the epistemological perspective of interpretivism as the most appropriate based on the discussion of ontological and epistemological viewpoints above in relation to the state intervention investigated, along with the author's own viewpoint. This study also undertakes a qualitative approach to address the Research Questions which require description and explanation of the state intervention under investigation.

The following section introduces the observed literature gaps and research questions. The discussion is then brought back to methodological considerations at the practical data gathering level; that is, considerations of research strategies, design and so on.

5.2 Research Gaps and Research Questions

In order to understand the theoretical contributions already made concerning the area of government interventions, and in particular those addressing emerging technologies, the academic literature was searched[1]. A large amount of research has discussed existing publicly funded schemes such as the Knowledge Transfer Partnership[2] (KTP). These range from the investigation of advanced manufacturing technologies using KTPs as comparative cases (Walters and Dorrington, 2004); organizational change through academic/ business collaborations (Peattie, 1993); to using them as case examples for developing theoretical perspectives to model the implementation of new products/processes (Edwards, 2001). However, despite this wide range of interest there is a gap in the current literature concerning publicly funded schemes developing emerging technologies in nascent fields.

Tovstiga and Birchall (2005) describe a number of important features of a new economic order of which one is the development of new and disruptive technologies, which are:

> '..*rewriting the rules of competition as they transform value chains, usher in new business models, and create new sources of value. Incumbents are left vulnerable as new players redefine competitive advantage that is often short-lived*'. They further describe how nanotechnology is '*a good example of how the technology revolution is being driven by new modes of knowledge production*' (Tovstiga and Birchall, 2005, p.9).

This illustrates another gap: that is, the importance of understanding how high-technology based economic growth designed to stimulate new industries from emerging technologies would benefit from further investigation. Particularly when one considers the recent emphasis that the UK government has placed on developing economic growth based on innovation. A large number of UK government white papers and reports were written concerning this around the time of the MNT Programme. They covered a range of sectors, both public and private. Each has its own recommendations and strategies for the 'UK's innovation future'. Important examples of these published in the lead up to the MNT government intervention can be seen in Table 5.1, and are included as they emphasise the importance placed on innovation by the UK Government at the time the MNT Programme was established.

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[1] Areas researched include: Emerging/disruptive technologies, National Systems of Innovation (NSI)/ government interventions and Institutional Theory

[2] Formerly known as the Teaching Company Scheme (TCS).

Table 5.1 – Influential Innovation Policies

Title	**Priority**	**Reference**
Excellence and Opportunity	Focus on the government investing in a strong science base. Addresses the need to develop higher education research and development into industry.	DTI, 2000a
Foresight 2020	Identified the key issues that will shape the future of UK manufacturing and the actions required to address them.	DTI, 2000b
Opportunity for all in a World of Change	About the vital next steps that Government, businesses and individuals must take to secure economic success in the decade ahead.	DTI, 2001
Taylor Report	The field of nanotechnology and its applications is crucial to the future competitiveness and productivity of the UK economy, and to the well being and prosperity of its people.	DTI, 2002
Lambert Report	Universities will have to get better at identifying their areas of competitive strength in research. Government will have to do more to support business-university collaboration. Business will have to learn how to exploit the innovative ideas that are being developed in the university sector.	Lambert, 2003

There appears to be a cycle of policy creation leading to innovation interventions, without robust discussions of their performance (Georghiou, 1998). This is particularly the case for the MNT intervention, and this PhD aims to address the function of this particular government intervention. The term function is firstly understood as a way of describing the purpose of the MNT government intervention in terms of why it was established by the UK government. The original purpose was the creation of a network:

> '*to provide a market-orientated focus for the facilities, people and organisations engaged in Micro and Nanotechnologies in the UK. The Network is helping to lower entry barriers and drive the widespread market development and exploitation of these technologies – building a prosperous, world-class MNT sector in the UK*' (DTI, 2005).

The MNT network in relation to this purpose can then be investigated by validating the interpretation of this from individual actors, along with observing the influence their actions have on their local MNT centres, and the extra local context of the MNT intervention. The connections between these actors will vary in terms of who is involved and in what capacity. The actions of all stakeholders, organisations and the structure of the MNT network are therefore implicit in the understanding of this MNT government intervention.

The Taylor report emphasises the importance of nanotechnology as a disruptive technology:

> '*A distinctive feature of genuinely disruptive technologies is that they can have very many different applications. This is particularly true for nanotechnology… Disruptive technologies are those that displace older technologies and enable radically new generations of existing products and processes to take over*'. (DTI, 2002a, p.17).

The MNT centres investigated within this study are developing micro- and nano-technologies. However, the characteristics of the human agents involved in this process will differ, e.g. experience, frustrations, and other interpretations of the *extra local* and *local* context within which they are bound. This is important as it complements the link between agency and structure presented in the interactive process perspective approach (IPP) i.e. agency and structure are not independent.

Through a deeper understanding of a recent government intervention, this work adds to the innovation policy and practice debate, building on the NIS literature.

5.3 Research Questions

This PhD study endeavored to answer a number of research questions highlighted from a review of the literature and a number of inductive pilot case studies.

Research Question 1 (RQ1)	How do government interventions such as the MNT network function?
Research Question 2 (RQ2)	How can we describe stakeholder values and understanding in relation to the role of a nascent government intervention?
Research Question 3 (RQ3)	How do the the following aspects of innovation management: *purpose, process, people, collaborations, context and outcomes* influence the success of emerging technologies in different organisational settings?

Research questions 1 and 2 are descriptive, and provide an opportunity to understand and explain the MNT network in more detail. Research question 3 then drives the analysis of a number of key constituents of the MNT government intervention (i.e.

constructs).

Research Questions 1 and 2 are deliberately designed to provide the study with a general focus, following the initial pilot research study and the literature review process. Saunders *et al.* (2009) describe how this approach often leads to further detailed research questions:

> *'It is often a useful starting point in the writing of research questions to begin with one general focus research question that flows from your research idea. This may lead to several more detailed questions or the definition of research objectives*'
> (p.24).

Research Question 3 helps to focus the investigation to a number of important constructs and particular areas of interest for examining the chosen UK MNT government intervention. Constructs are used in this research study to describe key variables from the extant literature that are of interest in terms of describing and understanding the research venue. In addition to those constructs adopted from the literature, a number were also developed following the pilot interviews. The term sensitising construct is also used in this thesis, which refers to the embryonic stage of construct development, as described by Poole *et al.* (2000)[3].

Furthermore Research Question 3 has a particular focus on the effect of different contexts on the development of technologies as part of the MNT government intervention. This research is particularly interested in explaining the role that different contexts have within a government intervention. For example, the comprehension of how different actors interpret the purpose of the government intervention in relation to their local organisation and the purpose of the wider MNT network. This work aims to shed further light on how a nascent network such as the MNT network functions.

[3] The background to constructs and sensitising constructs is described in Poole *et al*.'s book on organizational change and the innovation processes – theory and methods for research (Poole *et al*. 2000).

5.4 The Research Design

This section now describes how the research was carried out in order to answer the aforementioned research questions.

A research design provides a framework for the collection and analysis of data. The choice of research design reflects decisions about priorities given to the components of the research process (Bryman and Bell, 2003). A research method on the other hand, describes a tool or technique that is used to collect data; for example, a structured interview template or a survey questionnaire. This section begins by discussing the pilot data collection which led to the choice of research venue central to this study, and how it is researched by using an appropriate research design. The philosophical underpinnings of this research are also introduced within this chapter.

5.4.1 Establishing the Research Venue through Pilot Interviews

Prior to the decision to investigate the MNT government intervention a number of pilot interviews were carried out to help understand organizations developing emerging technologies in a variety of different environments. These pilot cases were carried out in parallel to early reviewing of the literature, and followed an inductive theoretical approach. Researchers generally adopt one of two theoretical perspectives when carrying out their investigations; the *inductive* or the *deductive* approach. Inductive theory is the outcome of research, i.e. the process of induction involves drawing generalisable inferences out of observations (i.e. theory building). Deductive theory is made on the basis of what is known; the researcher creates a hypothesis, and then tests it. The hypothesis is confirmed or unconfirmed and then the theory is revised (theory testing and modifying). This study uses an inductive approach throughout.

Purposive sampling refers to the interactive process carried out by a researcher when directing their data generation, analysis, theory and sampling activities (Mason, 2006). The pilot venues for this study were selected purposively to include organisations developing emerging technologies in a range of venues. In particular the pilot cases were selected according to their organisational size, e.g. global, SME, a university centre, and a start-up company. This particular form of sampling refers to ‘polar’ or ‘extreme’ case sampling; that is, the deliberate choice of extreme cases. Such extreme cases are expected to yield especially valuable information about the topic of interest.

These deviant cases provide interesting contrasts with other cases, thereby allowing for comparability across those cases (Teddlie and Tashakkori, 2009). According to Mason (2006) the investigator should first determine a dimension of interest, then generate a distribution of cases on that dimension, and then locate extreme/ deviant and other relevant cases on that distribution

For the pilot study, the dimension of interest was organisations developing emerging technologies. The location of deviant cases was made according to the different sizes of organisations and the different organisations they offered for investigation. The expectation was that they would offer a wide range of different examples of how organisations manage the innovation of emerging technologies. Access was successfully granted to four pilot organisations, and key individuals were identified and interviewed within them. The selection provided examples of one global company; one medium company and two small companies. Interviews were carried out in all four pilot organisations, and mapping workshops in a number of them.

Table 5.2 – List of Pilot Interviews

Pilot Org. / **Data collection**	**Pilot 1 – Global Company** ***Capital equipment manufacturer***	**Pilot 2 – SME** ***Fibre processing equipment***	**Pilot 3 – University-based** ***MNT technology development***	**Pilot 4 – Start-up Co.** ***Flexible displays***
Mapping workshop	2 days	Half day	Not carried out	Not carried out
Semi-structured face to face interviews	▪ Marketing Director ▪ Project Manager (2 hours in total)	▪ Technical Director ▪ Business Development Manager (3 ½ hours in total)	▪ Business Manager (1 ½ hours over two interviews)	▪ Integration Manager ▪ (3 hours, over two interviews)

Pilot 1 is an example of a capital equipment manufacturer, which is part of a private global organisation; it designs and manufactures silicon wafer production equipment, which encompasses an element of emerging technology development. A workshop was carried out to 'map-out' the innovation process followed to develop their products and technologies. A similar mapping process was used as documented in previous work by the researcher, seen in (Francis *et al*. 2008). This process essentially walked a range of stakeholders through the innovation process followed for a recent example of their products. The time taken for each action was recorded along with decision points along the way (see Appendix 5a). This mapping process appeared promising, and was therefore tried again in Pilots 2 and 3. In actuality, maps were only drawn in pilots 1 and

2; when an attempt was made to map the process in pilot 3, the products were too emergent to allow a sensible route to be followed.

Pilot 2 is an example of another private capital equipment manufacturer, but on the SME scale. They develop specialist laser-based equipment for the precision cutting of optical fibres. A similar research mapping method was followed in this venue. However, due to the more *emergent* nature of the technology, and smaller organisational size, the attempt at mapping/ drawing out the process flow was found to be less useful. The reason for this was that the innovation process in this smaller organisation with less formal processes, and a greater level of newness of the technologies under development, was idiosyncratic.

Out of all four examples Pilot 3 was the only example of a publicly-funded organisation. Its majority shareholder was a University, and it developed emerging micro- and nano- technologies. This university context provided quite different insights to those of the commercial pilots, which are further discussed in this chapter.

Pilot 4 is an example of a small organisation developing a mobile communication device using a novel flexible display. Two interviews were carried out in this pilot with the Manufacturing Director.

In the case of pilots 1 and 2, flow charts of the innovation process were created with inputs from key stakeholders at each junction of the flow chart. Appendix 5a shows examples of these. The initial reason for creating such a chart was to observe the key actors and their actions (grouped into design phases) involved in the innovation process. This method worked well for Pilot 1, however for Pilots 2 to 4, which were smaller organisations (10s of employees in comparison to 100s/1000s), this method did not work. The main reason being that the smaller companies displayed less formal development processes. This was particularly evident in Pilots 2 and 3; there was a 'reactive' element to the development process, i.e. actions were typically a reaction to events/ circumstances rather than planned events. Participants attributed this to the novelty and high market risk of the technologies under development. Pilot 1- although developing emerging technologies – was part of a global organisation with established procedures, and with existing products on the market already.

Within each pilot organisation senior technical managers and/or directors were interviewed using a semi-structured interview approach. The template for this approach can be seen in Appendix 5b.

The questions asked were mainly open in construction, in order to discuss a range of issues pertaining to innovation management that had emerged as potential gaps from the literature review. A number of questions also asked the participants to describe examples of successful and unsuccessful developments of new technologies, and how the related innovation processes were managed. Some example products or projects were discussed during interviews and workshops.

The pilot cases were analysed using thematic analysis of the transcripts. The theory behind coding and ways in which to carry out coding in a systematic and reproducible fashion was understood from the renowned work of Miles and Huberman (1994, pp. 55-72). In pragmatic terms, each transcript was read in detail and portions of the text were given codes inductively as part of the reading and analysis process. The reason for this was to see which themes emerged as important for organisations developing innovative technologies. This approach was chosen as the most suitable for investigating the organising principles of individual actors in relation to their actions and understanding of the MNT intervention, particularly in relation to their organisational venue. As part of the selection of research methods a thorough examination of different research designs and strategies was undertaken (refer to section 5.6).

<u>There were two further important outcomes from the pilot interviews:</u>

- Firstly, the choice of the research venue.
- Secondly, a list of inductive themes was generated – these were linked to the MIRP literature and constructs. Over forty of these were produced, refer to table 5.7.

These were linked together to create the research strategy.

5.4.2 Research Venue

Details of the pilot cases can be seen in the transcript addendum. Rather than spend time detailing all the findings from each of these, of which only one was subsequently used, this Chapter describes how they refined the focus of study and research strategy used.

Pilot 3 was one of the 24 MNT centres created as part of the UK MNT government intervention. It introduced the government intervention and how it was established to develop emerging micro- and nano- technologies in the UK. The interviewee was the Business Manager and the MNT Centre was based in a University (it later became the main case for this study, i.e. Mercury). Out of the pilot venues, the scale and scope of the MNT intervention offered the best opportunity for conceptualising innovation in a meaningful context. Pilot 3's interviewee talked openly and widely about the MNT government intervention, which highlighted both positive and negative points of trying to commercialise new technologies as part of a national system of innovation. Considering the large amount of UK state investment into these centres, the reasons why some centres had been successful and others not warranted investigation – coupled with the need for further empirical evidence in the NSI literature (Fri, 2003; Quere, 2004; and Harvey, 2010). This had the potential to add empirical evidence of a nascent field, whilst offering the opportunity to provide evidence and knowledge for future national innovation policies.

Further discussions took place with Pilot 3. During these discussions, it became apparent that Pilot 3 offered a unique opportunity to understand the difficulties faced by an organisation developing emerging technologies as part of a government intervention. The Business Manager described a number of barriers to the success of the centre; for example, there appeared to be internal contestation between individuals in the centre, as well as the reporting of similar issues between other centres and the governing body. The reporting of Pilot 3 as having been considered failing by the governing body (The TSB), by the Business Manager, presented an opportunity to find out why it was unsuccessful in the view of the state governing body.

A review of the innovation and EDT literature showed that few authors selected 'failing' examples of organisations for the main cases. Typically, organisations which are successful were chosen, so that 'best-practice' could be discovered and disseminated (Thornton, 2002). I saw this as an opportunity to investigate an organisation which appeared to be turbulent and would provide a good example of the 'real' difficulties faced when developing emerging technologies. Small Co. was subsequently renamed 'Mercury*'* and became the main case for this PhD study.

Access was granted to this main case, which allowed a within-case analysis in order to gain familiarity with the data collection and allow for preliminary theory generation, before moving on to the comparative case studies (Eisenhardt, 2007).

Scott's (2001) definition of an organizational field is drawn upon for this study; that is: a field which is made up of a set of diverse organizations engaged in a similar function and constituting a recognised area of life (Scott, 2001). In terms of this government intervention there is a field made up of a range of diverse organisations, established for the same purpose (i.e. function) which can be seen as having made up the MNT Network.

Scott (2001) describes how organisations within a field can be categorised as *state agencies*, *resource* and *product consumers*, and *other organisations that produce similar services or products*. In terms of the MNT government intervention, the fit with these categories are as follows:

- *key suppliers* - i.e. the MNT centres
- *state agencies* – Non-departmental government bodies, i.e. the DTI and the TSB
- *resource and product consumers* – customers (i.e. UK SMEs), and other MNT centres
- *other organisations that produce similar services or products* – i.e. those organisations not funded through the MNT intervention, but developing MNTs.

Furthermore, the individual actors within these organisations are understood as an essential part of this field. This study draws on data from a wide range of actors within the above organisations, and across the MNT field.

Figure 5.1 displays a snapshot of the MNT organisational field in terms of those organisations accessed, and individuals interviewed within this study. Clearly the full MNT field diagram would be far too unwieldy to try and represent at the detailed level of figure 5.1. This figure is used to demonstrate the levels of organisations, and where the actors fit in relation to one another and the field.

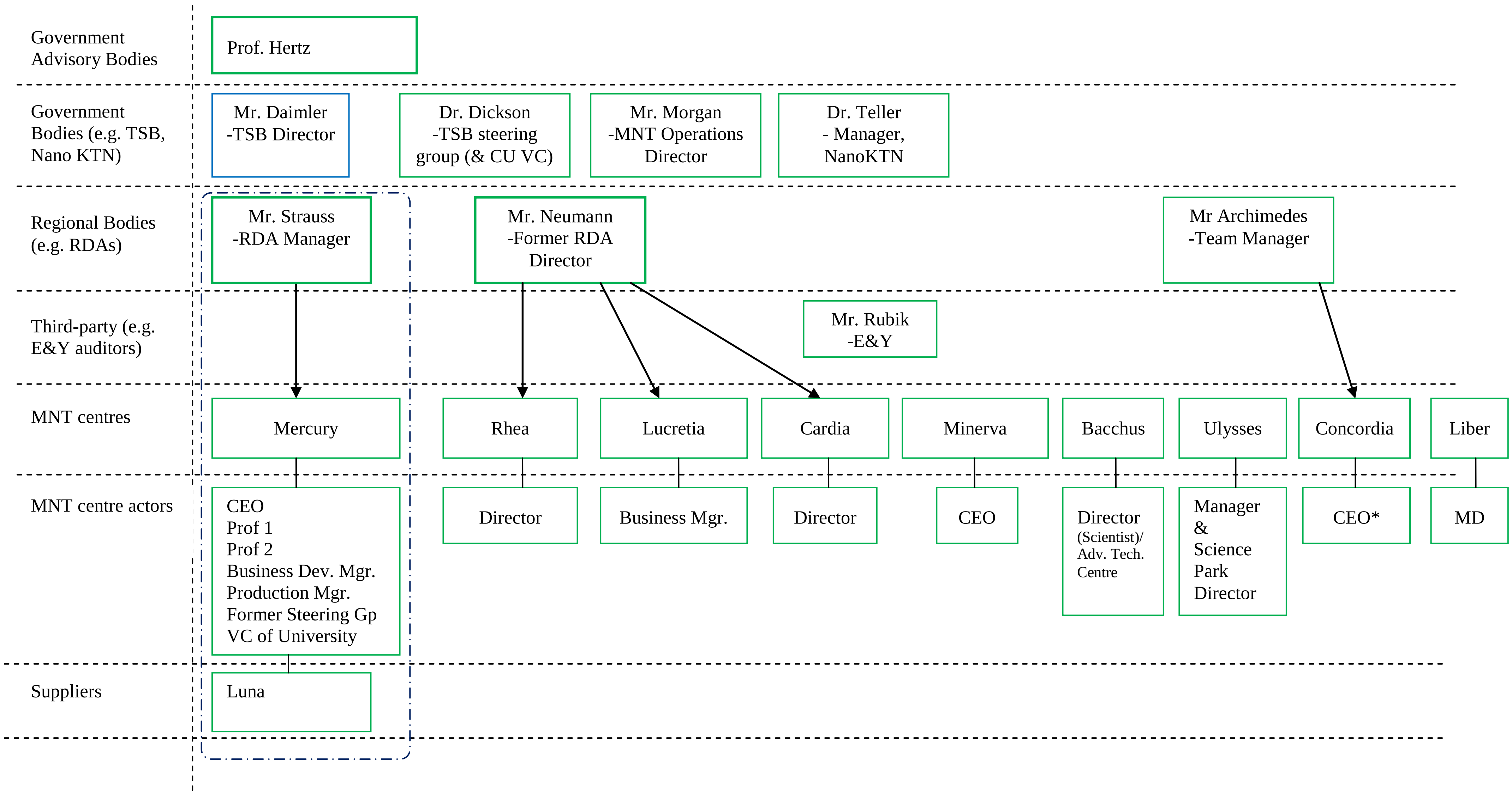

Figure 5.1- A Graphical Overview of the MNT Centres Accessed, along with the Cross-Field Actors

Pseudonyms have been used for organisations and actors alike. Further details of individuals are provided in the *major case*, and *cross-case comparison* chapters.

The specifics of the research design selected are now addressed.

5.5 Research Strategies and Situations

Following the literature review, identification of gaps, and choice of research venue, the next step was to consider the research philosophy, research strategy and situation; all essential to developing a successful research methodology.

A research strategy is the general plan of how the researcher will go about answering the research question(s) (Saunders *et al.* 2009). Research strategies are informed by the research question(s) and/or objectives, the extent of existing knowledge (e.g. the academic literature), the time and resources available to the researcher(s), and the philosophical underpinnings of the researcher. Strategies can be used together, for example, an online survey might be used as part of a case study. Details of research strategies by a number of different authors were studied when considering the most suitable strategy to answer the research questions (e.g. Yin, 2003; Saunders *et al.* 2009; Bryman and Bell 2003; Silverman, 2006). They included: processual research, surveys, archival analysis, history, case study, action research, grounded theory and ethnography.

Table 5.2 on the next page displays the research strategies that were considered most suitable for answering this study's research questions. The reason for this was to avoid elaborating on every potential strategy and my consideration of them (as outlined in Appendix 5c). Three strategies are presented here: case study, grounded theory and processual research.

*Case study***:** This strategy answers research questions in the form of 'how, and why?' A case study is defined by Robson as a 'a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence' (Robson, 2002, p.178). The researcher is concerned with the complexity and particular nature of the case in question. Multiple case studies provide opportunities for comparison of data (bearing in mind the contextual issues that these case studies present) (Yin, 2003). Multiple, small targeted case studies are useful for gathering rich data that can be used for describing, understanding, and explaining specific contexts.

There are three classifications of case study generally referred to: *exploratory*, *descriptive*, and *explanatory* (Yin, 1994). *Exploratory* refers to the process of finding out what is happening. It is not driven by proposition, however it is driven by a purpose. The ideas of exploratory research is to help clarify and understand a research problem, and further identify research questions/ hypotheses for subsequent study (Yin, 1994, p.22). *Descriptive* case studies, are those which provide a comprehensive account of the phenomenon under study, within its context. Robson states that the objective of a descriptive case study is to '*to portray an accurate profile of persons, events or situations*' (Robson, 2002, p.59). This may come before an exploratory stage of research, or be an extension to it. *Explanatory* cases are used to test 'cause and effect' relationships between variables (Saunders *et al.* 2003). Yin (1994, p.4) provides an example of explanatory cases, which shows how they do not necessarily require statistical analysis (as might be understood when discussing cause and effect).

Grounded Theory- Similar to the case study strategy, a grounded theory approach asks 'how and why?' questions. Theory building is carried out by researchers using a combination of inductive and deductive strategies, but is more associated with the inductive approach (Glaser and Strauss, 1967). Researchers adopting this approach begin without an initial framework. They develop theory from initial observations and data, which eventually leads to the generation of predictions. These are then tested using further observations.

Processual Research- Along with the above two approaches, processual research also asks the 'what?' question along with 'how and why?' The purpose of processual research is to explain the *what*, *why* and *how* of the links between context, processes and outcomes (Pettigrew, 1997).

Table 5.3 describes the appropriateness of the above research strategies in relation to their suitability for this study. The multiple case study approach along with elements of the processual research approach was selected for this study. Further justification for this decision is now made.

Table 5.3 - Research Strategies and their Suitability for this Research Study

Strategy	How suitable is this strategy for… ?			
	The Research questions and/or objectives?	**The existing literature?**	**The resources & time?**	**The researcher's world view/ and comments**
Case study	Innovation is a complex process; taking into account MNT centres in a range of contexts increases the complexity of this process. Case studies are concerned with investigation of such complexity, they allow deep and rich analysis of single organisations (Yin, 2003). External validity can be questioned when investigating single cases: use of triangulation using multiple case studies can overcome this.	A robust case study strategy would add to the existing body of knowledge. Often cases within the EDT literature area are published in more anecdotal/ narrative forms, lacking true case study rigour.	Triangulation is one way to increase external validity, but takes more time and resources. Gathering in-depth data from case studies is time-consuming in comparison to postal / electronic surveys, however the richness of data collected is essential when investigating such a nascent area, such as the MNT government intervention.	This strategy appeals to my critical realist ontology. The use of multiple case studies leads to common findings which may provide insights into future innovation policy design (whilst understanding the limitations of the sample size. Case studies can be complemented by a mixed methods approach if desired.
Grounded Theory	Would be suitable, however this research is looking to contribute to policy and practice, not theory development alone.	Not typically seen in the literature for EDTs.	Organisations prefer to have an outline of what the research access is for, therefore a truly grounded theory approach might be off-putting (e.g. participant observation).	The author prefers a more structured approach to data gathering. Access and trust would be major hurdles in companies developing emerging technologies with related issues of Intellectual Property (IP).

Strategy	How suitable is this strategy for… ?			
	The Research questions and/or objectives?	**The existing literature?**	**The resources & time?**	**The researcher's world view/ and comments**
Processual Research	Suited to the investigation of processes within a range of different contexts, addressing a number of different outcomes (Pettigrew, 1997). Highly relevant to the RQs.	Potential to build on the MIRP research work.	Scholars such as Van de Ven *et al.* (2000) offer a formulaic approach for process research; i.e. longitudinal recording of events and actions, for an organisational process. This generates a vast amount of data in order to overcome difficulties of generalisation which can occur with the smaller sample sizes typical of organisational research. Resource hungry.	Approach appeals to researcher's world view, with the acknowledgement that an adapted method without the highly prescriptive recording of temporal event data. This PhD study does not attempt to emulate such a depth of data collection.

5.5.1 The Case Study Research Strategy

The case study strategy was chosen as the most suitable research strategy for addressing this study's research questions. This strategy was interlinked with some elements of processual research (namely the use of constructs for gathering data). There were a number of reasons for this decision. One of which was that the use of case studies followed the interpretivist epistemology understood by the researcher. Clearly the research has been influenced by practical considerations as outlined throughout this chapter, however as Saunders *et al.* explain:

> '*..the philosophy you adopt will be influenced by practical considerations. However, the main influence is likely to be your particular view of the relationship between knowledge and the process by which it is developed'* (Saunders *et al.* 2009, p.34).

Furthermore, the logic underpinning the use of multiple case studies is also based on replication and can be seen to provide a stronger case for theory building than single cases (Yin, 1994; Eisenhardt, 2007).

Yin (1994) states that:

> '*Multiple cases are likely to result in better theory... The choice is based less on the uniqueness of a given case, and more on the contribution to the theory development within the set of cases… multiple cases are chosen for theoretical reasons such as replication, extension of theory, contrary replication, and elimination of alternative explanations*' (Yin, 2003).

To achieve this it is necessary to select each case on the basis that it either predicts similar results (which is a literal replication), or *as in this study*, **that it produced contrasting results for predictable reasons** (Yin, 1994). That is, MNT centres demonstrating a range of local contexts were approached for selection from the overall 24 centres. When making this selection, the questions '*what is this similar to, what does it contradict, and why?*' (Eisenhardt, 2007, p.544) was asked. This resulted in nine accessible centres, constituting a range of venues, including: *universities*, *SMEs, global organisations*, and *science parks*. It made sense to choose cases such as extreme situations (i.e. in terms of contexts) in which the '*process of interest is 'transparently observable'…thus, the goal of theoretical sampling is to choose cases which are likely to replicate or extend the emergent theory*' (Pettigrew, 1997, p.537).

These were understood to contain competing logics and conflicts of purpose amongst actors, and their resulting actions, based on the findings from interviews with the Business Manager from Pilot number 3.

The following variables were kept constant through the very choice of the MNT intervention as the research venue:

(i) All were developing, measuring or researching MNTs, with a view to helping UK PLC 'step-up' the MNT technology ladder, in comparison with other countries;

(ii) They were UK based and in a nascent field;

(iii) All were either SMEs or SME-sized cost centres within larger companies (and acting as SMEs);

(iv) They all received a government grant as part of the UK MNT Capital Facilities Programme for the provision of MNT facilities to UK firms on an open-access basis;

(v) Without public funding, they would not have existed;

(vi) Each centre should have become self-financing by the end of the grant period (with the exception of medical and characterisation centres);

(vii) They were overseen by non-departmental government bodies (NDGBs);

(viii) Each centre should add value to the wider UK economy.

In turn, this allowed for a more robust comparison across cases, and added to the validity of findings.

The MNT government intervention was created to develop a new emerging sector of technologies, namely micro- and nano- technologies. This is a nascent sector, and as such, is less firmly established in the academic literature. The use of case studies allows for an inductive, deeper understanding of organisations developing these technologies, which has the potential to pave the way for future research (which may then be able to use more generalisable strategies when the sector is more developed).

The use of a case study approach allowed for a range of research methods to be used which included both primary and secondary data collection. For example, interviewing individuals within a case, or gathering reports or public-domain documents, or even financial records, can all be used to add to case data. A final observation from this Table was the need to gain early access to cases in order to gather data. In terms of the MNT centres, this was one of the most problematic aspects of this research study and was detailed later in this Chapter.

Table 5.4 – Summary of the Interviews carried out for the Study

Type of Interview	**MNT local context** (i.e. interviews in MNT centres)	**MNT extra local context** (i.e. state actors and cross-field actors)	**Total**
Semi-structured face to face	16	6	*22*
Semi-structured telephone	3	3	*6*
Total	*19*	*9*	**28**

Table 5.4 outlines the total number of interviews carried out for this study. The preferred interview strategy was to conduct interviews face-to-face, travelling to the participant's venue. This provided a better understanding of the venue of the MNT

centre being investigated. However, in a number of cases this was not possible, and telephone interviews, with follow-up email correspondence had to suffice.

5.5.2 Limitations of the Multiple Case Strategy

Clearly, this strategy had limitations; there was only one researcher to visit each organisation and different organisations provided differing levels of access. Therefore, the logistics of visiting many centres on a limited budget needed to be considered. However, the researcher felt that it was essential to gain an understanding of a wide range of organisations to further validate the understanding of innovation management processes (in the tens, rather than hundreds). The positivist person with a natural science view of the world might argue that hundreds - if not thousands – of data sets are required for generalisation. The author's counter argument was that he was not trying to produce statistical generalisations from a large sample population, but rather, was trying to overcome the single sample criticism often aimed at qualitative research. The investigation of tens of cross-field actors - using rich data collection techniques such as interviewing – addressed the key elements of an organisation's processes that constituted 'success' or 'failure' within each such organisation.

5.5.3 Data Gathering

Due to the complexity of the innovation processes for emerging technologies, the author believed that the best way to gain an overall understanding of an organisation and its innovation processes was to locate key senior figures within each organisation, and then conduct expert interviews. Interview data – in narrative form - were the main empirical data collected for this thesis. The term empirical stems from empiricism, which in this instance refers to the importance of direct contact with social reality '…writers on qualitative research frequently stress the importance of direct experience of social settings and fashioning an understanding of social worlds via that contact' (Bryman and Bell, 2003, p.467). Secondary sources were used for validation where appropriate, for example Government White Papers and Company Reports.

5.5.4 Interviewing

An important challenge to consider when conducting interviews is that of limiting bias (Silverman, 2006). According to Eisenhardt the use of 'numerous and highly knowledgeable informants who view the focal phenomena from diverse perspectives'

(Eisenhardt, 2007, p.28). Senior, knowledgeable informants were targeted during the initial contact with each of the MNT Centres. Generally speaking, these were the Centre Directors (whose titles ranged from 'CEO', 'Director' to 'Manager').

5.5.5 Issues of Data Access

Access was afforded to nine Centres (and Centre Directors) out of twenty-four, which was considered satisfactory, bearing in mind the difficulties of gaining access to data concerning the MNT government intervention. Furthermore, seven actors were interviewed within the major case, and an additional ten cross-field actors were also interviewed. In all cases, only knowledgeable, senior actors were interviewed. That is, actors of a senior role, with experience and responsibility for running an MNT centre were selected for interview. The twenty-eight interviewees provided experiential knowledge from a range of different backgrounds, working in business environments, academic environments, or in some cases, both. **Such a multiplicity of perspectives was deliberately sought in order to answer the research questions more effectively to enable the triangulation of data** (Poole *et al.* 2000).

Semi-structured interviewing: A semi-structured interviewing approach was used to gather data across the organisational field. Some advantages and disadvantages of qualitative interviewing were reported in the literature and a summary of these can be found in Table 5.5:

Table 5.5 – Some Perceived Advantages and Disadvantages of Qualitative Interviewing

Advantages	Disadvantages
Pilot interviews aid understanding of research environment & clarify interview structure.	Time consuming.
Researcher can gain deeper understanding than a ‘tick-box’ survey questionnaire.	Access to individuals (particularly senior staff). Poor responses from staff that have been ‘instructed’ (i.e. stonewalling answers).
Open questions can expose new avenues.	The participant’s mood-may be having a bad day.
Ability to deconstruct large research questions into smaller sub-questions-easier for interviewee.	Is the view of the ultimate boss the ‘God’s eye view’ – or is anybody’s, for that matter?
Recording can provide a complete record of interview.	Researcher could use leading questions to gain certain responses or bring own bias to interview.
Interviewing an individual removes any peer pressure present in focus groups or group interviews (as well as use of anonymity).	Some respondents try to guess the answers or may have their own agenda & want to answer their own questions; or they may interpret them differently to how they are intended.
Multiple interviews provide a means for triangulation and validation of data.	Recording can be obtrusive & take time to transcribe.

Interviews can be carried out in a structured, semi-structured or unstructured way (Saunders *et al.*, 2003), all of which have advantages and disadvantages in their use. The interview template designed for this study used a semi-structured approach, with predominantly open questions being used, and a small number of closed questions.

Semi-structured interviews are suitable to address ‘what’, ‘how’ and ‘why’ questions (Saunders *et al.*, 2003). When conducting a semi-structured research, ‘the researcher has a list of questions on fairly specific topics to be covered, often referred to as an interview guide, but the interviewee has a great deal of leeway in how to reply*’* (Bryman and Bell, 2003, p.343). They allow the interviewees to respond to questions in their own words and put their own views across. Generally, all of the questions are asked in a similar way, with similar wording from interviewee to interviewee. However, they do not necessarily follow on exactly as outlined in the interview schedule.

Because semi-structured interviews were flexible in nature, they allowed me to ask questions which may not have been included in the guide. Figure 5.2 shows the final template used, and a number of prompts and probes in the form of bullet-points can be seen as a reminder of further questions to elicit responses from interviewees. Whilst interview data is more difficult to compare than structured interviews or survey methods, the use of a semi-structured approach offers the opportunity to triangulate the data from a range of cross-field participants in order to support reliability and validity (Lindlof & Taylor, 2002).

In order to carry out semi-structured interviews, an interview template was designed to provide consistency and structure throughout each interview. An important consideration when preparing the format of a semi-structured interview is how to ask the questions. There are two main types of questions that can be asked; either ‘closed’ questions or ‘open’ questions (Bryman and Bell, 2003, p.156). Closed questions are the most commonly used type of questions as they are easier to analyse and can take many forms (Bryman and Bell, 2003; Outhwaite, 2006) For example, one of the closed questions asked at the end of my interview script was ‘*do you think that publicly-funded initiatives such as nanotechnology centres help industry to exploit emerging technologies?*’. As this example shows, they can be easily quantified and often, questions only require a simple ‘yes’ or ‘no’ answer. Closed questions help to confirm the interviewee’s thoughts, and validate other questions asked. In this example, the answer to this question typically prompted further questioning. Closed questions can take a more prescriptive form too, where interviewees are asked a question and presented with a list of answers to choose from. However, this approach was considered too restrictive for the purposes of my research questions. The purpose of gaining access to senior, knowledgeable experts in the MNT field was to gather a deeper understanding of the field, rather than have them merely ‘ticking boxes’.

Figure 5.2 – Final Interview Template

Accreditation?
Collaborations – Industry/Nanocentres/KTNs/Other?
Patents?
Staff Objectives?
MRL?

Agenda, and interview questions

<u>5 minute Introduction</u>
<u>Questions:</u>

1. Can you tell me about your [*organisation*] and who your key customers are?
- Main objectives?
- Public-Private split?
- Likely to break-even at end of funding period?
- What do they want?
- How good are you at achieving that?
- Revenue generation?

2. How would you describe a <u>successful outcome</u> from the development/ application of your [nano] technology (and/or expertise)?

3. Conversely, how would you describe a <u>failed outcome</u>? Or, an outcome that results in elements of success and failure (i.e. positive and negative results).

4. Can you discuss the <u>collaborations</u> that you have with other organisations, companies or groups?
- Do you compliment each other? (i.e. reduce risk)
- Flexibility?
- Significance? (Formal, informal?)
- Who with?
- Uni/ Industry/ Public Sector?
- Drivers?

5. Are there any events outside of your organisation that have an affect upon the services and technologies that you sell?
- Political
- Economical
- Social
- Technological analysis

6. How does your organisational set-up help you or otherwise?
- Sustainability? Ongoing after public-funding finishes.
- Issues of demand management (i.e. of state-aid equipment)

7. People
- Management structure?
- Staff engagement?
- What drives them? (strategy?)
- Managed or afforded flexibility (pros and cons)
- Project champions (or change agents?)

8. Can you describe a recent successful application of your micro technology?
- Was this process formally managed? Yes/No?
  - Milestones?
  - Stakeholders? Roles & activities
  - Benefit of hindsight?
  - Key activities enabling success?
  - Create customer value?
  - Competitors? Knowledge?

9. Can you give an example where the application of your technology (or expertise) was unsuccessful? Perhaps think about the sector in general?
  - Any elements of success & failure?
  - Why?
  - Contributory activities?
  - Were any particular groups or people involved?

10a. Technologically ahead of non-publicly-funded companies?

11a. Do you think that publicly-funded initiatives such as [nanotechnology centres] help industry to exploit emerging technologies?

12. Your view on the measures that the TSB use to assess your centre? How appropriate are they?

Interview-development-v8-my-script

Peter Dorrington, Cardiff Business School

‘Open questions’ are those where respondents are asked a question and can reply however they wish. In the main, the questions in this study’s template guide were designed to be deliberately open, in order to gain a deeper insight from the expert being interviewed, rather than try and force them down the path of closed questioning (i.e. ‘yes/no’ answers to pre-ordained questions). This helped to overcome the issue of interviewer bias. One of the major advantages of open questions is that the interviewee often expands upon the questions asked and gives additional information that may not have been considered when creating the interview template. Further advantages of open questioning are outlined by Bryman and Bell (2003, p.156), which further justified my decision to use open questions:

a) Respondents were not forced to answer in the same terms as those foisted on them by the closed questions:
b) The questions did not suggest certain kinds of answer to respondents. Therefore, respondents’ levels of knowledge and understanding could be ascertained. The salience of issues for respondents could also be explored:
c) They proved useful for exploring new areas (such as the nascent MNT field).

However, as with all methods, there are potential disadvantages to using open-ended questioning. They are time-consuming for data collection and analysis; interviewees are likely to talk for longer than they would if asked closed questions. Answers are transcribed (for robust data collection) which is immensely time consuming, and then require ‘coding’. ‘For each open question entails reading through answers, deriving themes that can be employed to form the basis for codes, and then going through the answers again so that the answers can be coded for entry into a computer spreadsheet [or programme]’ (Bryman and Bell, 2003, p.157). Interviewing coupled with open questioning requires greater effort from respondents. Moreover, access needs to be elicited, which is difficult when not all respondents are willing to meet with a researcher to discuss their business. These difficulties aside, I still considered these obstacles worth overcoming in order to gain deep and rich data for my study.

The initial interview template was trialled with a number of ‘friendly’ interviewees, and feedback from my supervisors. Actually running through an interview with the template enabled important decisions to be made. For example, the introduction slides used needed some refining (e.g. the removal of academic jargon), when introducing the research to the participants. The time allocated was tested to see if it was sufficient, and altered where necessary[4]. The template was then redesigned for field use. The pilot interview template can be seen in Appendix 5b, along with the final in Figure 5.2. The final template was redesigned more in the form of questions and prompts. This was to make the template easier to refer to and keep the interview more fluid, allowing for a more natural conversation to ensue.

The expert interviews were based around a number of sensitising constructs relating to the research questions for this PhD study. These constructs provided a way of ensuring that the data gathered linked to existing literature, whilst also ensuring a focus for the data being gathered. Sensitising constructs were used in order to code the data (i.e. transcripts) resulting from the interviews.

These constructs were adapted from the previously mentioned Minnesota Innovation Research Programme (MIRP).

The following sections provide further information to this research programme pertinent to the research methodology for this study. An introduction to the theoretical constructs introduced from this research is provided. The way in which they have been utilised for this research study is then explained.

5.5.6 Introduction to the Minnesota Innovation Research Programme (MIRP)

Large scale research programmes such as the Minnesota Innovation Research Programme (MIRP) were embarked on to investigate the complexity of innovation processes. When considering suitable research strategies for this study, the MIRP was considered for a number of reasons.

Firstly, as it is one of the major academic innovation research programmes in recent years, it was a natural starting point to appreciate how data can be collected to understand how organisations produce innovative products and services.

Secondly, the MIRP research programme was designed to be flexible and cover a wide range of organisations developing a diverse array of products and services.

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[4] The issue of time is highly important when those being interviewed are senior members of the organisation being researched. Access to many of the interviewees was on the understanding that the interview would not exceed a certain duration (typically an hour, although most participants usually provided more time once a rapport had been established).

Examples include studies of technological developments (e.g. cochlear implants); administrative innovations (e.g. public policy innovations); and studies of the adoption of innovations. Methods from this programme have been transferred to the investigation of the MNT government intervention.

5.5.7 Background to MIRP

The MIRP research programme was created to develop a process theory that explains innovation development (Van de Ven and Poole, 1990). The researchers wanted to carry out a longitudinal research programme which took into account the temporal order and sequence of steps that take place when an innovative idea makes the transition to a concrete reality. They refer to theory building for producing '*fundamental laws of innovating useful for explaining how a broad class of processes, sequences, and performance conditions unfold along the innovation journey. A process theory may also identify certain paths more likely to be effective under certain developmental conditions*' (Van de Ven and Poole, 1990, p.313). They collected a common core of empirical data by using a consistent framework across a range of innovation study groups. In total, 14 studies were carried out, with different research teams. The teams comprised 34 people (15 faculty and 19 doctoral students) from eight different academic departments and five schools in Minnesota, making it a considerable piece of research work in the area of innovation. Their work increased awareness of the need to investigate a wider range of characteristics of the innovation process, rather than being preoccupied with stage models, and generalisation.

5.5.8 The MIRP framework

Poole *et al.* (2000) describe the definition of innovation used in the MIRP study as follows:

> 'the process of innovation.. [is] defined as the development of new *ideas* by *people* who engage in *transactions* with others within a changing environmental *context* and who change their behaviours based on the *outcomes* of their actions' (Poole *et al.* 2000, p.100).

This definition establishes the importance of a number of constructs which when investigated allow for a deeper understanding of the complex innovation process. The focus on ideas leading to outcomes is still a priority, however the range of variables around this are also now considered. In terms of the MIRP programme, outcomes were the result of studying a 'wide variety of product, process, and administrative innovations from concept to implementation or termination' (Poole *et al.* 2000, p.108). They were also selected 'because they constitute the central factors of concern to manage in directing innovations' (Van de Ven, Angle and Poole, 2000, p.9).

These constructs are; *ideas*, *people*, *transactions* (referred to as collaborations in this PhD), *context* and *outcomes*.

The original descriptions from Van de Ven and Poole (2000) are shown in table 5.5.

Table 5.6 – Original Constructs used in the Minnesota Innovation Research Programme (Source: Adapted from Van de Ven and Poole, 2000)

Construct	**Description**
Ideas	A coding of the substantive ideas… that innovation group members use to describe the context of their innovation at a given point in time.
People	A coding of the people/ groups involved in an activity, the roles and activities they perform at a given pointing time, and how they formulate problems and make decisions
Transactions* [collaborations]	The informal and formal relationships among innovation group members, other firms, and groups involved in the innovation effort.
Context/ environmental	A coding of the exogenous events outside of the innovation unit in the larger organization and industry/ community that are perceived by innovation group members to affect the innovation.
Outcomes	A coding of success criteria and ratings by innovation participants of how well the innovation is progressing and accomplishing their expectations of effectiveness at a given point in time.

*Note: this later became 'collaborations' to make a distinction from MIRP's method of capturing and recording each individual transaction. The term collaboration is used to emphasise the more macro view of transactions observed in this thesis between the MNT network actors.

In summary, the adapted constructs from MIRP provide this research with peer-reviewed, credible methods for gathering and ordering data from the government intervention. However, it is the interactive process perspective that will allow analysis of this data and the link between agency and structure to be made.

5.5.9 Coding and use of Research Constructs

The literature review for this study covered a range of different areas and brought to the surface a number of important concepts to help in understanding and describing the identified MNT government intervention. Van de Ven *et al.* (2000), describe these as *research constructs*. The use of such research constructs are seen as a way of guiding the data gathering and analysis for this study. '*The development of research constructs involves an iterative process of developing initial conceptual categories, observations, and progressive redefinition and refinement of categories*' (Van de Ven *et al.* (2000, p.68).

5.5.10 Method for Selecting Research Constructs

A staged approach was followed in order to develop the final sensitising constructs within which this research would be framed. Interview templates were created around these constructs to ensure that data was collected in accordance with the major focus of this research. In addition, these constructs acted as the key categories with which to code interview transcripts and analyse data. Tracey *et al.* (2004) provided an example of how qualitative data were grouped into 1st order themes (constructs), then refined further into 2nd order themes, and finally, to a number of aggregated theoretical dimensions. I followed a staged approach also, where the 1st order themes were adopted from an initial literature review. These consisted of: *ideas*, *people*, *transactions* and *context*, which were adopted from the MIRP Programme introduced in the literature chapters. In addition to these, I selected *purpose, process* and *people*, which were discussed a number of times in the relevant literature.

The pilot interviews were then carried out and transcripts created, from which the 2nd order codes were created. These codes were generated by re-reading the transcripts and generating a list of codes using an inductive process. 48 codes were generated from this process, which can be seen in table 5.7. These codes were then printed out, and aligned with the aforementioned constructs selected from the literature. A retroductive approach then followed, where I matched up the inductive codes with the literature codes in order to move to the 3rd stage of coding development. This was carried out using 'post-it' notes, coloured pens and a large piece of paper. Figure 5.3 displays photographs showing evidence of this process, along with an electronic version in Figure 5.4.

Table 5.7 – List of Codes Generated from Inductive Analysis of Pilot Case Interview Transcripts

Code generated	**Comments recorded as part of the inductive coding process**
COLLABORATION	
Collaboration – SIGNIFICANCE	How does collaboration help UK industry? What is its significance?
Collaboration – UNIVERSITY	Collaboration with a university
Collaboration with INDUSTRY DRIVER	What was the driver for this interaction (or was it forced? e.g. requirements for a grant)
Collaboration with PUBLIC SECTOR	Comments on whether new technologies developed within public-sector funded research organisations affect industry.
Collaboration with UNIVERSITY DRIVER	What was the driver for this interaction?
Collaboration with INDUSTRY	Any collaboration with an industrial company?
COMMERCIALISATION IN INDUSTRY	
Commercialisation in Industry ACTORS	
Commercialisation in Industry BARRIERS	
Commercialisation in Industry DRIVERS	
Commercialisation in Industry RISK	e.g. Pilot 2: the risk of entering the Chinese market
COMERCIALISATION IN UNI	
Commercialisation in Nano's ACTORS	Drivers/ barriers for actors
Commercialisation in Nano's BARRIERS	e.g. no VC funding/ IP issues/ NDAs etc. are barriers. e.g. for Pilot 2 NDAs prevent them selling some machines/technologies.
Commercialisation in Nano's DRIVERS	
COMMERCIALISATION IN UNIVERSITY	Understanding the realities of commercialisation in universities
Commercialisation in Uni's ACTORS	Drivers/ barriers for actors in universities
Commercialisation in Uni's BARRIERS	Barriers to commercialisation in universities
Commercialisation in Uni's DRIVERS	Drivers for commercialisation in universities (e.g. to get funding to carry on 'me-too' work.. no interest in commercial gains)
INFERENTIAL CODES	
CAUSAL LINK	Iniital causal links observed (use 'sets/ nvivo features for this')
PATTERN	Initial patterns observed
THEME	Emerging themes – need to sub-code

Code generated	**Comments recorded as part of the inductive coding process**
INNOVATION MANAGEMENT	Coding to innovation management in..
Innovation Management – INNOVATION TYPES	Types.. use of typology for new product introductions, i.e. 'new to world', 'incremental' etc. (this could easily be captured in the summary table for each piece of research)
Innovation Management – PROCESSES	Themes relating to IM processes (does this duplicate previous 'themes' code?)
Innovation Management – FLEXIBILITY	Relates to flexibility given to those developing the new technologies (i.e. are people 'free to go off and invent?') linked to context & people.
Innovation Management – IDEA GENERATION	Links to MIRP's 'idea' concept. Any idea generating sessions? / workshops?
Innovation Management – RETROSPECTIVE	A retrospective view of the innovation management process. Is there anything that would be done differently in future? [too vague - remove]
Innovation Management – ROLES	reference to any role/ responsibility changes. Are there any product champions?
Innovation Management – **SUCCESS MEASURES**	What is success? What are the characteristics of success? [include project ex's]
Innovation Management – **FAILURE MEASURES**	What is failure? … and characteristics? [include project ex's]
MARKET ORIENTATION	Where are their markets? background….position in pecking order/ value chain.
Market BRAND	Is the company well-known? [put in info. table]
Market COMPETITION	Codes to competition etc. who are their rivals?
Market CUSTOMERS (Need and Frequency)	Why do they buy the product (need) and freqency of purchase.
Market PRODUCTS	Their products/ technologies
Market CURRENT STRATEGY	Do they have a strategy? Where do they want to go? what is their philosophy? What is their pricing structure plan?..
Market FUTURE STRATEGY	
QUERIES	
Queries – PUZZLES	Are these needed?
Queries – SURPRISES	
SITUATION ANALYSIS	A case report could be created for this
Situation CULTURE	Culture in the organisation (attitudes etc.)
Situation ENVIRONMENTAL	Issues relating to the external environment: to political, to economic, to social, to technological.. [PEST analysis]
Situation FINANCIALS	Financial analysis: comparison with competitors, industry
Situation STRUCTURE	Overall structure.. hierarchical/ flexible; lines of responsibility; lines of authority; issues of communication flow etc.

Figure 5.3 – Paper Development of Research Constructs

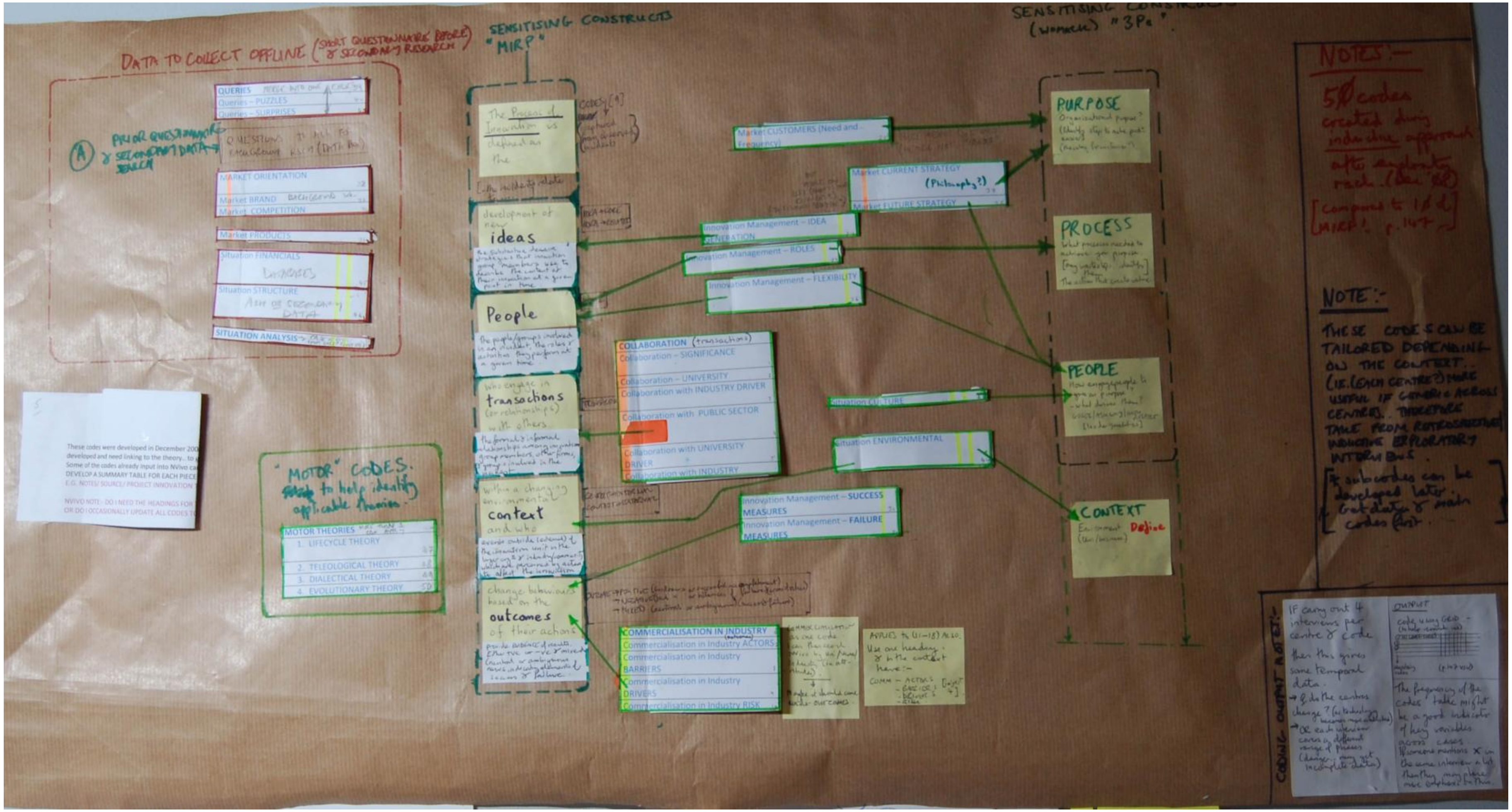
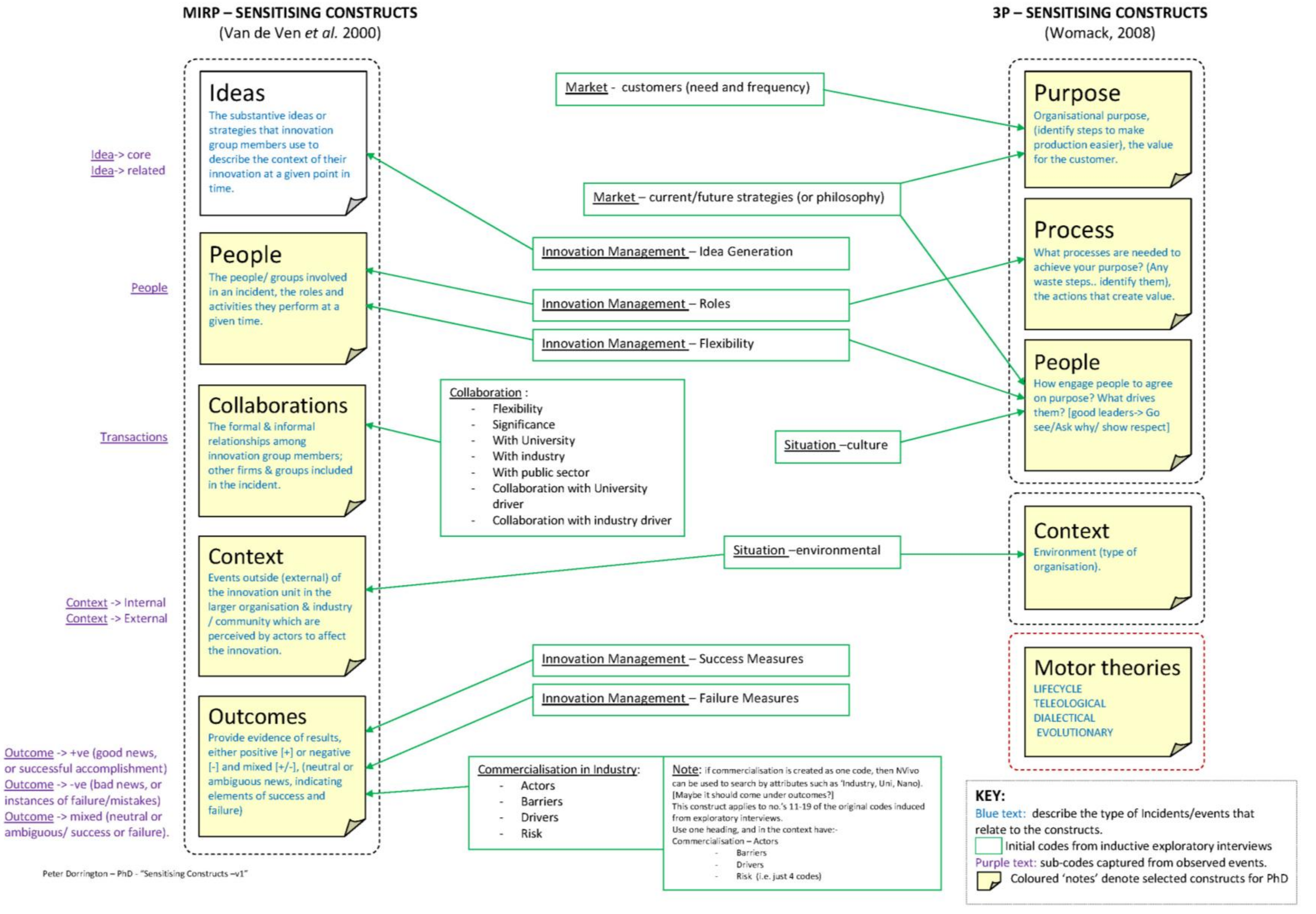


Figure 5.4 – Electronic Development of Research Constructs



This process enabled the construction of categories or themes with which the research questions could be answered (Morse, 2008). These were termed ‘sensitising constructs’. The selected sensitising constructs were: *purpose, process, people, collaborations, context*, and *outcomes*. They are described further in Table 5.6 below.

The constructs selected (i.e. codes) in Table 5.8 therefore, guided the analysis, rather than constrained it. While these constructs were likely to change as the study evolved, they provided however, a way to describe the complex nature of government interventions. For example, the generation of sub-codes was likely to follow as some quite subtle differences between cases needed to be catered for.

Table 5.8 – Sensitising Constructs chosen for this Study.

Sensitising Construct	Interpretation for this PhD study
Purpose	Organisational purpose, the value for the customer. **a) Generic Nanocentre purpose** (the interviewee’s understanding of the overall purpose of nanocentres) **b) Individual Nanocentre Purpose** (issues relating to the purpose of an individual centre) **c) Perceived Government purpose & measures** -> interviewee’s perceptions of the Government view. Note: this category includes the perception of *success* and *failure* within an organisation.
Process	What processes are needed to achieve your purpose? The actions that create value. Flexibility of role. Product Lifecycle method? Stage-gate?
People	How to engage people to agree on purpose? What drives them? The people/ groups involved in an incident, the roles and activities they perform at a given time. **a) Academics (researchers)** **b) Industrialists (experience levels)**
Collaborations	The formal & informal relationships among innovation group members; other firms & groups included in the incident.
Context	Environment (type of organisation, structure). The circumstances that form the setting for an event. External events outside of the innovation department (in larger organisation and industry) that interviewees perceive to affect the innovation process.
Outcomes	Provide evidence of results, either positive [+] or negative [-] and mixed [+/-], (neutral or ambiguous news, indicating elements of success and failure). Understanding of success and failure.

Outcomes in terms of positive or negative differed between research informants within the pilot studies; consequently, participants in the main cases were also asked to provide positive and negative empirical examples (i.e. successful or failed enterprises). The rationale here was that the researcher wanted to see if the differing stances were linked to the organisational environment and other aspects of the constructs under investigation.

5.5.11 Data Management

Due to the selected semi-structured interviewing process, a massive amount of narrative data were produced in the form of transcripts. This data needed to be analysed in a manageable way. The use of sensitising constructs and coding in order to link data to existing literature and the research questions of interest in this study, was outlined above. Once the interviews were transcribed, the electronic files were manually read and portions coded to those shown in Table 5.6. With the use of a generic qualitative software programme, the coded files could then be analysed for themes and data analysis (The programme used was 'NVivo Version 8', produced by QSR International. Alternative programmes could also have been used). While such software was useful, large meta-tables of the data were also produced in order to aid thematic analysis and pattern-matching[5]. A large table (or 'meta-table'), was created for comparison of the data from actors within each MNT centre. This meta-table was printed out on an A1 sheet of paper, which was referred to for data analysis and reduction purposes. This table was developed following advice on data reduction from Miles and Huberman (1994, p.10). Due to the large amount of data and size of this Table, it has been reproduced in the Appendix 5d.

Analysis of the non-MNT centre based actors was carried out by comparing coded sections of transcripts with the other actors - i.e. all extracts from transcripts coded as 'purpose' were printed and compared together. This process allowed for a large data set to be managed and used in a valid and credible way for qualitative analysis.

5.6 Research Ethics

Due to the emerging nature of the technologies being developed within each MNT Centre, and the sensitive nature of some of the questions being asked, an appropriate confidentiality agreement was signed prior to conducting interviews. Bryman and Bell (2003), describe the purpose of confidentiality agreements as *'[defining] what type of*

[5] In reality, the use of large meta-tables created in spreadsheets was essential to pattern-matching and thematic analysis of data. These were printed on A1 sheets and joined together so that analysis across all of the cases was possible.

information you can have access to and to establish what information you are and are not able to disclose about the company' (p.51). As such, I ensured that due process was carefully followed in terms of gaining ethical approval and carrying out the research for this study (see Appendix 5e and 5f). With every interview, the five minute introduction slides were presented, which incorporated issues around confidentiality. Interviewees were then asked to sign the individual consent form to show that they agreed with the interview conditions (see Appendix 5g).

Any information that I gathered during my research was subject to a moratorium period, participant anonymity and the use of a number of pseudonyms. There was also due cognisance given to the fact that '*ethical issues frequently arise from a clash between personal and professional interests*' (Punch, 1986, p.53). This suggests that a keen researcher must be careful not to overstep the boundaries of what can and cannot be published. Consideration of whether the use of pseudonyms was sufficient for some companies was also important. Hofstede's (1984) research into a well-known organisation did its best to hide its identity; however, due to the company's size and uniqueness, the data would have had to be distorted to fully hide it. For the organisations and individuals discussed within this PhD study, pseudonyms were used. Furthermore, any details concerning location and specific metrics - such as total grants – were rendered anonymous as much as possible. Where Reports have been used that contained potentially identifying data, then this data were redacted (i.e. blacked out in order to remove it).

5.7 Reflections on Data Access

In any research study, access to data is of paramount concern. A large amount of primary data was collected for this study using the methodology outlined in this present Chapter[6]. Those responsible for each MNT Centre (generally the CEOs, Directors or Managers) were targeted for contact. A series of introductory e-mails

[6]28 interviews were analysed across the MNT organisational field. This comprised multiple hours of data and many miles of travelling. Although not included in the Thesis, further interviews and workshops were carried out as part of the research journey. These included: one MNT centre customer, one MNT centre supplier (and its competitor), and a interview at IMEC (an equivalent government intervention in Leuven, showing an MNT intervention focused on one large centre rather than the distributed model in the UK. Although not used due to space limitation, these were important in further developing my ideas for this research study.

were sent to each Centre, followed by telephone calls to discuss my research and potential access to each centre.

In total, nine Centres were kind enough to allow some access for my research study, with one of these (Mercury) providing full access. In some cases, a determined effort was required in order to obtain interview access. I was keen to interview one particular Centre - referred to as 'Liber' in later Chapters – as a number of interviewees had described it as a particularly successful example of an MNT centre. Initial contact with MNT Centre 'Liber' included an e-mail and a follow-up telephone call with the Centre’s Director; however, access was denied. The Director apparently did not see the need for my research. However, a subsequent conversation he had with another interviewee from the main case Mercury gave this Director more confidence in my research, and an interview was finally arranged.

Another example is that of the Centre Bacchus which was part of a larger global organisation. Due to the size of the organisation and limited information of the MNT Centre it hosted in the public domain, it was very difficult to locate the particular Centre Director. Eventually, he was contacted and access was secured. In other cases, it was just a case of a telephone conversation to build a rapport with the participant. In cases where some participants were less positive about being interviewed due to their time commitments, I was able to arrange some telephone interviews. These followed exactly the same template and process as the face-to-face interviews. The only disadvantage was that I was unable to visit the actual sites and gain a bit more contextual background information.

At the start of data collection process, a meeting with the NDGB responsible for the MNT centres was arranged. This meeting was to discuss potential access to the centres in the MNT field with the MNT Operations Director – Mr Morgan.

At the start of data collection process, a meeting with the NDGB responsible for the MNT centres was arranged. This meeting was to discuss potential access to the centres in the MNT field with the MNT Operations Director – Mr Morgan. He was able to provide basic data such as the financial value of grants allocated to each centre, along with a number of useful contacts. However, he explained that the TSB was unable to provide more detailed data for each centre in relation to the audits that they carry out via the management consultants ‘Ernst and Young’. Mr Morgan explained that this was due to the restrictions written into the contract between each MNT centre and the TSB (and formerly in the original DTI contracts). In addition to correspondence with Mr Morgan, a senior auditor from Ernst and Young was also interviewed (Mr. Rubik).

Through the cross-case analysis, I was made aware of a report that the TSB had recently commissioned from a third-party MNT consultancy. The objective of this report to benchmark the UK MNT centres with world class facilities, and was referred to as the Yole Report (named after ‘Yole Développement’, the consultancy commissioned for the report). Having been made aware of this report I asked Mr Morgan for a copy of this data. Unfortunately, I was informed that all aspects of this report were considered commercial-in-confidence. I therefore contacted the centres individually and the auditors for secondary data. However, I had limited success in this. Therefore I put in a Freedom of Information (FoI) request in to the Information Commissioner's Office (ICO) in order to obtain this report. The outcome from this process was a copy of a couple of pages of the Yole report, but no commercially confidential data.

On mature reflection, my own perseverance and commitment as well as the suitability of my research approach, allowed me to eventually gain enough rich data to investigate the research questions in sufficient depth for this PhD study. As such the failure to obtain the Yole report had no impact on this research.

5.8 Chapter Summary

This Chapter began by discussing my ontological and epistemological views in relation to this research project, with clarification of my research perspective as being that of an interpretivist.

The research gaps and research questions were introduced along with the research design. The way in which the research venue was established - following an interpretive approach – through a number of pilot organisations first, sets the scene for a description of this study’s research venue.

Research strategies and situations have been critiqued in order to answer the research questions, along with a discussion of how they relate to the interpretivist research position adopted.

In summary, this study adopted a case study research strategy which gathered data using a semi-structured interview approach. The influence that the MIRP framework had on the data gathering process and coding of research constructs is described in detail. The development and use of codes enabled the linking of data to the extant literature along with cross-case analysis.

The next chapter provides detailed background information for the research venue; that is, the ‘UK MNT government intervention’.

Chapter 6 - Presentation of Organisational Field: the UK Micro- and Nano- Technology Network

6.1 Background to the Department of Trade and Industry's Micro- and Nano- Technology (MNT) Manufacturing Initiative

In June 2001 an advisory group on nanotechnology applications was appointed to establish a UK nanotechnology strategy. This advisory group was called the UK Advisory Group on Nanotechnology Applications, and was chaired by Dr John Taylor. The resulting DTI report – known as the 'Taylor Report' - began with a stark warning that '*any industry that fails to investigate the potential of nanotechnology, and to put in place its own strategy for dealing with it, is putting its business at risk*' (DTI, 2002, p.6). The evidence behind the report came from the advisory group, consisting of both academic and industry experts; chaired by the Director General of the Research Councils.

The strategy put forward was: '*specifically designed to support the academic research and industrial capability necessary to allow the UK to benefit from the commercial potential of nanotechnology*' (House of Commons, 2003, p.3).

Furthermore, the advisory group were '*..charged with reviewing the current state of nanotechnology applications in industry in the UK, and proposing, if appropriate, actions to accelerate and support increased industrial investment in nanotechnology exploitation* (DTI, 2002a, p.7).

The Taylor report also describes how nanotechnology is a disruptive technology:

> '*A distinctive feature of genuinely disruptive technologies is that they can have very many different applications. This is particularly true for nanotechnology. For example, nanoparticles technology alone can influence a large number of products and services (see Figure 1 below). Disruptive technologies are those that displace older technologies and enable radically new generations of existing products and processes to take over. For example, optical data storage, through such devices as compact disks, has changed the face of home entertainment and computing; digital cameras based on solid-state memory and imaging technologies are replacing photographic film*' (DTI, 2002a, p.17).

A month after the Taylor report, the government released its science strategy 'Investing in Innovation' (DTI, 2002b). In this report there was further attention drawn to the importance of nanotechnology to the economy.

In July 2003, one year after the Taylor report, Lord Sainsbury of Turville (the then Minister for Science and Innovation), announced 'a package of funding for nanotechnology worth £90 million over six years, along with the establishment of a Micro and Nanotechnology (MNT) Network to direct the spending of this money' (House of Commons, 2003, p.5). This funding was split into £50M for applied research and £40M for capital projects. The latter concerning the creation of a regionally dispersed network of MNT facilities.

6.1.1 The MNT Network

The purpose of the MNT Network is described as follows:

> '*The UK Micro and Nanotechnology (MNT) Network has been established by the DTI and the 12 Regional Development Agencies, and Devolved Administrations working together, to provide a market-orientated focus for the facilities, people and organisations engaged in Micro and Nanotechnologies in the UK. The Network is helping to lower entry barriers and drive the widespread market development and exploitation of these technologies – building a prosperous, world-class MNT sector in the UK*' (DTI, 2005).

A number of important benefits – which are directly linked to the creation of the MNT capital facilities programme - were to result from this network:

- Improved access to the critical mass of world-class knowledge and facilities in the UK and overseas.
- Facilitation of a complete supply-chain and better use of facilities, to take 'blue-skies research' through to high-volume and high-value-added manufacture by UK companies.
- Identifying the demand for, and working with stakeholders to provide the new facilities needed to build the UK MNT capability.
- Encouraging a coordinated approach to applied research programmes and business support.

(DTI, 2005)

6.1.2 Raison d'être of the Micro- and Nano- Technology Centres

The MNT Capital Facilities Programme describes the second part of the UK MNT manufacturing initiative, where £40 million was allocated to provide UK businesses with a new network of MNT facilities. The presentation by the MNT Network Director at the MNT manufacturing initiative information day (Clare, 2004), broke this figure down into £30 million for capital costs, and £10 million for running costs. He emphasised that in order to be successful 'additional industry money' was required to succeed.

The MNT Capital Facilities Programme is referred to as the 'UK MNT government intervention' or the 'MNT intervention' throughout this thesis. The 24 facilities created are referred to as MNT centres.

This MNT network was created to provide UK businesses with access to the latest range of MNT services and capabilities within key sectors; thus enabling UK industry to gain a 'step-up' the ladder, without the initial burden of investing in expensive capital equipment and facilities.

In 2007 the DTI became the Department for Business, Enterprise & Regulatory Reform (DBERR). As part of this metamorphosis, the Technology Strategy Board (TSB) was formed. The TSB was established in July of this year as a non-departmental Government body (NDGB). The aim of this new NDGB was to promote '*business investment in, and use of science, technology and innovation in the UK, with the aim of increasing economic growth and improving quality of life*'. The TSB are now responsible for overseeing the MNT Programme.

Table 6.1 provides extracts from public domain sources which outline the intended purpose of the MNT government intervention.

Table 6.1 – Extracts from the Original MNT and Current MNT Public Domain Sources Describing the Purpose of the MNT Programme.

Extract from original MNT network website, April 2004. In the context of the UK MNT Network, Capital Projects are defined as projects which implement: 'Industry/market facing UK based facilities which provide cost-effective **open access** for organisations and individuals to capabilities, processes and associated knowledge leading to marketable products, and services'. The objective of Capital Projects fund is to invest in the development of UK technology infrastructure to: • Accelerate the commercialisation of MNT for the wider benefit of the UK economy; • Provide open access on equitable commercial terms to Microsystems and Nano Technology platforms and associated knowledge. • Develop a critical mass of capability whilst avoiding duplication of provision. The intention of these Capital Projects Calls is thus to deliver open-access MNT facilities of national significance. (DTI, 2004)
Extract from TSB website, 2009 'The aspiration was for a distributed network of world-class manufacturing facilities with focus on strategic areas for the UK. The facilities were structured to cover the continuum from micro to nano scale. The facilities generally built on existing University or business expertise, and were established with the intention of becoming, in time, self financing (with the exception of the nano-medicine and metrology fields, where a measure of ongoing public support is likely to be required)' (TSB, 2009).

In real terms the figure of £90 million was achieved through a joint investment of the UK Government with the UK Regional Development Agencies (RDAs) and the Devolved Administrations (DAs) of Wales and Scotland. One third of this money was allocated to collaborative R&D MNT projects, with two-thirds meeting the cost of capital infrastructure.

6.1.3 How were the Host Organisations Selected?

The TSB describes how ‘50 projects were approved through targeted competitions run in 2004-5’ (TSB, 2009).

The centres were selected via a number of calls for proposals which were organised using an electronic submission process on the MNT Network website. As such little hard copy information is hard to come by. Fortunately, use of an internet archive search engine (Internet Archive, 2010) has allowed original documentation (albeit electronic), to be recovered. Appendix 6a contains print-outs of this secondary data, which outlines the assessment criteria used for selecting suitable recipients of funding for this capital facilities programme.

Tender applications for each call were then reviewed by an expert selection committee, and decisions made. Following the initial call there was an additional - more selective – call, addressing technology areas that were not additionally addressed

The majority of projects were funded for five years, with a number funded for two or three years. A number of projects will have reached completion in 2009, with the more recent ones continuing until 2012.

24 Micro and Nanotechnology Centres were created (MNT centres), a list of which can be seen in table 6.2. Note that ‘SafeNano I’ and ‘SafeNano II’ are counted by the TSB as one centre.

Table 6.2 – List of Micro- and Nano- Technology Centres

MNT Centre (anonymised)	**Local Context**	**Government Grant**	**Start**	**Finish**
Centre A	Existing SME	£2m or under	2005	2010
Centre B	Existing SME	£4m or under	2006	2011
Liber	Science Park	£2m or under	2005	2010
Centre C	University	£2m or under	2007	2012
Centre D	Existing SME	£1m or under	2006	2009
Lucretia	University	£3m or under	2005	2010
Centre E	University	£1m or under	2006	2009
Centre F	University	£1m or under	2006	2009
Centre G	University	£5m or under	2006	2011
Ulysses	University Science Park	£2m or under	2005	2010
Centre H	University	£4m or under	2005	2010
Concordia	Science Park	£4m or under	2005	2010
Rhea	Existing SME	£2m or under	2006	2011
Centre I	Existing SME	£3m or under	2006	2011
Cardia	R&D Centre	£6m or under	2006	2011
Centre J	Spin-out from Government body	£1m or under	2006	2011
Centre K	University	£5m or under	2006	2011
Mercury	University	£3m or under	2005	2010
Centre L	University	£2m or under	2005	2010
Centre M	University	£1m or under	2006	2009
Bacchus	Global Organisation	£1m or under	2006	2009
Centre N	Science Park	£2m	2007	2009
SafeNano I	Independent centre	£1m or under	2006	2009
SafeNano II	Independent centre	£1m or under	2008	2012
Centre Q	Science Park	£6m or under	2008	2013

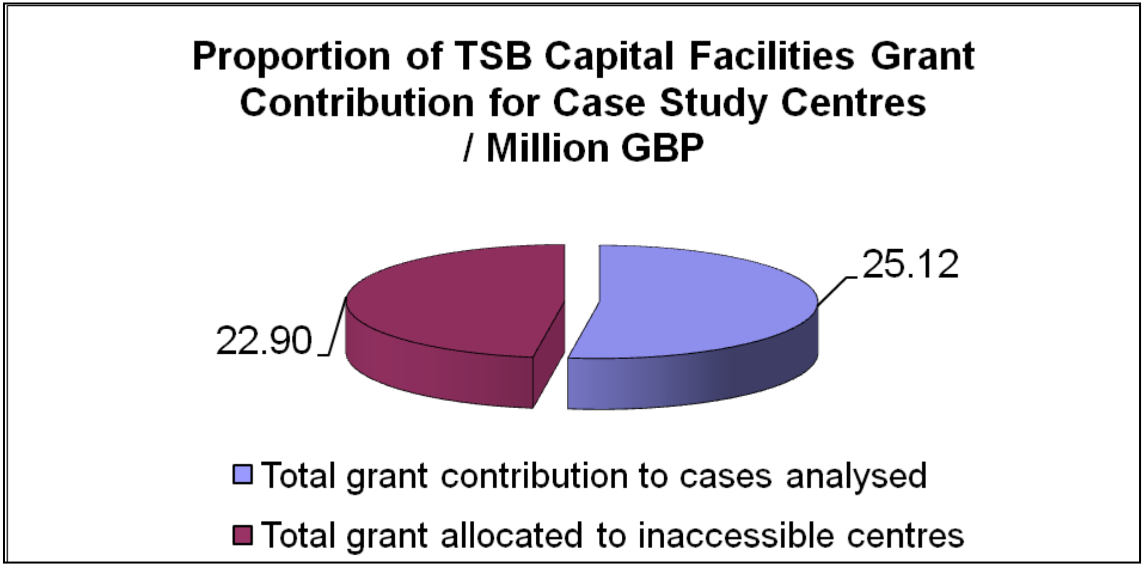
The MNT centres were established in a range of organisational settings. These settings consist of the following:

- New businesses
- Cost-centres within an existing business
- Centres within a University School
- Centres within a Science Park

These are outlined in Table 6.2, which lists the micro- and nano- technology centres. Pseudonyms are used for issues of confidentiality, and grant figures are put into ranges.

Graph 6.1 below shows the total amount of grant contributions received for those cases investigated within this PhD study. As the chart shows this sample represents over half of the government spend for the Capital Facilities Programme (i.e. MNT Centres).

Figure 6.1 – Proportion of Capital Facilities Grant Contributions in relation to the sample Case Centres accessed



A timeline for the creation of the MNT centres was produced by the researcher, and is shown in figure 6.2. This was validated by a number of key stakeholders within the MNT network. Figure 6.2 was attached to an email and validation and comment was asked for from a number of those involved at the planning stage of the government intervention. These included the architect of the centres, and many of the RDA actors.

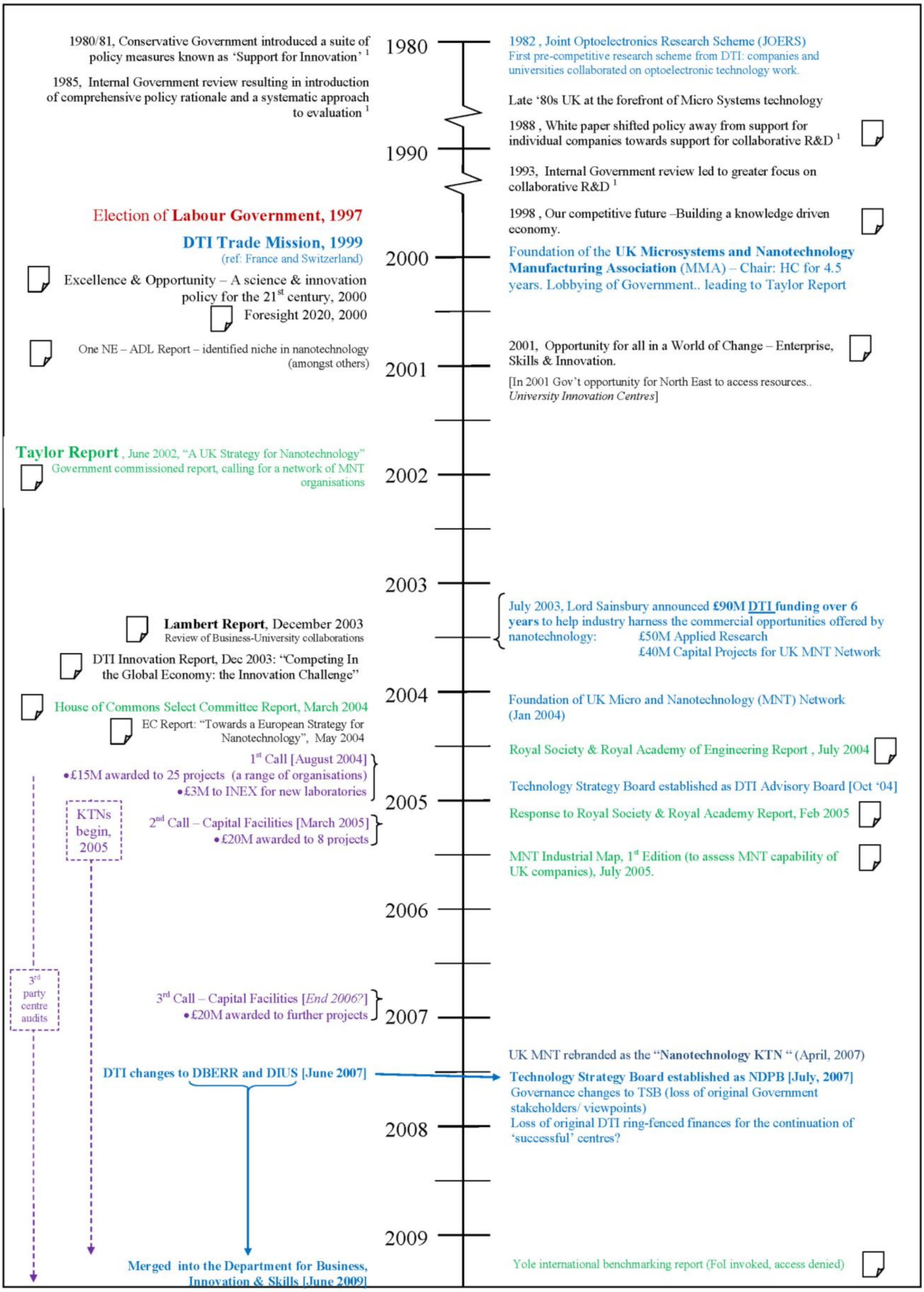


Figure 6.2 – Timeline for the Creation of the Micro- and Nano- Technology (MNT) Manufacturing Initiative.

6.2 Nature of Funding for the UK Micro- and Nano- Technology Network

The funding of MNT centres involved a large amount of financial support for the purchasing of expensive capital equipment. This introduces rules pertaining to state aid and the EC treaty (BIS, 2009), for reasons outlined in the following:

> '*One of the fundamental objectives of the EC Treaty is to create a single market in which competition is not distorted. If Member States were free to give subsidies, grants or other forms of favourable financial treatment to individual companies (or "undertakings"), there would be an inevitable risk that those "undertakings" would have an unfair advantage over competitors who do not benefit from State Aid… To eliminate this risk, the EC Treaty in principle prohibits subsidies which distort competition and affect trade between Member States in the EU. State aid is permitted only in limited circumstances where it can be shown to be necessary to achieve certain specified Community objectives*' (BIS, 2009).

The TSB reinforce the need to avoid distorting the market with the MNT intervention programme. The current MNT Operations Director describes how they [government interveners] '..really only want to step in where help is needed - for example in this case there was deemed to be a <u>prohibitively high cost of entry for the technologies</u>. We can't meet the whole cost of running the centres through public funds, typically we fund around 50%. The centres must charge a commercial rate for their services and have to provide open-access (i.e. they can't use the equipment just for their own research or production ends). One of the reasons why we measure the centres as commercial enterprise is that we want technology to be proactively marketed - the idea is to stimulate wider commercial exploitation of the technology across UK businesses' (emphasis added).

The 'commercial' nature of the centres makes them very interesting for research, as they have been set-up in a range of organisational contexts, some of which are not typically geared towards generating commercial revenue, e.g. university research departments. Also there is a paradox of wanting to adhere to state aid regulations, but also wanting the centres to generate revenue; in a number of centres investigated, this has been the cause of some confusion. For example, if a centre is set in a large global organisation, then it the mechanisms for becoming 'open access' to external companies may prove problematic (e.g. shown in Bacchus later). At the other end of the spectrum, a university might find that it is trying to be commercially focused, when traditionally the university institution is driven by knowledge acquisition and sharing.

6.3 Fit with Organisational Theory

It is important to clearly state the understanding of 'organisational field' and 'field of action' in relation to the studied intervention programme (i.e. the UK MNT Network). The MNT government intervention is understood as the 'organisational field' for this research study, where intervention refers to the policy initiative. The outcome of this intervention is understood in terms of the actors involved in this programme. The conception of the MNT government intervention as a field has been discussed already in the *bridging literature* chapter, and is further discussed in the *cross-case comparison* chapter.

6.4 Data Accessed within the MNT Government Intervention

A number of diagrams have been created to display the MNT centres accessed as part of this research. These can be seen in appendix 6b, and 6c. They are as follows:

- Appendix 6b - A graphical overview of the MNT centres accessed, along with the cross-field actors.

- Appendix 6c - A graphical overview of the MNT centres accessed, along with the cross-field actors, <u>and</u> with details of the data collected.

Further details of individual actors and centres are provided in the *main case study* chapter and *cross-case study* chapter. The reason for this is to make it easier for readers to refer back to this important data in the most relevant and accessible location.

6.5 Chapter Summary

This chapter has provided detailed background information for the UK MNT government intervention. It has been included to enable a deeper understanding of the initial intentions of the MNT government intervention, and the historical events which have had an influence on its development.

The next chapter presents the findings from the major MNT case study.

Chapter 7 – Major Case Study

The previous chapter introduced the micro- and nano- technology government intervention. The creation of this MNT field and its associated actors constitute the object of inquiry for this PhD. The creation of the MNT field is understood in terms of a field of action with resulting outcomes from this government intervention understood in terms of the actions of actors within it. Following on from the conceptualisation of the MNT network as a field, the major case study is now introduced and findings reported.

7.1 Introduction to Major Case Study

The researcher was successful in gaining in-depth access to one of the MNT centres. The rationale for this access was to gain a more detailed understanding of a centre within its local context, and that of the extra local context of the MNT field. This organisation has been renamed '*Mercury*' for issues of confidentiality. Actors throughout the organization with a range of organizational responsibilities and roles were interviewed for primary data collection. Reference to secondary source documents were used to triangulate the perceptions of interviewed actors.

During the data collection all constructs were used according to the original research design and data gathering strategy. However, it became clear during the analysis of data for the major case study that the data coded to the 'process' construct did not provide as rich an insight as originally forecast; where 'rich' refers to an understanding of any formalised processes followed by an organisation developing emerging technologies. The interpretivist approach adopted by the author was particularly interested in understanding innovation as a function of particular contexts, motivations and people coming together at a point in time. As such, the author excluded the discussion of results gathered from this construct as they offered little interpretive value to the research questions asked.

7.2 Background to the Major Case Study: 'Mercury'

The following list provides an overview of both primary and secondary data collected within this case study.

- 11 interviews:
    - 5 interviews with day-to-day staff
    - 1 interview with Vice Chancellor of the University
    - 1 interview with the Regional Development Agency manger for the region
    - 1 interview with a former steering group member
    - 1 interview with supplier (of in-kind/ matched kit)
- 2 customers
- Mercury's project application proposal document (written June, 2004)
- Details of the TSB 'traffic-light' monitoring measurement system
- Extracts from recent benchmarking report

Mercury is hosted by a large UK university's engineering department. The university - referred to as Venus - submitted its tender to the DTI MNT network capital facilities project in June 2004. The university department already offered a range of micro manufacturing and precision manufacturing technologies and expertise. They saw a gap in the micro engineering field for a number of bridging technologies to be developed for the benefit of the wider UK economy. This submission was in answer to the second call from the DTI for funded projects (see appendix 6a for the tender application process).

The project application proposal document can be seen in the transcript addendum, it has been redacted to protect sensitive and identifiable information. This will be referred to as the 'proposal document' throughout this chapter. The intended aim for 'Mercury' is clearly outlined in the proposal document as follows:

> '*The **aim of the project is to establish unique facilities** at Venus university to provide an industry facing micro-manufacture service in the UK for closing the existing 'machining gap' between the 'classical' micro machining technologies and semiconductor .. technologies..*' (proposal document, p.1).

The proposed project objectives extracted from the project application form are reproduced in the following list, in general terms:

1. to improve the access to the existing micro-manufacture facilities and expertise at the [university] and integrate this major resource into the MNT Network;
2. to create and integrate a critical mass of batch fabrication expertise in the UK that will underpin the development of microtechnologies beyond the ones that rely on conventional .. tools and material.
3. to provide specialist training alongside these unique facilities to address the existing shortage of people experienced and skilled in “classical” micro-machining and micro-fabrication technologies…
4. .. be a catalyst for the growth of a UK industry in precision…microcomponents
5. ..will stimulate the development of a supply chain, become an attractor for investors and start-up companies thus providing valued high-technology jobs in [this region and the UK].
6. Furthermore in terms of collaboration, a strong indication that existing university links with European projects would benefit the MNT centre tendered for.

The project was approved, and began in 2005. The grant period agreed was for five years, ending in 2010. The grant allocated was 2.59 Million GBP, to be matched with industry support and sales. In-kind support came from a number of suppliers – two manufacturing companies; one clean room company and one marketing company. Of these one of the manufacturing suppliers was also interviewed (at the beginning of the project). This supplier will be referred to as *Luna* within this thesis.

Throughout the life of the project there was contestation between the professional academic actors leading the centre, the business manager and the state actors (i.e. TSB actors). This contestation was directly linked to the perceived purpose of the centre by different actor groups, which is discussed in detail in this chapter. A clear indicator of this was when Mercury was made into a limited company, in order for the University to demonstrate to the TSB that grant funding and activities would be ‘ring-fenced’ solely for Mercury. In reality, this appeared to be more of a paper exercise, and interviewees described how Mercury remained in the same context, and continued in the same vein.

In an attempt to redress the balance between key actor groups, a number of individuals were recruited to help. Firstly, in August 2008, Professor Stephenson asked Dr Newton to join the steering group, recognising that having someone with both academic and business experience might be beneficial. He was also someone with a reputation of not shying from making hard decisions, which may be indicative of the period at which things began to become contested between the actor groups in Mercury. Dr Newton remained on the steering group until March 2009, when he had to step down due to other work commitments. During this time, he described how the issue of running such a 'commercial' centre in a university was extremely difficult. He emphasised the difficulties of having to follow strict state-aid rules whilst still generating revenue.

Mercury continued to have problems and the TSB made it a condition of continued funding, that an external CEO would be appointed. Shortly after October 2008 this happened, and Dr Plunkett was recruited. This coincided with the only time at which Mercury received an 'amber' rating for its progress (refer to figure 7.2) – at all other times the progress was red-flagged, which means 'critical' or 'off-track'.

In an unprecedented move, the TSB withdrew funding from the centre eight months before the project's completion date. Such drastic action would have been a last resort, because it is unlikely to reflect well on both Venus university and the government bodies involved. Angle (2000) describes how:

> '*as situations deteriorate gradually, people adapt to the changes and are not motivated to act… In the extreme, innovative response to threats or opportunities become forestalled until situations change to a fairly drastic extent*' (Angle, 2000, p.149).

This may be an illustration of what happened for those actors within Mercury.

The Technology Strategy Board MNT operations manager did make a point of saying that the TSB doesn't run the centre, only sponsor them. This action seems to suggest a stronger influence than just sponsoring a centre. However, at the time of writing, the centre has continued to trade. The business manager of Mercury explained how this was '*in order to run-out the contracts.. [but]..once [they are] out of the system, that's it*'.

For the difficulties mentioned above, Mercury provides an ideal case demonstrating failure of a government intervention. Often case studies only account for successful cases or organisations – Mercury therefore provides a chance to add further understanding of why interventions *can* and *do* fail.

7.2.1 Organization Structure

The structure of Mercury is shown in Figure 7.1 below:

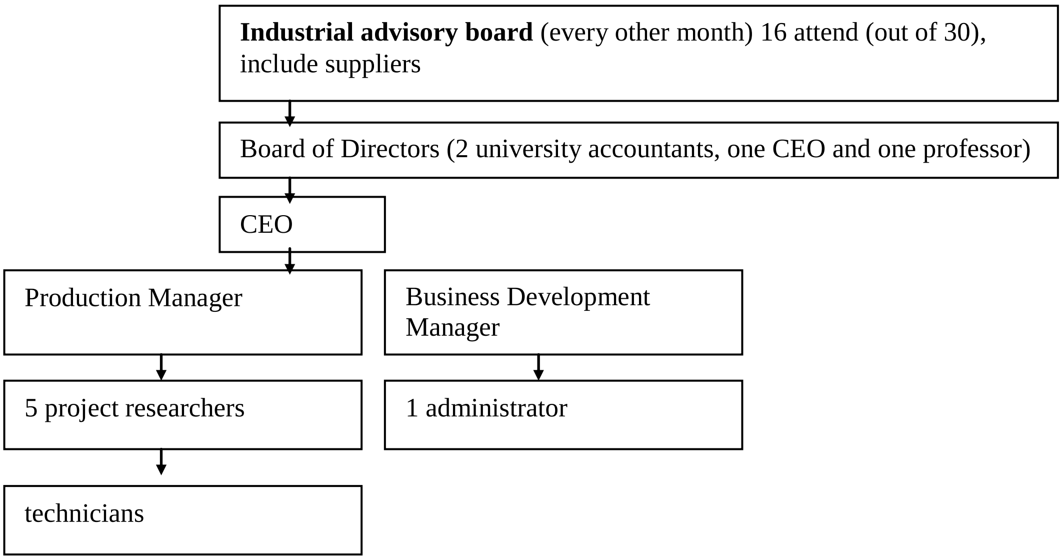


Figure 7.1 – Organisational Structure of Mercury.

Figure 7.1 illustrates the organisational structure as provided by descriptions from interviewees within Mercury. A simple hierarchical approach appears to have been adopted. The Business Development Manager - Dr. Rubin - explained that originally a flat line management approach was tried out for Mercury:

> '*we tried the flat line, when the project was launched everyone was project manager and it was up to them to liaise with the customers and get the deadlines but that didn't work as [it] wasn't structured enough… because a lot of what we do is ..[multiple processes] so things weren't being distributed correctly.. so they brought me in to try and control that*' (Dr. Rubin).

The proposal describes how an industrial advisory board was formed to include users and technology providers to direct the management of Mercury '*as a service that is industry facing and at the same time sufficiently flexible to adapt quickly to changing demands and commercial priorities through:*

- *Concentrating on areas that will have the highest impact on the commercialisation of MST (Micro Systems Technologies) products;*
- *Positioning it correctly in relation to other MNT providers in the UK;*
- *Engaging in long term partnerships with the client companies;*
- *Adopting best practice methods and processes in its core operation;*
- *Ensuring the marketing strategy is targeted upon priority industrial clusters and groups*'.

(Source: Proposal document, 2004, p.13, see transcript addendum, not in library copy)

Considering the nature of the university as an institution: i.e. an institution for education, learning and discovery, the suggestion that one could be *industry facing* and *flexible* is questionable. Universities are large organisations with associated bureaucratic structures, the concept of flexibility does not easily fit. However, in terms of a research centre within a university, there is the potential that a flexible unit could be created as part of the larger organisation (university); this is analogous to the ideas presented in the EDT literature (e.g. Loutfy and Belkhir, 2001). If this is the case then the potential for Mercury to be flexible and commercially focused by detaching itself from the wider university bureaucracy was certainly possible. The issue and challenge of the organising principles of key actors within such an environment and the resulting issues are investigated in this thesis.

Table 7.1 displays the pseudonyms of actors within Mercury, along with their associated roles.

The industrial advisory board consists of actors from funding bodies, large private industries, and Mercury's suppliers. Newton explains how there are typically 16 members at each meeting, out of a total membership of 30.

> '*In a normal environment they would probably come along, review the past performance, look at the last 6 months figures, look at the last 6 months activity, and say things like ' have you thought about looking at this business centre', 'do you need this many people?', 'why aren't you going to more exhibitions?'.. the 'steering' stuff. The critical friends stuff*' (Dr Plunkett).

For confidentiality reasons it was not possible for me to obtain a list of the members of the advisory board. In terms of funding bodies there will have been actors from the TSB on the board, and the suppliers mentioned earlier, including Luna.

Initial plans were for the board to meet quarterly. Newton – a former steering group member - adds that the steering group '*does have a lot of industrialists on it..[and is] quite a powerful group*'. He believes it to be an advantage to Mercury, considering the '*sheer amount of talent ..on the group*'. The business development manager acted as secretary to the advisory board.

The CEO, Dr. Plunkett, is the direct link to the board of directors from the steering committee. Alongside Plunkett, there are 3 additional actors; firstly the head of the university finance department; secondly one of his colleagues in finance; and thirdly

Professor Stephenson (lead professor and board member). For a short period Dr. Newton was also a director on this board. Three out of the four actors are university staff and one is an industrialist. The role of the board of directors is for '*prudence and ensuring the business is run in an effective manner*'. The board meets once a month for three hours. According to Dr. Newton, it is '*probably not as joined up as it should be*'.

The board covers standard items; trading profit or loss balance accounts; minutes of the steering group meetings; compliance with all the public sector regulations; and generally due diligence. Dr. Newton describes how there is '*a lot of bureaucracy involved in a company like this one, an awful lot more than you would in a typical [..] business*'.

Below the board of directors sits the production manager and the business development manager. The production manager manages a number of researchers/ technicians, and the business development manager attends to marketing of Mercury.

7.2.2 Products and Services Offered by Mercury

Mercury as a centre offers a number of unique services. In order to protect the anonymity of the centre, the services and products it offers are described in general terms only. Needless to say the centre is developing emerging technologies; unlike a number of other centres, Mercury is focused on the micro scale of technology development. In some cases applications can include nanoscale machining, but in general the focus is in the micro range. One micrometer (or micron) is one-millionth of a meter, i.e. 1×10^{-6} m. In physical terms we can think of the diameter of a human hair as being 17 times larger than that of a micron.

In terms of technology and services offered, Mercury was established to focus on reducing the gap between traditional micro machining technologies and semiconductor patterning technologies for non-silicon materials. Microbridge services include the development of technologies using mechanical or energy-assisted processes (e.g. laser, and electrode discharge machining - EDM). In terms of products, Mercury produce master/tool-making, as well as small scale production. They work on a range of metals and polymers.

The application of Mercury's technologies cover a wide range of sectors; including: life sciences (e.g. health); automotive; consumer products (e.g. mobile phone components); micro components (e.g. small gears) and micro-fluidics (e.g. micro pumps).

7.3 Primary Data

The most influential decision-makers within Mercury were interviewed face-to-face, and the data transcribed and coded for analysis. Table 7.1 lists those interviewed along with a description of their roles or association with Mercury. Only senior members of staff were interviewed to increase the quality (in terms of experience) of the data gathered. Six out of the ten have PhDs and one is working towards his. The other 3 are in very senior management positions. Mr Strauss – the related regional development agency manager - was involved in the selection of the MNT centres as part of the original selection panel, making his views particularly insightful. Dr. Dickson has strong business experience and academic experience; his position as Venus university's vice chancellor provides him with a wide range of experience.

Table 7.1 – Stakeholders Interviewed Concerning the Mercury case

Pseudonym	**Role/ link to Mercury**	**Background** /business, academic or both	**Interview duration(s) /mins [no. of interviews]**
Dr Plunkett	CEO	Business	77 [1]
Dr Dickson	Uni VC & steering group	Both	30 [1]
Prof. Stephenson	Prof. 1 & board member	Academic	62 [1]
Prof. Pascal	Prof. 2	Academic	50 [1]
Dr. Rubin	Business development manager	Business	106 [3]
Mr Anderson	Production manager	Academic	70 [1]
Dr Newton	Former steering group member	Both	66 [1]
Mr Strauss	RDA manager/ managed link between development agency and Mercury	State	30 [1]
Mr Morgan	TSB MNT operations director/ discussed details of Mercury	Business	100 [2]
Mr Rubik	Management consultant for TSB/ discussed details of	Business	130 [2]

Pseudonym	Role/ link to Mercury	Background /business, academic or both	Interview duration(s) /mins [no. of interviews]
	Mercury		

7.3.1 Type of Actor

Each interviewee has been categorised according to their background and bias toward industry/ business or academia or the public sector (i.e. state). 'P*eople exhibit a strong bias toward incorporating incoming information in such a way as to make sense against the backdrop of personal schema or scripts'* (Stotland and Canon 1972, in Angle, 2000, p.148). The bridging literature chapter put forward a way of conceiving the MNT government intervention through an institutional theory lens. This includes understanding the organising principles of actors borrowing theorisation from institutional logics. For the presentation of the findings from this main case study, the notion of collective identities will be used in order to help us understand the actions of the different types of field actors. That is, those who were driven by publications and research fitted into the 'professional academic' category; those driven by reaching financial targets, commercialising technologies and making profit were deemed 'industrial/ business'. In some – rarer - cases individuals had been exposed to both environments, and have been labelled as 'both' or 'hybrid'.

Mr Anderson was an interesting case, as he felt he had more of a business leaning. However, the examples of his actions and the needs which drive him, suggested a more natural fit with the academic category. Another interesting example is that of Drs. Plunkett and Rubin. They have both worked predominantly in industry, however both gained PhDs whilst in industry so have some academic experience. Nonetheless, their background was clearly that of an industrial/ business nature.

The following chapter builds a deeper conceptualisation of the MNT field using concepts from institutional theory as required to understand the increased number of field actors introduced. The initial higher level conceptualisation of actor types and collective identities has been used in the first instance for understanding the main case study, Mercury.

Of the interviewees, the most guarded during the interviews were Mr Morgan and Mr Rubik. Notably these were the two actors responsible for overseeing and auditing the centres, respectively. Coupled with the difficulty of gaining access to information from the TSB, and my resulting FoI request, this may be indicative of the policy of prevention of negative information being released, and an attempt at presenting any available information in a positive frame (Dornblaser *et al*., 2000).

7.4 Secondary Data for Mercury

7.4.1 Measurement of Centres

Quarterly audits of the MNT centres are carried out by three monitoring officers. The monitoring officers are management consultants from Ernst & Young. An outline of the criteria which they use to assess each centre is provided in Appendix 5h. The source of this criteria list was an example review document for one centre. Unfortunately permission for including this full document was not granted. This list is purely to highlight the hard business measures favoured by the third-party consultants.

At the end of each quarterly review a 9-box model is generated to provide a summary of that review. This 9-box model grades the MNT centres in terms of project risk and project performance. The grading system is referred to by many actors as the 'traffic light' system, owing to the use of red/ amber/ green colours displaying progress. Mr Morgan – MNT operations director, TSB - describes how allocating a red means revenue down; green means on track (e.g. plans in place beyond the grant period); and amber suggesting somewhere in the middle.

Following the assigned grades a number of resulting actions are implemented. Appendix 7a shows an extract from one of the TSB's 'micro- and nano- technology centres communications' documents which provides evidence of this process. Figure 7.2 displays the 9-box model used by the monitors, Appendix 7a displays the resulting actions from the monitoring review process considering a range of scenarios.

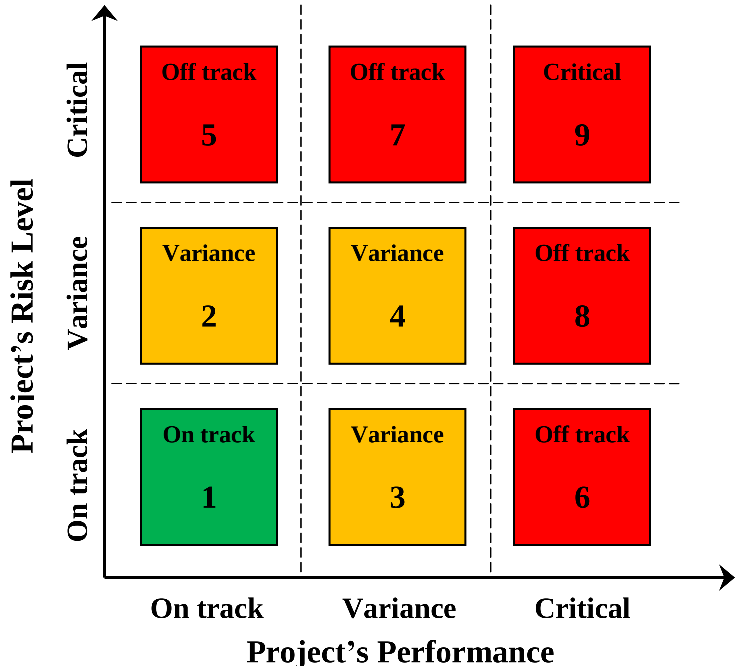


Figure 7.2 – 9-box Traffic Light Performance Measures used by the TSB

7.4.2 Mercury's 'Traffic Light' Performance

Due to the 'commercial in confidence' nature of the quarterly E&Y reports created for the TSB, access was withheld. However, by understanding the 9-box traffic light system, inferences can be made of Mercury's progress from descriptions given by the actors. The following statements show how Mercury had a turbulent time at best when it came to E&Ys interpretation of their progress:

- 'Mercury on the very 1st measurement was red. It stayed red for 22 months … for the vast bulk of the measured time or monitored time it was red. It has very recently gone amber' (Dr. Rubin, 10th October 2008).

- 9 months later, Rubin describes how Mercury are back to 'red' status on the traffic light system. Why? He describes Professor Stephenson as the major problem. Rubin is having to sub-contract a lot of the work out to another centre or others in the host-university department because he explains how his staff can't do the job on the machines. 'They are researchers' (21st July 2009). This helps to confirm the organizational features that inform how technologies are adopted and used.
- '…we have a commercial centre at [our] university, Dr. Jones [another University professor] has [another] commercial centre [in our university], neither of us produces commercial outcome yet he gets a green flag and we are always red or

amber… [because] …they [the TSB/monitors] are happy with the research happening there and the way that it is progressing, [there is] a huge amount of politics' (Mr Anderson).

- 'There's a 3x3 matrix, that if you fall into certain parts of that matrix you obviously look bad. So yeh they'd love you to commercialise the stuff that you're doing.. [but] your covenants surrounding that technology mean that you can't necessarily do it' (Dr. Newton).

The last two examples agree with the findings of Dornblaser *et al.* (2000) who describe the difficulties associated with measuring outcomes from the innovation processes observed in the MIRP programme:

> '*…when innovation implementation efforts went awry… [and results were disappointing], the external resource controllers tended to focus on input criteria …if outcome assessments of resource controllers and innovation managers did not converge, the assessments that mattered in determining the fate of an innovation were those of the resource controllers… observations on the relative power of evaluators were observed in both positive (continuation) and negative (termination) directions on innovation development*' (p.202)

The state actors in the TSB can be seen as analogous to the external resource controllers in the above, and the innovation managers seen as MNT Centre Directors. If so, then the above examples fit with the idea that as long as a centre pleases the state actors (i.e. TSB) then positive actions are bestowed upon the centres (i.e. little intervention); and conversely, if the centre does not fit the criteria of the state, then negative actions follow. This may also be a result of a breakdown of communication between the state and MNT centre actors, in terms of what the limits/ measurement criteria are for the centres.

7.4.3 Proposed Financials for Mercury

The project proposal states that 'Mercury is cash neutral over the 5-year life of the project and the service becomes self-sustainable, after five years of operation at the moderate level of sales included' (proposal document, p.7).

Table 7.2 displays the breakdown of the forecast income and expenditure at the time the proposal document was submitted; the data has been presented as a percentage of total funding to preserve anonymity.

The total funding over the duration of the project was estimated at 9.65 Million GBP; the total cash outflow was estimated as 9.61 Million GBP. A breakdown of figures making up the total income and outcome have been outlined.

Table 7.2 - Proposed Income and Expenditure as on Mercury's Project Application Proposal in 2004 (Source: adapted from proposal document, 2004, p.7)

Organization	**Contribution /** % of total funding	**Notes**
Income		
DTI MNT Programme	31.5	Actual figure awarded was £2.59 Million
Other public sector:		
RDA grant	7.8	'Mercury service is important component of the [local RDA] MNT strategic plan'. (p.9, Mercury application form)
University department existing projects	5.2	Projects with synergies to Mercury
University	10.0	From a parallel manufacturing project grant
Private sector:		
4 Development partners,	22.9	Company A, company 'Luna' (cash-back contributions covering 50% of the system development and maintenance costs). Clean room company contribution and marketing company providing in-kind support to the technology awareness of the transfer programme.
Companies for collaborative projects	7.0	The companies that will be involved in feasibility studies and pilot projects.. to develop new applications and demonstrators for Mercury (p.9, Mercury application form). In-kind and cash over the 5 years.
University department commercial income	15.3	From existing commercial services operated by the department.
Total project funding ('000s)	100 %	
Expenditure		
Equipment	46.4	
Staff	36.2	Operations manager and project engineers
Running costs	8.4	Includes consumables
Maintenance	5.7	
Marketing	3.2	
Total cash outflow ('000s)	100 %	

A number of additional interviews were carried out with suppliers and customers of Mercury. Details of these are listed in appendix 7b. For the purpose of this chapter the internal stakeholders are concentrated on.

7.5 Semi-Structured Interview Data for Mercury

The background detail of the major case study Mercury has now been introduced in order to provide important details before analysing the main interview data. This section will now introduce the findings from the interview data. This data is used to discuss the findings from Mercury in terms of the adapted MIRP constructs. These constructs provide a way of grouping the data so that it can be presented and initial analysis can begin. The constructs are: purpose, people, collaborations, context, outcomes and process.

7.5.1 Purpose – Relating to the MNT Government Intervention

When understanding and explaining the *purpose* of the MNT government intervention extracts from a number of key sources need to be considered. The original purpose of the intervention from the view of the government body who introduced it (DTI), and TSB were sourced. In addition, extracts from the project application proposal document are referred to along with interviewee quotes and actions to understand the extra local and local (in terms of Mercury) views of purpose.

The DTI's purpose statement outlines the MNT government intervention as projects which implement:

> '*Industry/market facing UK based facilities which provide cost-effective* ***open access*** *for organisations and individuals to capabilities, processes and associated knowledge leading to marketable products, and services*' (DTI, 2004).

Furthermore the objective of the Capital Projects was to:

> '*invest in the development of UK technology infrastructure to: accelerate the commercialisation of MNT for the wider benefit of the UK economy; provide open access on equitable commercial terms to Microsystems and Nano Technology platforms and associated knowledge; develop a critical mass of capability whilst avoiding duplication of provision…The intention of these Capital Projects Calls is thus to deliver open-access MNT facilities of national significance*' (DTI, 2004).

Further public domain documents referring to the purpose of the MNT government intervention were searched for. However, surprisingly few papers/ hard-copy documents appear to be in circulation for the centres since the TSB took over. Fortunately archive websites enabled access to more background data during the DTI period. These were coupled with interviews from the architect of the centres (Prof. Hertz). The view from the TSB for the purpose of the intervention was outlined on their website in the following statement:

> '*The aspiration was for a distributed network of world-class manufacturing facilities with focus on strategic areas for the UK. The facilities were structured to cover the continuum from micro to nano scale. The facilities generally built on existing University or business expertise, and were established with the intention of becoming, in time, self financing (with the exception of the nano-medicine and metrology fields, where a measure of ongoing public support is likely to be required)*' (TSB, 2009).

This definition appears less authoritative than the DTI definition and comes across as vague. Due to the important position that the TSB hold over auditing and management of the centres, it was felt that further clarification for their view on the overall purpose of the centres should be investigated. As such Mr Morgan – the Technology Strategy Board's MNT operations director – was interviewed. He explained that the understanding of purpose of the MNT government intervention from the TSB's perspective is as follows: '*to address a market failure' and create 'open-access facilities, <u>selling</u> to the wider community*'. Mr Morgan described open-access:

> '*in the broadest sense, i.e. to enable access to the technology for the wider community. Open-access does not mean 'for free' and not for people to just walk in and use the equipment. The phrase 'available for wider community' has gone into the offer letters*' (Mr Morgan).

Extracts from Mercury's tender document relating to the purpose of the intervention align with the DTI and TSB understanding of developing an MNT infrastructure:

> '*The establishment of such capabilities will help companies, especially SMEs, overcome some of the problems associated with the cost of entry into micro-manufacturing technologies…The proposed [MNT centres]…will enable companies to test a range of state-of-the-art or new technologies for micro-machining and micro-fabrication in feasibility studies and pilot projects with the [MNT centres], and in this way to gain experience and confidence in their application in the context of their specific application requirements*' (p.3, Mercury proposal document).

This description also refers to the open-access nature of the centres, introducing the advantage to SMEs.

All three sources infer the development of MNT technologies to give UK companies global advantage. A UK white paper further emphasises the need for this intervention:

> '*These benefits and opportunities will give UK manufacturing companies a competitive advantage in existing and new markets for micro- and nano-technology-based products…Without such dedicated facilities as those proposed in this project, British companies will not be able to gain a significant presence in markets that will be vitally important to manufacturing competitiveness in the next 10-20 years*' (DTI, 2002).

The actors interviewed within Mercury are in general agreement with the purpose of the MNT government intervention; i.e. a catalyst for MNT growth; to de-risk entry into MNTs for UK businesses; and to create open-access facilities for companies. Interpretations differed when the actors came to describe the purpose of their individual centre. The local situation they were in – i.e. a university-based MNT centre – clearly affected their interpretation.

The majority accepted that the TSB required the centre to be revenue-generating, even when this contradicted their own aspirations/ motivations. This can be understood further using the concept of embedded agency - and more specifically - *competing logics* described using institutional theory. Holm asks '*How can actors change institutions if their actions, intentions, and rationality are all conditioned by the very institution they wish to change?*' (Holm, 1995, p.398).

In relation to the university institution in which Mercury is situated, this asks the question of how traditional academic actors can alter their MNT centre to be revenue-generating, and open-access. The local context of Mercury (i.e. a University venue) is an essential part of how its actors understand the purpose of the centre. Actors such as Prof. Stephenson, Mr Anderson and Prof. Pascal proved good examples of how traditional academic actors can become institutionalised by the institution within which they exist. All three emphasised the importance of developing high-risk technologies more in line with academic research as opposed to commercial applications, even though a number of times they each acknowledged the requirements from the TSB to be commercially-focused. The local environment of Mercury (i.e. university, with key decision-makers who are traditional academics) is in clear contestation with the extra-local environment the DTI and TSB have tried to create with this intervention.

The state actors thought they could overcome the problems associated with the university as a local environment for this MNT centre by parachuting in a number of external business actors. They believed that this would increase the commercial focus of the centre; interviews with the business actors certainly showed a strong business steer. However, the ingrained institutional logics of a large, slow moving bureaucratic university system (Lambert, 2003) appeared only to result in further competing logics. Competing logics are not necessarily a barrier to change, but in the case of Mercury it would appear that '*..competing logics can facilitate resistance to institutional change*' (Greenwood *et al*,. 2010, p117). Relevant mechanisms for this resistance include *environmental selection*, *pressures*, and *political contestation*, the latter being particularly prevalent.

Dr. Plunkett described his understanding of the idea behind the MNT centres:

> '*The concept from the TSB.. and <u>I do believe that they have changed their view during the process</u>. But my very clear understanding is that the TSB is there to fund what I call 'close to market research'. So that means research that has real commercial drive, or 'commercial pull'. And that given 4 years and a significant amount of money, at the end of that you should have a spin-out business that should be able to stand on its own*' (Dr. Plunkett, CEO, emphasis added).

He adds that '*research establishments ..have expertise .. 'scientific rigour'..that they can bring to a process, which a company could ..or would never do. But they don't have commercial flair*' (Dr. Plunkett). He purports that by putting research establishments together with companies, then research can be directed in a commercial and timely fashion. He does add *'..again that tends not to be the view of academics*'. Dr Plunkett illustrates an understanding of both academic and industrial institutions with his views. The use of research establishments for the scientific rigour they bring to the innovation process in collusion with industrial organisations is a very logical rationale for collaboration (as illustrated by the establishment of the MNT government intervention). The data from Mercury suggests that some actors have an ability to empathise with different institutional logics. In the case of Dr. Plunkett he was awarded an academic PhD, so has an understanding of the workings of academia, however has spent his career in business.

Dr. Rubin was very clear about the purpose of the centres, stating '*it's all about commercialisation and <u>not</u> about doing academic research*'. He further explained that normal companies (i.e. small companies, unable to develop the capabilities themselves) would not be able to survive the set-up costs of such new technologies, and that is why the funding is there.

> '*All 23 were issued with guidelines to set up the MNT Capital facilities. And it's all about setting up independently very much [with] a commercial drive in mind... so it talks about commercialisation of the technology, it doesn't talk about researching the technology, it talks about commercialising the technology. And these are the <u>guidelines</u> issued by the DTI and the MNT network*' (Dr. Rubin, emphasis added).

Conversely, Professor Stephenson stated that the '*commercial [purpose] was not emphasised, and then it became the main [purpose]*'. He described how the DTI wanted to build on existing infrastructure to create capability for nano technology in the UK. He states that the DTI wanted them to '*come up with new technologies to extend your offerings*'. He also emphasised the need to go for risky technologies, rather than something close to market. The issue with adopting technology close to the market is that the government is potentially subsidising competitors for companies already established in the market.

Mr Strauss was part of the original DTI selection panel for the MNT centres. He describes how the panel were '*looking at applications which were giving UK PLC a wide MNT provision for UK industry*' (Mr Strauss). He describes how this included being 'open-access' to industry and acting as a commercial business. Strauss says they also had to demonstrate a plan to become self-funding within 3-5 years.

The descriptions so far from Mercury's actors display how confused the purpose of this government intervention becomes with multiple stakeholders in just one MNT centre. Mr Anderson (production manager) portrays this when describing the TSB review process (carried out by external consultants) versus their strategy:

> '*..the review is working. I think that the strategy is different.. and it's one of the biggest frustrations I have, it is very [much an] individual interpretation …within personnel who are auditing you, they have an opinion on something.. or telling you how you should work.. [if you] then go on to the TSB's website .. it's the opposite to what they are doing… the university personnel as well. I can guarantee you, if you interview three of us, three senior managers of Mercury, two of them will have one opinion, one will have the other*' (Mr. Anderson)

Mr Anderson's statement indicates that the actions of the external management consultants reviewing Mercury were misaligned with the description of the MNT government intervention in the public domain, some of which is shown in table 7.3 Comparing Anderson's transcript to the TSB website and table, the confusion is likely to be linked to the financial, 'self-funding' part of the statement. Anderson disagrees with the heavy commercial measure used by the consultants. This ambiguity is further compounded by the commercial auditors who confirm the disconnections between the actors.

Anderson also refers to the different interpretation of purpose taken by his colleagues. The last line perhaps referring to the common views of the two professors versus the business development manager. Mr Anderson explains how this confused purpose causes problems with his role as production manager:

> '*one of my biggest problems I have got as a manager … is getting people to work in it, because it's a grey area and for the life of me I can't understand.. like we are getting audited and we are getting heavy stripped [because] there's no commercial activity…It's the worst thing of the project, forget the pressures of the commercial output, it's this grey area.. you know, it's what do the TSB actually want? Do they convey that to their auditors correctly, because they are independent auditors..*' (Mr Anderson).

Mr Anderson refers to a potential issue of dis-connect in communication between important field actors when he refers to this grey area of how the TSB measure the centres. This confusion was also displayed during interviews with Mr Morgan and Mr Rubik (TSB actors), when both of them described the difficulty they faced when assessing the MNT centres. In an email received on the 11th August 2009, Mr Morgan said the following:

> *'A key question for me (maybe one your research can answer) is how to robustly quantify the effect of the centres on the wider economy? My concern with looking at the financial data collected by the monitoring system is that the return on investment will always appear very low because the boundaries are not being drawn widely enough'* (Mr Morgan, MNT Operations Director, email correspondence, 11th August 2009).

The above discussion along with the extracts in this chapter highlight the significance of the conflicting interpretations of the MNT government intervention purpose. They show that actors have a contested view of the criteria used to measure the centres, such as 'open-access' and 'self-financing'. This notion of conflicting interpretations is an important finding within the MNT field. Elaborations on this across the wider MNT field are presented in the following cross-case analysis chapter.

7.5.2 Purpose – Relating to Mercury

A range of views have emerged concerning the commercial implications for the MNT centres. The nature of each actor's understanding of the purpose relating to Mercury, and how their individual actions play out through this understanding, enable further analysis of the university venue as one of the many venues selected in the MNT network. Extracts from Mercury's proposal document are used to illustrate how the *intended* purpose of the MNT centre aligns or otherwise with the views of individual actors.

7.5.2.1 Intended Purpose

The way in which Mercury's actors described their understanding of their centre's purpose was compared with data extracted from the initial tender document[1]. The most striking observation was the frequency of references to 'commercialisation' and 'industry'; for example, '*The aim of the project is to establish unique facilities at Mercury [in the] University to provide an <u>industry facing</u> micro-manufacture service in the UK…' (p.1, Mercury tender document).* In addition*, 'Within the scope of the Mercury project it is envisaged the <u>commercial usage</u> of these facilities <u>will increase to 80%</u> within the next five years benefiting from synergistic links with the [University's] ongoing R&D programmes*' (p.2). These intentions were clearly published in an official document used to win the funding for Mercury. Somewhere along the timeline of the university being awarded the funding and Mercury evolving, this interpretation appears to have been shifted. Clear evidence for this is given through a number of actions taken by the TSB; firstly they made it a recommendation that funding would only continue with the appointment of an external CEO, with a business background to steer the centre back toward a commercial focus. Coupled with this was their decision that the steering group had to approve any major decisions made for the centre. The normal activity of a steering group is to 'advise' and 'steer', rather than be a decision-making body. Finally,

[1] i.e. the document was coded according to constructs, and data relating to intended purpose was extracted.

the funding was withdrawn from the centre – a major indication that the interpretation of Mercury by its actors differed from those of the state.

The difficulty of Mercury in achieving the purpose required from the perspective of the state actors can be theorised by considering the resulting purpose of the centre, as understood by its actors, and in particular those senior actors who were able to drive their agenda through more forcibly than others. The next section provides details and examples which reinforce this finding.

7.5.2.2 Resulting Purpose

Interviewees did recognise that Mercury was not intended for basic research, and that it was a vehicle for commercially exploiting emerging micro- and nano- technologies; for example:

- '*to transfer processes from the laboratory into industrial applications*' (Mr Anderson, production manager)
- '*Any work that's done is commercial. The commercial work comes first… there is a written agreement*' (Dr. Plunket, CEO)
- '*..in Mercury we're not supposed to have basic research. Tends to be to assist us in the development of processes which can commercialise, because we are not paid to do basic research within that project. [more commercial?] 'Yes, more applied*' (Prof. Pascal)

However, there appeared to be a contradiction for a number of these actors. For example, Mr Anderson talked of industrial application, yet he described one example where he deliberately went against the wishes of the CEO to attend an academic conference, which was unrelated to the day-to-day remit of Mercury.

Professor Pascal, spoke of his experience of managing other programmes developing emerging technologies:

> '*…you know my experience with the rapid prototyping work, which started life very similar, in a similar way to Mercury, it is still not standing on its own feet. You know, it still requires input from local Government and other sources. So I don't think Mercury would, be ..in at least the next 3,4, 5 years, be a standalone company that does not require any subsidy*' (Prof. Pascal).

This contradicted the CEO's view, who when asked about whether the failure of Mercury to become self-sustaining in the funded time was due to the riskiness of emerging technologies, said *'[No] It's to do with management*' (Dr Plunkett). This is one example of the clear difference of thinking between the CEO with a strong history of a business logic versus the professional academic logic. Professor Pascal – although not technically still part of the management of Mercury at the point of interview – was the overall Director of the host department, and had a very strong influence on its direction along with Professor Stephenson. Professor Stephenson was the only actor who strongly asserted his disagreement with the commercial focus on Mercury, saying '*..commercial was not emphasised, and then it became the main [objective]. They [the DTI/TSB] were saying it is open access, it was stated, open access..*'. Being in such an influential position in Mercury, along with his observed autocratic management style (during data gathering visits to Mercury), coupled with a strong, determined personality highlights the impact a senior actor can have on an organisation.

The influential position of Profs Stephenson and Pascal, along with the fact that the majority of staff employed within Mercury had an academic background, and setting within a university all directed Mercury away from the state's purpose for the MNT intervention. The local context of the centre was seen to have an enormous effect on the actors and overall direction of the centre, in this instance.

Of note is that Prof. Stephenson was instrumental in writing the proposal document for Mercury. This fits well with the notion that '*people exhibit a strong bias toward incorporating incoming information in such a way as to make sense against the backdrop of personal schema or scripts*' (Stotland and Canon 1972, in Angle, 2000, p.148). That is, Prof. Stephenson has altered his cognition of the original proposal to suit his own bias, and interests. Another reason for his behaviour may be linked to Dornblaser *et al's* observation that '*in the fear of not obtaining startup capital, innovation managers committed themselves to courses of action and outcome criteria that had low probabilities of being achieved..*' (Dornblaser *et al.* 2000, p.213).

When asked 'did the aforementioned proposal document say there would be a commercial focus?' controversially, Dr. Plunkett replied: '*Oh yes..there was.'* [they didn't follow it up?] '*No. No, it's as raw.. it's as simple as that. They wrote a document, got their money and filed the document*'. This assertion was strongly reinforced by Dr. Rubin: the '*capital facilities [programme] never was a research project.. it always was.. (Mercury).. always was a commercial project. It was 'hijacked' by.. by the* *university people to satisfy their own academic requirements..It never was supposed to be academic*'. The term 'hijacked' refers to the implication from Dr Plunkett that the university actors were awarded funding for a commercially-focused project, yet once awarded the funding directed it toward their own interests and purpose.

It is important to understand that Dr Rubin is coming from a background of working in industrial institutions, however similar to Dr. Plunkett he has experience of studying in academia for a PhD, and has worked within industry projects linked to university research departments before. His comments highlight the antecedents of the project and make a link to the fact that staff working at the centre were hired academics, rather than sought-out business people. As such they have their own research interests (e.g. Mr Anderson working toward a PhD) and in many cases, little commercial experience. This is significant when considering that the review of the NIS literature showed a key them of universities as an important context for systems of innovation as a means of addressing an economic void (for example, Charles, 2006; and Rampersad *et al*., 2010). These results show that actually they may not be the most appropriate to generate innovation for commercial exploitation. The results of Mercury show that professional academics are driven by innovation; Dr Pascal even describes how *'innovation is part of our daily activities* [for a researcher]'. The reason universities are good at innovating and not commercialising could be this lack of business logic as part of the institutional fabric of a university context. Universities have traditionally been established to further knowledge creation and educate people, not generate revenue.

This in mind, the proposal document for Mercury clearly specified that researchers would be employed in the centre. This PhD study therefore raises the question that if universities are championed as important venues for government innovation interventions, then how individual actors (and their organising principles) align with the university venue also need to be considered when developing policy.

Drs Rubin and Plunkett both joined the university department after Mercury had started, having come from industry-focused backgrounds; they no longer work there. Their comments (above) suggest that the proposal document was written purely with the purpose of winning the funding, so that senior academics could create actions fulfilling their own research agenda/objectives.

Prof. Stephenson does suggest that the DTI changed Mercury's objectives part-way through the government intervention programme. Dr. Dickson (the university vice-chancellor) also agreed that the purpose had changed, although not in terms of a shift in commercial focus. In his words:

> '*Well, yes, the purpose.. well certainly on Mercury, the purpose has changed. When it was started originally it was a facility that added to a number of existing facilities, and the offering would have been from all of those facilities together. Whereas in order to satisfy.. I suppose it was DTI initially, and then the TSB, they've had to put a fence around it and say that this project is a standalone project*' (Dr. Dickson, university vice-chancellor).

Rubin describes how the governing bodies '*forced*' the university to take things a '*step further*' and register Mercury as a limited company. This is an example of how the state actors (TSB) forced Mercury to adopt strategies to try and assert a specific viewpoint. As seen in the proposal document, this was not part of the original strategy. The justification for this was a:

> '*lack of delivery on the commercial requirements of the project. It was thought that the best way to make it be more commercial was to have a limited company to run it*' (Dr, Rubin).

Although a number of actors expressed concern that '*the TSB judges us on our commercial outcome[s]… but the technology is so advanced that there is a lot more to it than making money*' (Mr. Anderson). Anderson did add that as the project went on the TSB became more sympathetic to these issues which may explain the one amber rating they did receive.

Plunkett describes how other centres '*set themselves out as a commercial organisation… and .. tended to focus therefore on the technologies that will bring money to the business*'. The inference here being that by focussing on closer-to-market technologies, it is easier to show commercial success (i.e. revenue). Dickson and Stephenson concurred with this view.

Stephenson refers to the clear requirement of the government intervention to develop emerging technologies:

‘*Everybody can come and use this for a cost but [the DTI also ask] for risky equipment which [is] not currently commercially available.. [Furthermore] you can imagine the government subsidis[ing] the purchase [of equipment] and creat[ing] a competitor [to] somebody already established in the market. Immediately people start talking about this and that is why we went with technologies which were not available. But some of the companies did not go for this…you have to go for risky [technologies], not something very close to the market [however] later on it was transferred and moved very close to the market or it is almost the market*’ (Prof. Stephenson).

Plunkett adds:

[on MNT centre Liber] ‘*I think that some of the other centres are just.. they've set themselves out as a commercial organisation. Right, and they've tended to focus therefore on the technologies that will bring money to the business. Whereas Mercury is probably.. well it sits within the [university centre], the [university centre]has got quite a strong research portfolio*’ (Dr. Plunkett).

Stephenson also stresses the concept of ‘open-access’ as a key requirement of the MNT centres.

This and the previous comments allude to the problems linked to institutional norms, i.e. state-aid and government funding. These norms reveal contradictions in rationale.

‘*they [the TSB] want you to be more commercial but it’s difficult when you’re under state-aid regulations… it’s a whole minefield that frustrates everybody.. [the university] aren’t happy with the situation, the TSB certainly aren’t happy with it because they’re not getting what they want as their outputs, and our potential client base are either ignorant of what we can do because we haven't been quite commercial enough in marketing, or we haven't found a means of engaging them that satisfies every partner*’ (Dr. Newton).

Such comments display the inherent difficulties faced by Mercury being based in a non-commercial university and required to act as a business by the funding bodies.

A number of criticisms of the intended purpose of *Mercury* were also voiced:

- Rubin (business development manager) - *Whereas the problem with Mercury has been the fundamental mis-interpretation of what the requirements are. And it's been interpreted – certainly in the first 2 ½ / 3 years as an academic research led rather than a professionally led project*.
- Plunkett (CEO) – ‘*the original business case, business plan was flawed. Flawed fundamentally in two ways: one was unrealistic commercial [ways], commercial*

> *income. The other area in which it was floored was in .. the way in which it interacted within the university.. so it sits within the university and relies upon the university, and somewhere there has to be a working relationship, and that relationship was never clearly defined. And that's really what I've spent the last 6 months trying to do, bring some clarity to both*'.

The vice chancellor went so far as to say that the University would not have created such an organisation by itself: '*we wouldn't have put in money from [the University department] or indeed [the] university for that facility because it wouldn't have been seen as absolutely vital to our academic purpose, <u>nor would it have been seen as a good commercial earner</u>, so Government was really putting in money on the basis, well it might give extra facilities and ability to the UK manufacturing base.. that as I said a few times earlier is going to add value in other parts of the supply chain*' (Dickson, emphasis added).

This section has raised important issues in terms of the interpretations formed by actor groups in relation to the purpose of their MNT centre. Furthermore these understandings are linked to the university context within which their MNT centre is situated. This context brings with it institutional logics that define and shape the actions of the aforementioned groups, and how they cope with the competing logics of running a commercial centre in a research environment have been discussed. The contradictions exhibited by Prof. Stephenson are suggestive of how an individual actor, in a senior influential position, can steer the purpose of a centre according to their own logics and actions.

Furthermore the confusion produced as a result of the DTI transferring the MNT capital facilities programme over to the TSB has been highlighted. Building on the observation about actors and their interpretation of purpose – the next section will examine actors linked to outcomes in terms of success and failure, and the ensuing actions.

7.5.3 People

How the people aspect of an innovation process influences the function/ purpose of Mercury is discussed in this section. What drives them; their roles and individual actions.

One of the main issues (in terms of people) to be addressed by Mercury as outlined in its tender document was that of providing specialist training to staff and industry actors as a whole. The document talks of *'[providing] specialist training alongside these unique facilities to address the existing shortage of people experienced and skilled in "classical" micro-machining and micro-fabrication technologies'* (p.1, Mercury tender document). One of the mechanisms for this was the development of workshops and training courses with an aim to '*provide hands-on experience in using the range of micro- machining and fabrication technologies available within the [university host]*' (p.14, Mercury tender document). Mercury – being positioned within a University department – should have provided the ideal environment for such training events. Gathering data on the success in terms of these objectives was not addressed in this research, although none of the interviewees emphasised any official training courses or workshops. Mercury is a research centre within an engineering department, but does not traditionally run undergraduate courses. This separation of Mercury's host research centre may have been one of the initial attractions for it to host the MNT centre, i.e. the perceived autonomy from the larger university.

A key issue considered essential by Anderson was flexibility; he described how Mercury has '*three key personnel who are very flexible in design terms that they can do processing, they know the market and the customers*'. This may be indicative of the level of flexibility required amongst staff when developing such new technologies. Mr Anderson did however say that '*other people aren't introduced to customers*'.

He was referring to the more 'academic' staff when he said this, as he describes when asked about staff backgrounds;

> '*we haven't got the same blend of people throughout the six members of staff ..[which is] as it has to be. We wouldn't dare expose some of the academic staff to the customers its not very academic and its not fair on the customer. academics like the project but they don't really want to work with the customer*' (Mr Anderson).

Prof. Stephenson says himself that he is '*not a front person, it is really for there is some companies visiting us, a major company, maybe I will take part but mostly it is done by my colleagues*'.

The idea that academics do not wish to work with ‘customers’ introduces an important concept for university-based MNT centres, i.e. whether academics can act commercially.

When Dr. Dickson (VC) was asked to comment on the effect that actors with different backgrounds and aspirations have on organisations such as Mercury, he talked generally of the establishment of such a centre;

> ‘*I think that it's difficult. We're comparing 'apples' and 'pears', and that's one of the difficulties with these centres. Because they came about for different reasons. I'm sure that those that are in an industrial setting came about because of a very clearly defined need for that particular manufacturer - and no doubt they were able to put a convincing case to DTI to say that if we had that centre in our facility that would add value to our products.. and that's a very clear case. In contrast those that are in a University environment, the outputs are going to be academic in the sense of papers, are going to be obviously work 'with' industry, but not necessarily just with one manufacturer in mind, and therein I think you have the challenge of judging a return on investment (ROI)*’ (Dr. Dickson).

Mr Strauss describes how ‘*in many cases the academic was trying to combine the two roles, and deviated from the original plans*’. Dr. Newton adds that there is just ‘*a real conflict between commercialisation and academic pedigree*’.

Dr Plunkett, the CEO brought in by the TSB to instil a more commercial focus to Mercury adds, ‘*If you had started the project with the intention of making a commercial entity at the end of it, you would not have employed the staff that they employed at the beginning of the project’.*

Dr. Rubin discusses the feasibility of having academics and business actors working together, and associated issues from his experience:

> ‘*It's possible to have them sitting side-by-side, as partners. It's very much more difficult.. to get it to happen.. if academics are in charge. You've got to have business, industrial people.. people who have worked in industry and know what industry is all about. And if you have those people in charge or running the show, then it CAN happen within an academic environment. which is far less likely than if you've set up in the instance of Mercury.. independently of its host organisation, and staff it with the correct industrialists and have it working as a partner with its host organisation; rather than as a sub-set of the host organisation*’ (Dr. Rubin).

His justification for needing commercial actors running such centres is their focus on commercial demands and outcomes, coupled with the ability to have control over a centre's own resources to delivering these.

In defence of academic actors he says:

> '*unless they've worked in industry how would you expect them to know anything about what industry is all about?.. [it's] a completely differently world, culturally and philosophically. Everything about them is.. just.. unless you've had an academic who's spent many years.. I don't just mean 1 year.. a decade in industry, they will not understand what industry is about. And any project that is dreamed up by an academic that is supposed to be .. commercially focused will fail*' (Dr. Rubin).

He continually comes back to the notion of 'academic-style' activity versus 'industrial manufacturing' style activity:

> '*Manufacturing is very much aimed at achieving a specific goal and a defining goal from the very start. Whereas research activity is very much more open-ended: 'let's see what interesting things we can find out' rather than we have to make this particular structure*' (Dr. Rubin).

With reference to the above quotes, the dualism of actors and purpose appears evident. Considering the responses from academic actors versus business actors, clear differences emerge. The next sub-sections will consider the data concerning each type of actor (including those considered to have experience of 'both' worlds).

7.5.3.1 Actors and Perception of Success

A role-ordered matrix – as described by Miles and Huberman (1994, p.125) - was created in order to emphasize the different backgrounds and roles of actors in terms of their perceptions of success/ failure. This can be seen in table 7-3. Additional columns have been added to firstly tease out the actions that are perceived to be driving the individual actors (direct quotes are used where possible). Secondly to provide examples of the contribution individual actors made to Mercury (and in some cases the wider MNT government intervention). The responses from the different actors were grouped and analysed. The most important elements of this table are now discussed in detail.

Table 7.3 - Role-Ordered Matrix: Linking Actors, Roles and Action.

Name/ responsibility	Academic/ business	Understanding of outcomes for Mercury		Actions driving actor (perceived)	Contribution to important events/ actions
		Success	**Failure**		
Dr. Plunkett/ CEO	Business	'..regular, sustainable, commercial activity from repeat customers' Standalone business	TSB stop the project. Or, reach end and not a sustainable business.	To bring clarity to the business plans, and the relationship issues between Mercury and the host-university department. Finding applications for new technologies (university to industry) Interfacing between academia and commercial world (including collaborative research)	Formerly on the industrial advisory board, then hired as CEO of Mercury to fulfil 'commercial' requirements set by the TSB.
Dr. Rubin/ Business development manager	Business	Revenue generating (if useful for industry, then industry will pay for it). Helps small companies unable to develop capabilities themselves. Successful product applications. Standalone business (after grant funding).	Not standalone. Industry perception as '*a bunch of researchers..playing with ..technology..*' rather than having '*manufacturing disciplines*' in place. Sub-contracting because 'staff can't do the job…they are researchers'.	To help manufacturing. Achieving industrial manufacturing goals.	Promoted commercial side of business. Fought the 'academic' resistance to his understanding of Mercury's commercial purpose.

Mr Strauss/ RDA manager / part of MNT review panel	Business	Application of technologies (examples given in medical sector).	‘should have had business development people recruited to drive the business for them’. Academics trying to combine two roles and deviating from original plans.	Public-sector motivations? Marketing the regional technologies nationally and internationally. Awareness raising: understand technology/ implications of it/ translate those into local businesses.	Part of MNT initial review panel for centres.
Mr Morgan/ TSB MNT operations director	Business	DK	[specific to Mercury] ‘*Dominated by professors, it is not outward looking for business*’. Sanction: withholding the grant. Worst case: stop funding. [understood to refer to Mercury] Not to fund ‘further university investment’. ‘It’s not about subsidising Uni/firm development projects, they need to go out and charge a commercial rate’.	To look after the public-funding side of the MNT intervention. Overseeing MNT centres. Protecting the confidentiality of centres: he describes most documents relating to governance of MNT centres as ‘commercial in confidence’.	Withholding grant. Instrumental in appointing the commercially focused external CEO. Increased authority of industrial steering group (required sign-off for decisions concerning *Mercury*). Resetting of objectives. Eventual grant cancellation.

Mr Rubik/ Management consultant for TSB	Business	DK	'failing'.	Employed by third-party management consultants (duty to them first?) Auditing and measurement of the success of the MNT centres.	Manages the review audit of centres and presents to TSB (includes data from *Mercury)*.
Prof. Stephenson/ Senior Professor	Academic	Adoption of technologies by companies Developing manufacturing platforms for emerging products.	'*we don't have anything to report along these lines*' If a technology does not prove to have industrial application, this is still an outcome (general view for research centre)	Curiosity-driven research (& winning grants to continue this work). Development of emerging technologies	Influential in project proposal and winning the grant. On board of directors, and very influential in running of centre, and influencing initial academic focus of the business. University paid supplier [Luna] a settlement concerning *Mercury's* failure to uphold agreed actions: '*Politically charged, issues with [Prof. Stephenson] senior professor upsetting the relationship*' (ref. Dr. Rubin).
Prof. Pascal/ Senior Professor	Academic	Income generation from companies. Achieving and exceeding project targets.	Not meeting objectives. (in terms of research centre) 'we haven't' [been unsuccessful].	'..I would say innovation is part of our daily activities'. 'Curiosity. We want to try new things, test and see if they work. And we feel happy when we've got something new.. and it's a creativity urge'. Applied research.	Influential in proposal and grant.

Mr Anderson/ Production manager	Academic	Customer happy. Researcher published from the project and Mercury has emerged and grown. ‘Hasn’t necessarily got to be profitable to be counted as a success’.	When equipment lets us down (due to emerging status). Confusion of Mercury’s purpose: less reliance of specialist/ researchers running equipment. High daily rates [*counters other actor views]	‘personally I’m more concerned with the processes rather than pure profit’. Example given of attending an academic conference without authorisation required by CEO: i.e. displays preference for the academic priority. Completion of a postgraduate degree and associated study.	DK
Dr. Dickson/ Uni VC & industrial advisory group	Both	Ability to connect to customers. Customer-demand: value add to their product or their own technologies.	Significance between estimated income and actual income. Poor quality of planning in the centres; i.e. ‘over-ambitious’ not managed well.	Interests of both industry and academia important. Need pull rather than technology push, e.g. TSB challenge-led projects, rather than MNT centres. Focus on next-generation big things (e.g. next gen aircraft wing) Need to add value to UK supply chain (often ROI only seen further down chain, which is not measured)	DK
Dr Newton/ former steering group member	Both	Payment for service. Output of some kind: could be machine setting/ report or study/ or generation of new knowledge. IP has potential to be sold.	Failure to prove something is nonetheless a result. Project stopped half-way through: no conclusion/ external community benefit/ no valuable experience for researcher.	‘*The reason I came on here was to try and rebalance things.. and to take away some of the risk I think.. I'd quite happy call a decision that would go against one or other of the parties*’ Driven to help as a favour to the University. Concerns over breaching state-aid regulations.	Invited to join steering group by Prof. Pascal: to provide an academic and business view. On board for 8 months (stopped due to work commitments, as this role was unpaid).

7.5.3.2 Business Actors

When the business actors were asked how they understood the outcomes of Mercury in terms of success, agreement in a number of main areas was apparent. Firstly the need for revenue generating, commercial activity. Dr Plunkett describes '*regular, sustainable, commercial activities and repeat customers'* in terms of success, as well as a *'standalone business*' (Dr Plunkett). The development of '*successful product applications*' is added to this by Dr Rubin and Mr Strauss.

Secondly, the ability to trade without grant support at the end of the DTI funding was understood as a successful outcome. The strong business logics of these actors aligned with the commercial purpose provided by the funding bodies for the MNT centres. From supplementary meetings with Dr Rubin, it became clear that promoting the commercial purpose of Mercury was met with resistance from the professional academics, who were senior (in terms of management position) within the university. Their position of authority and the university bureaucracy (from the point of view of the business actors) was seen as a barrier to running the centre in a commercial way. For example, the CEO and Business Development Manager felt constrained by the academic staff they had to use, because they wanted commercial staff. This meant that the Business Development Manager – rather than being able to employ the staff he wanted – had to sub-contract work because (in his view) '*the staff can't do the job… they are researchers*' (Dr Rubin). This was echoed by Dr Plunkett, and meant that rather than working together, staff were finding alternative ways of overcoming what they saw as obstacles.

Failure was an acknowledged concept for the business actors. They conceived failure as either the business not becoming sustainable by the end of the grant, or the worst case scenario being that the TSB stop the funding. The RDA manager described how he believed that Mercury '*should have had business development people recruited to drive the business for them*' (Mr. Strauss).

Interestingly, the proposal document does make reference to the type of staff Mercury would employ; these were 'full-time graduate level researchers' (Mercury proposal document). This example therefore highlights the need for careful consideration of the actors employed for national systems of innovation within a university environment.

The more common *actions* across the business actors were; firstly to find applications for new technologies (including awareness raising to the market), and secondly to look after the public-funding element of the government intervention. The second driver comes from those industrialists (more specifically management consultants) employed by the TSB to audit the MNT centres. The first group of actors are concerned with the local context of their centre, whereas the latter group are concerned with the extra-local context of the MNT government intervention. As such, the context individuals are concerned with also has the potential to create conflict/ disagreement as to the actions required for the smooth running of a centre. The difference in the case of Mercury is far more noticeable when comparing the professional academics with the business actors.

Two of the business actors were employed to refocus the direction of Mercury toward a commercial organisation. The business development manager was brought in early on to promote the commercial side of the business. Then over half way into the grant period, the TSB made it a condition of continued funding, that an industrial CEO should also be appointed. Subsequently a former member of the industrial advisory board, Dr. Plunkett, joined as part-time CEO. His role was to fulfil the commercial requirements set by the TSB. Both of these business actors had to fight 'resistance' from the tenured senior academic staff in order to push the commercial remit. Dr. Rubin described how it was not uncommon to have '*stand-up rows*' with one senior professor in particular. All of which describes a turbulent environment for the actors within Mercury.

Mr Morgan and Mr Rubik were responsible for overseeing the MNT centres and managing the review audit of the centres, respectively. Mr Morgan was particularly instrumental in withholding grant money and appointing the external CEO. As previously mentioned - the industrial steering group were also given increased authority in order to refocus the commercial direction of Mercury.

7.5.3.3 Academic Actors

The academic actors were less concerned with traditional business outcomes when interviewed. Professor Pascal did mention 'income generation', but more in reference to it being one of the many deliverables of Mercury. He was much of the view that success meant '*achieving and exceeding project targets*'. Professor Stephenson described the adoption of new technologies by companies, and the development of new technology platforms for emerging technologies as successful outcomes. This aligned strongly with the clear actions driving him, i.e. interpreted as curiosity-driven research. His senior position and influence in the university research department, coupled with a forceful nature (observed by the researcher on more than one occasion) are seen as instrumental in the direction that Mercury took. This initial direction was toward academic outputs, and led to the eventual instatement of the commercial CEO and increased authority of the steering group. Furthermore, communications with one of the main suppliers – Luna – became '*politically charged*'.. due to '*issues with [Prof. Stephenson] senior professor upsetting the relationship*' (Dr. Rubin). This agrees with Mr. Anderson's comment that some '*other people aren't introduced to customers*': suggestive that certain individuals were less interested at customer-facing roles.

Mr Anderson described success in terms of making the customer happy, the researcher having published from the project, and Mercury having emerged and grown. He also stated that a project '*hasn't necessarily got to be profitable to be counted as success*'. This view is counter to the business actors, and when discussing failure both senior professors adopt similar stances. When asked whether they could describe failure in the university centre and Mercury, both professors did not conceive failure to be an issue. Professor Stephenson and Professor Pascal said '*we don't have anything to report along those lines*' and '*we haven't [been unsuccessful]*', respectively.

The main drivers for the three academic actors can be summed up as 'curiosity-driven research' and 'technology development'. Professor Pascal states '*innovation is part of our daily lives.. curiosity.. We want to try new things, test and see if they work. And we feel happy when we've got something new… and it's a creativity urge*'.

Mr Anderson also adds '*personally I'm more concerned with the processes rather than pure profit*'. An example was given where the CEO felt that his authorisation was required in order for Mr. Anderson to travel to an academic conference, in preference to the commercial work at Mercury. Mr Anderson decided to go to the conference anyway, showing a clear priority for his academic work. This follows Anderson's drive to complete his postgraduate degree and associated study.

7.5.3.4 Actors with Academic and Business Backgrounds

Two actors in Mercury were categorised as having both academic and business backgrounds. Accordingly their views appeared to empathise with both world views. Dr Newton describes Mercury's success as covering a range of outcomes:

> '*Payment for the service or on-going use of product so literally getting it to a proposition for the market which may or may not succeed or fail but actually to have produced something - machine setting, a study of material degradation, whatever it happens to be, but an output of some kind. A generation of new knowledge*'. (Dr. Newton).

Dr. Dickson adds the '*ability to connect to customers*', and describes the '*value-add*' to customers' products and/or technologies. Failure for Dr. Dickson is where there is a significant difference between the estimated income and the actual income of Mercury. In addition he describes how:

> '*there are questions about the quality of planning that takes place in the centre. In other words you've been over ambitious and you haven't managed it particularly well.. and I would think that's where there is a real issue.. and indeed Mercury I'm sure there was greater optimism at one stage than we now have*' (Dr. Dickson).

In terms of failure, Newton states that '*failure to prove something is nonetheless a result*', in agreement with the academic actors. Furthermore he describes a failure as if '*it has not reached a conclusion and has not given the external community a benefit and by consequence hasn't given the researcher any valuable experience*' (Dr. Newton).

Dickson and Newton appear to be driven by the interests of academia and industry. Dr. Newton was asked by Prof. Pascal to join the steering board. He describes how: '*the reason I came on here was to try and rebalance things.. and to take away some of the risk I think.. I'd quite happy call a decision that would go against one or other of the parties*' (Dr. Newton). He describes a clear strategy to 'take-control' of the process. His experience of both world views was clearly important in his appointment. He maintained the voluntary role for eight months, but then had to stop due to work commitments. He was initially driven to 'help the university'.. and stated that he '*found it very interesting.. of all the companies I've worked with at board level, this is probably the most interest[ing].. [and] most frustrating.. [this is] the hardest to solve*'. He views Mercury as hard to solve in relation to the concerns he raises over breaching state-aid regulations by running Mercury commercially. Dr. Newton brings up a very important issue here, which surprisingly is not raised so vociferously by others in Mercury. Dr. Plunkett does describe issues concerning MNT centres who in his view are developing technologies which are very close to the market already, and potentially unfair competition to existing organisations and he outlines the need for the MNT centres to be developing emerging technologies.

7.5.4 Context

This section takes a detailed look at Mercury's context, with a particular focus on the influence it has on how Mercury functions as a local MNT centre, along with its extra local context in the government intervention. Table 7.4 presents data from interviewees evidencing the positive and negative outcomes of Mercury's context (where 'outcomes' are the achievement of the goals set out by the DTI for the MNT government intervention, i.e. commercial outputs). This data is then used to provide support for a discussion on the findings from the main case in terms of its struggle to be a limited company in a university environment. In addition the advantages of being located in this context are also discussed.

Extracts from Mercury's tender document relating to context are displayed in appendix 7c. The general point to note is that the proposal looked to build on existing facilities and experience located in the university host department. This includes recognised quality standards. A strong point of this argument was that the *risk* of establishing a centre is vastly reduced by locating at the existing facilities.

This section presents data concerning how the context[2] of Mercury influences its function as an MNT centre and part of the wider MNT government intervention.

The advantage of investigating the context of Mercury is that it struggles to be a limited company within a university research centre. As such it has to deal with a somewhat multifaceted personality. The presentation of findings relating to the people construct display how context appears to be closely interrelated with the actors and their world

[2] Note: context meaning environment (type of organization, structure); circumstances that form the setting for an event. External events outside of the innovation department (if larger organisation and industry) that interviewees perceive to affect the innovation process.

views. The action of the actors and the link this has to the structure/ context they are in will be further explored in this section by referring to context.

Table 7.4 categorises actors' comments about Mercury being based in a university. The positive and negative connotations of being in a university context are considered in relation to the original commercial DTI/TSB purpose of the intervention[3]. What the table illustrates is that in the main there are more negative comments of running this particular MNT centre in a university context. However there are a number of positive comments, which will be discussed first.

7.5.4.1 Positive Aspects of Mercury's Context

Mr Anderson describes how the technology progressed more by being part of a university environment. Mr Strauss adds that the wide range of existing technologies within the host university adds to the services that Mercury can offer its customers. However he does describe how the setting also constrains Mercury.

Dr Stephenson emphasises the advantages of running such a new technology centre in an established university in comparison to new start-up ventures. Firstly he describes the financial benefit in terms of being able to access university credit in order to purchase required equipment. From an employee perspective, he emphasises the attraction of having the university as an employer for would-be staff; e.g. good pension schemes. Lastly he describes how the university is an ideal context for developing emerging technologies, according to his perception of the original purpose of Mercury (i.e. to develop risky technologies, rather than commercial technologies).

[3] The UK Micro and Nanotechnology (MNT) Network .. established by the DTI and the 12 Regional Development Agencies, and Devolved Administrations .. to provide a market-orientated focus for the facilities, people and organisations engaged in Micro and Nanotechnologies in the UK. The Network is helping to lower entry barriers and drive the widespread market development and exploitation of these technologies – building a prosperous, world-class MNT sector in the UK (DTI, 2005)

Table 7.4 – Positive and Negative Associations of Mercury's University Context

Name/ background	**Positive Outcomes of Mercury's Context***	**Negative Outcomes of Mercury's Context***
Mr Anderson/ academic	▪ [if Mercury was set up on its own…] '*I'd probably think our project timelines would be shorter and more focused, being away from the university. but I don't think that the technology would have progressed to the level that it has, without the balance*'.	▪ '*..some people forget.. that Mercury has academic staff who are academically driven, they aren't just research staff because they want to publish and they have academic careers to work on*'. ▪ Difficulty with getting academics to work on a commercial project. ▪ '*..we are getting audited and we are getting heavy stripped [because] there's no commercial activity*'.
Dr. Dickson / both	▪ Helps the university department earn some money from industry (although not the primary purpose). ▪ The more applied research department hosting Mercury was able to boost the academic rankings of the other engineering research departments.	▪ '*.. in a university environment, the outputs are going to be academic in the sense of papers.. work with industry, but not necessarily just with one manufacturer in mind*'. ▪ Working with one manufacturer makes it easier to judge return on investment. ▪ Mercury undercharges (in comparison with industry) ▪ '*one of the disadvantages of having these facilities in the university is that manufacturers will think well they're going to do it cheaply anyway*'.
Dr. Newton/ both		▪ '*I think it's caused us in the initial stages schizophrenia as to whether you're an academic or whether you are a limited company*'. ▪ '*.. prior to the appointment of Dr. Plunkett, there were part time members of staff, acting in the best interests of the company but not necessarily with hard nose commercial experience*'. Also appointment of industrialist Dr. Rubin to manage Mercury, considering all other appointments were from the university academic team. ▪ '*weakness of the structure, it's not marketing*-orientated *enough*'.

Table 7.4 – Positive and Negative Associations of Mercury's University Context

Name/ background	**Positive Outcomes of Mercury's Context***	**Negative Outcomes of Mercury's Context***
Dr. Plunkett/ business		▪ Fundamental problem trying to be commercial in a university. ▪ Fostering of underperforming staff: 'almost impossible to lose your job whilst working in a university'. Contrary to industry.
Prof. Stephenson/ academic	▪ Buying power better, university accounts ensure credit immediately. Typically having to pay for everything in advance is a major problem for start-up companies. ▪ HR, staff recruitment – working for university offers security. Difficulty of finding right people in a start-up company. ▪ University offers pension schemes, important to secure the staff: '*If it is a company on its own, you will not find the staff*'. ▪ University very appropriate for developing emerging technologies, if '*it goes for the initial objectives*' i.e. risky technologies, '*you have the right environment to develop them*'.	▪ '*If [the objectives, i.e. technologies] are very close to the market, then the companies are the best [to develop] but it depends on the problem objectives*'.
Mr Strauss/ RDA manager	▪ Mercury needs the university facilities to widen their offering, but '*the university itself constrains them for other reasons*'.	▪ '*In my experience the university infrastructure is a big constraining factor on the centre*': ▪ Barriers to intellectual property & becoming self-sustaining. '*It just seems the university structure prevents them from doing that. What we are trying to do here is get academics to act commercially and to become professional*'.

*In terms of achieving the original goals of the DTI/TSB government intervention (i.e. commercial outputs).

7.5.4.2 Negative Aspects of Mercury's Context

Mr Anderson introduces the important link between academic actors and their actions in a university environment: '*Mercury has academic staff who are academically driven, they aren't just research staff because they want to publish and they have academic careers to work on*'. With the exception of Rubin and Plunkett, all of the other actors employed for Mercury were transferred from previous university projects. The production manager is one example, and he states:

> '*..with the environment we are in its one of the hardest things to balance because we all want to keep progressing as academics and <u>not be totally focused on industrial work</u>, its one of the hardest things we have on the project at the moment is getting people to work on it because with academics especially its taking them out of their comfort zones a bit. I say making money is one thing but without personnel its not [anywhere] tomorrow, not all people see the big picture of it*' (Mr Anderson).

As production manager one might assume that his actions would be driven by achieving commercial production as his position implies. However, this appears at odds with his focus on an academic career, and that of his university colleagues. He argues that if making commercial revenue is the most important thing for the TSB, then why do they bring it to a university?

> '*It stops the argument there for me. You are not going to have a commercial company in a university. It's not fair to start*' (Anderson).

In terms of fairness he is referring to measuring a university with commercial indicators rather than academic ones (even though the purpose of the MNT centres were for commercial exploitation). The institutional context of Mercury – i.e. within a university – has an important bearing upon the institutional academic actors. As Mr Anderson alludes to, academic work and the need to publish to ensure the international standing of the home university are paramount for a university.

Dr Newton sums this up in the following: '*I think it's caused us in the initial stages - schizophrenia - as to whether you're an academic or whether you are a limited company*'. Actors are clearly confused as to the purpose of working in Mercury. They are torn between actions for their academic career development and commercial actions for Mercury.

This organizational schizophrenia is an important theme shown in table 7.4, and continued by Dr. Plunkett. He says:

> '*where to start? It's got a fundamental problem in that trying to become commercial, whilst it's within a university and everybody is paid by the university brings a dimension to it that is difficult to manage because what I've learnt is it is almost impossible to lose your job whilst working in a university.. you know.. whilst that project is running..it's almost impossible to get sacked. Whereas if you're in the 'real world' if you are not performing to a relatively good level you are probably not going to be there. So it can foster underperformers*'.

His views are informed by his business experience, and raise an important point about the performance of individual actors. Clearly the university context would appear a difficult one in which to transplant industrialists. Only two actors from a business background were brought in to realign Mercury toward the TSB's intended commercial focus. Newton explains that '*Prior to the appointment of Dr. Plunkett, there were part-time members of staff, acting in the best interests of the company but not necessarily with hard nose commercial experience*'. The other actor with business background is that of Dr. Rubin. Both no longer work at the university.

When asked about different aspirations actors have in different contexts, Dickson referred to the initial tendering organisation and their needs for an MNT centre:

> '*I think that it's difficult. We're comparing 'apples' and 'pears', and that's one of the difficulties with these centres. Because they came about for different reasons. I'm sure that those that are in an industrial setting came about because of a very clearly defined need for that particular manufacturer - and no doubt they were able to put a convincing case to DTI to say that if we had that centre in our facility that would add value to our products.. and that's a very clear case. In contrast those that are in a University environment, the outputs are going to be academic in the sense of papers, are going to be obviously work 'with' industry, but not necessarily just with one manufacturer in mind, and therein I think you have the challenge of judging a return on investment (ROI)*' (Dr. Dickson).

The implication Dr. Dickson makes here is that some of the industrial centres have clearly set themselves up as a centre working solely for one manufacturer, probably a large OEM. By doing so, clear revenue can be obtained, and there is the potential of an exit strategy at the end of the grant period (e.g. a buyout). A number of centres, e.g. Bacchus and Cardia potentially fit this description. One of the difficulties of running an MNT centre developing riskier technologies for an unknown customer base, will therefore be the difficulty in obtaining financial revenue. Prof. Stephenson '*if [the* *objectives, i.e. technologies] are very close to the market, then the companies are the best [to develop] but it depends on the problem objectives*'. In other words he is suggesting that it is easier to show commercial revenue when developing technologies closer to the market, rather than risky technologies, as in Mercury. The DTI were originally responsible for selecting the contexts and organisations for the MNT centres.

Mr Strauss refers to the university bureaucracy as '*a big constraining factor on the centre*'. He is referring in particular to the difficulties in exploiting intellectual property, one of the main ones being that the university has an external organisation through which IP must be administered. This adds bureaucracy and also reduces any incentive of return for Mercury or any related staff. With such emerging technologies, licensing of IP is an important route for developing revenue.

Perhaps one of the most important themes coming out of table 7.4 is how difficult it appears to get '*academics to act commercially and to become professional*' (Mr. Strauss). Dr. Dickson explains how companies envisage that they will get a 'bargain deal' by going to a university. He describes how companies can economically exploit universities because they know '*you've got a negotiation between someone who's a tough commercial individual, and an academic who doesn't see life in exactly the same way*'. Again, this introduces the notion of contestation, but this time between a centre and its customers.

Mr Strauss was part of the DTI selection committee for the MNT centres. He was asked whether particular contexts were preferred for the MNT centres, or if a range was considered. He answered:

> '*We just invited people to tender for this, we had no preconceived ideas of the structure of the organisations, they were a wide mix, some were private sector companies, some were university groups. The relationship within universities changes dramatically from [one] organisation to organisation. So we had <u>no preconceived ideas</u>, because we wanted as wide an MNT provision as we could, to <u>satisfy the needs</u> of UK businesses*' (Mr Strauss).

This suggests that the panel were not biased to any individual settings at the beginning, and perhaps unaware of the ramifications of one setting over another.

Overall the university context in which Mercury has been established appears to have constrained the commercially facing objective required by the TSB. One of the strengths championed throughout the proposal document for Mercury was that it would be able to leverage existing university experience and expertise. Conversely, this university context appears to have stifled the commercial exploitation of the emerging MNT technologies. The next section discusses how these collaborations have affected Mercury.

7.5.5 Collaborations

This section describes the collaborations associated with Mercury, and how actors within Mercury utilised additional collaborations to develop their services. The original tender document is referred to which provides an indication of how collaborations were originally conceived for the centre. In addition the positive and negative associations of different types of collaborations are discussed.

The collaborations construct concerns how the formal and informal relationships among innovation group members; other firms and groups influence the function of the MNT government intervention (and Mercury more specifically). Extracts from this proposal document relating to collaboration have been summarised in table 7.5. Emphasis is placed upon existing collaborations with industry, European networks, the then proposed UK MNT network to facilitate the integrations of a complete MNT supply chain. Once again, these existing collaborations were seen as advantageous for Mercury, and a way of reducing risk by setting up a centre in a pre-established environment.

Table 7.5 Extracts from Mercury's Tender Document Relating to Collaborations.

p.2	[Mercury will capitalise on existing European collaborations/ networks which the University co-ordinates], by establishing links to key technology and service providers in Europe.
p.8	PLCs will be specifically targeted - possibly in concert with other elements of the MNT Network to promote a 'joined-up approach'.
p.8	A major assisting factor in the sales development process is the active involvement of the equipment suppliers in *Mercury***.** They will, in effect, act as 'agents' for the *Mercury* service[s]. *Mercury* will act as a reference site for *company Luna* and company A, but their prospective clients will be charged for use of the service[s] at the same rate as other clients.

p.11	The commercial risk is effectively reduced by good knowledge of the needs of current clients/contacts and the extremely good connections of all of the partners to the MNT world and the linkage to the rest of the UK's MNT Network. The financial risk is minimal because of the public sector involvement and the cash-back and in-kind arrangements between the partners.
p.12	The [research centre] has won acclaim for its work in establishing lasting and fruitful partnerships with industry.
p.13	The project will benefit from the support of Venus university’s research and development section.
p.14	Synergistic links with [a number of] networks, projects and centres in the UK and the EU will be created to multiply the impact of the proposed *Mercury* service.
p.15	The links to these centres and major programmes will facilitate the integration of the complete supply chain related to product development stages from design to scale manufacture of micro-components in non-silicon materials. Also, these links will used as a mechanism for marketing the *Mercury* service to the wider community.

The recognised collaborations along with the understanding of actors in terms of positive and negative influences on Mercury, are weighed up in table 7.6. Reference initials of the source of the data are provided (i.e. the actor’s initials).

A glance over table 7.6 indicates a fairly balanced view in terms of positive and negative influences of Mercury’s collaborations. The strong links to the host university are emphasised by the senior professors, having spent a large amount of their careers building up the centre.

Anderson and Stephenson highlight the importance of existing EU projects and networks from which Mercury benefits. Thinking even further afield, Anderson describes successful collaborations on medical devices with American universities, and the merging of a European conference with an Asian and USA counterpart. As a regional development manager, Mr Strauss talks of marketing Mercury and other regional centres on a global playing field.

Anderson, Stephenson and Pascal refer to the collaboration with in-kind suppliers. There is a very positive side to this collaboration, which enables development of new machines and technology benefiting both Mercury and the supplier. For the university host and Mercury there is the additional benefit of funded equipment, for developing emerging micro technologies. For the suppliers it enables them to gather data of the product in use, and use the university as a showcase for marketing purposes.

On the negative side, these relationships and collaborations need to be managed with interests of individual parties considered. Newton explains how suppliers put pressure on Mercury to generate commercial payback through buying more parts, or by developing the technology and saleable intellectual property further. The importance of this has increased due to the pressures of the recent economic downturn.

Suppliers are not always interested in developing the equipment, according to Anderson. He gave one example of a very large supplier who was less interested in developing a certain piece of equipment as it wasn't their core business, and offered less return. The different interest groups are able to play against the interpretative flexibility of the technology – being able to emphasise the potential for further development (academic) and the potential for new applications (commercial). Clearly such interpretative flexibility appears to facilitate competing interpretations and actions (Swan and Scarborough, 2005). This is compounded by the institutional context and appears to problematise the commercial concerns of nearness to the market.

Table 7.6 – Types of Collaboration Existing in Mercury (positive and negative associations)

Type of collaboration	**Positive influence/ comment** [source: actor]	**Negative influence/ comment** [source: actor]
Host university	▪ Strong European links already exist with the host-university department, these can be accessed by Mercury [Pascal] ▪ Mercury benefits from the networking with existing departmental EU research networks.. '*finding more about the potential applications, developing applications, learning from their experience with their own regions, with customers, developing the technology: advantages*' [Stephenson]	

Type of collaboration	**Positive influence/ comment** [source: actor]	**Negative influence/ comment** [source: actor]
Supplier (in-kind investment, e.g. equipment)	▪ Work together to develop machines. Example given: processing parameters sent monthly to equipment manufacturers, for database & marketing [Anderson] ▪ Suppliers contribute to cost of machine, and interested in developing new applications and use *Mercury* as a test be and reference site for their machines. Marketing for the supplier is important [Stephenson]	▪ Not all suppliers are interested in developing the systems [Anderson] ▪ Equipment from one supplier needed to work over a wider scale range than originally specified. The supplier didn't see any payback for developing further. ▪ As economy worsens in-kind suppliers put pressure on Mercury to generate 'commercial payback' through buying more parts or by developing their technology further (intellectual property). They want Mercury to grow the business quickly to create a revenue stream for them. Leads to 'uneasy tension'. [Newton] ▪ '*we do have one or two 'so-called' partners. The suppliers of our equipment, they do give us funding to do the work*'. There is a poor relationship with Luna, '*not worked too well*'[Pascal] ▪ Dispute with *Luna* in terms of not achieving the specifications.
European	▪ Effective collaborations- help to concentrate *research* activities and learn from other EU colleagues [Anderson] ▪ The host-centre has two major European projects.. setting EU infrastructure in this area.. brings Mercury together with other similar infrastructures [Stephenson]	

Type of collaboration	**Positive influence/ comment** [source: actor]	**Negative influence/ comment** [source: actor]
International	▪ Merging of a European conference and International (Asia, US). Good for benchmarking and collaboration [Anderson] ▪ Relationship with US university researcher to develop application. '*He was very sympathetic to our problems [technical]'*. *'He knew the medical side..we knew the engineering'* [Anderson] ▪ Market region's MNT centres internationally as an RDA. '*They have a lot to bring to industry.. so help them market themselves both nationally and internationally*' [Strauss]	
Customers/ users	▪ Businesses looking into micro/nano technology '*need to have collaborations with universities*'. Also more funding and expertise available [Anderson] ▪ Industry collaborations generated from enquiries: need to educate customer on what Mercury can/ can't do: 'got to get designers to be thinking differently'. [Anderson] ▪ Some good '*classic collaborations*' with companies, i.e. using expertise to develop their process [Plunkett] ▪ New technologies require demonstrators, '*educate with examples*'. Use of forums or groups, conferences and exhibitions. Face-to-face meetings to develop relations further with them [Stephenson]	▪ Link to academic research-type institute puts some companies off collaborating. Poor perception of university commercial activities [Rubin] ▪ *'[bureaucracy and timescales fair comment] to a certain extent.. it's not universal by any means.. have turned around work very, very quickly*'. Some non-repeat work takes too long, '*tends to be patchy*' [Rubin]

Type of collaboration	**Positive influence/ comment** [source: actor]	**Negative influence/ comment** [source: actor]
Regional networks (e.g. RDA)	▪ Involved in regional networks to gain more support for MEMS technology in the region [Anderson]	▪ The KTNs should be networking the whole group of MNT centres, but '*that's something the KTNs should be doing.. they're patently not doing it*'. An RDA MNT network did carry out such networking, but this has recently finished [Strauss] ▪ Led to the RDA manager setting up his own regional network for the local MNT centres [Strauss]
KTN networks		▪ KTN emerged and overlapped with a lot of RDAs work. '*I don't believe they represent the network as this particular group I sit on does*' [RDA MNT network] [Strauss]. ▪ KTNs failing prompted Strauss to set up his own network [Strauss].
Public sector (e.g. funding bodies)	▪ Strong & deep collaborations needed with public sector, it gives funding security.. '*good for the economy*'. Organisations like Mercury provide a service in terms of saying where those bodies should fund/ invest money [Newton] ▪ CEOs appointment strengthened links with RDA, TSB and in-kind suppliers [Newton]	▪ '*At the moment I think the system [i.e. public sector funding] is biased to not sharing, looking after yourself, and retaining as much knowledge as you can.. caveat.. the retained knowledge isn't used for generating an income.. purely retained knowledge that people use to do the next generation research*' [Newton]

Type of collaboration	**Positive influence/ comment** [source: actor]	**Negative influence/ comment** [source: actor]
Academic institutions/ Other MNT centres		▪ Historically Mercury didn't collaboration with other universities. CEO actively promoting this because '*why would you want to duplicate?*' [Plunkett, CEO] ▪ Mercury has a huge cross-over with *Liber* in terms of technological applications. '*they've also got their uniquenesses*'[Plunkett] ▪ Other centres have duplication of key machinery, why so many? [Plunkett]
Workshops	▪ Run workshops to get industries to come to Mercury [Anderson]	

Relations with one of the main suppliers, Luna, became increasingly fractious as time went on. Professor Pascal describes his dispute with Luna in terms of them not achieving specifications:

> '*Luna were not competent in that area.. so .. the technical development of the machine has not been perfect.. and then they blame us for not providing them with data and so on and so forth'* (Pascal).

Conversely Plunkett said that the relationship was '*an increasingly healthy relationship*' one month after the above comment. However, in the final stages of Mercury, Dr. Rubin described how the university had to pay Luna a settlement concerning *Mercury's* failure to uphold agreed actions. These were probably in part due to the '*Politically charged, issues with [Prof. Stephenson] senior professor upsetting the relationship*' (ref. Dr. Rubin).

When it came to revenue-generating collaborations with customers and/or users, there were a number of both positive and negative examples. On the plus side Mercury was seen to provide valuable expertise and process development capabilities required by external companies (Anderson and Plunkett). However, a number of observed customer perceptions of commercial centres in universities were raised: firstly, Rubin described how commercial university activities are perceived as '*extremely slow..[with a].. lack of urgency, lack of focus, a lot of bureaucracy, and [it's] just somewhere you don't go to get commercial work done*'. He does add that more enlightened customers realise the potential benefits of working with a university commercial centre, and how work can be turned around very quickly when necessary.

A key issue was that the knowledge transfer networks (KTNs) created by the government to help manufacturing companies network and find resources etc. were seen to be lacking. Originally the MNT Network was created to provide access to a UK-based micro- and nano- technology infrastructure. However this morphed into the Nanotechnology KTN, which is meant to network the whole group of MNT centres. Although, as Strauss explains: '*that's something the KTNs should be doing.. they're patently not doing it!*'.

An important point to pick up from table 7.6 is the relationship Mercury has with the rest of the MNT network. The proposal states '*the commercial risk is effectively reduced by good knowledge of the needs of current clients/contacts and the extremely* *good connections of all of the partners to the MNT world and the linkage to the rest of the UK's MNT Network'* (proposal document, p.11). According to CEO, Dr. Plunkett, there was potentially a huge cross-over of technologies with other MNT centres and universities. Part of his revised strategy on entering Mercury was to address this issue, and he asked the question '*why would you want to duplicate?*' with regard to technologies that other centres have. He suggested the reason this occurred was that '*academics are [in a] very published or be damned-type environment, so why would you want to share?*'.

During the last interview with Dr. Rubin, the business development manager in August 2009, a major collaboration was in development with another MNT centre, to bolster performance, and move from the recent 'red flag' Mercury had once again received. This collaboration never came to fruition, despite drafting in Professor Hertz (the originator of the MNT programme), and other senior TSB actors.

7.5.5.1 General Comments Concerning Collaborations

A number of comments concerning collaborations in general were also discussed. These are now briefly described to further enrich our understanding of Mercury's collaborations.

Dr. Plunkett emphasised the importance of collaborating with others who complement your services, rather than doing similar things: '*you should be 1+1 = 3, 4, 5. That's what is should be, otherwise don't do it*'. He also describes how the development of new technology is more organic and how it requires close collaboration with the customers. '*By definition organic organisations are those in which information flows, particularly lateral flows, are facilitated, expertise replaces position power as the basis on which input is evaluated, and decision authority is decentralized*' Angle (2000).

Dr. Rubin describes the importance of marketing to gain further collaborations. He explains how some companies find them, and that Mercury:

> *'..has quite an active promotional/marketing campaign. I advertise, and have written many articles in trade magazines, journals, as well as articles appearing in academic type activity; I've spoken at various conferences..commercially-driven type conferences, and that kind of thing… and then of course exhibitions, trade-shows where we actually exhibit'* (Dr. Rubin).

Prof. Stephenson adds how a lot of time goes into developing these collaborations, and how such time is usually unpaid.

7.6 Outcomes - Secondary Data

The DTI and more recently TSB commissioned a number of audits and reviews to measure the numerous outcomes of the MNT centres. The majority of their data on Mercury is considered as ‘commercial in confidence’ by the TSB, even though it pertains to a publicly-funded government intervention.

The researcher made some inroads into gaining access to secondary data collected for the TSB’s auditing purposes. These include:

- The detailed proposal form for Mercury.
- Documents relating to the ‘traffic light’ system for summarising the progress of each MNT centre following each quarterly review.
- One example of a quarterly review for Mercury. Unfortunately permission was not granted to reproduce this in detail, however descriptions of the measurement used within this document by Ernst and Young is presented in Appendix 5h. This provides an understanding of the more quantitative measures that the centres are subject to.

Other than these documents, there is a paucity of information obtainable in the public-domain for these centres. The difficulty of obtaining information has been described in the Methodology chapter in detail.

The outcomes outlined in the proposal document are provided in Table 7.7. However, data pertaining to the achievement or otherwise of these outcomes has been difficult if not impossible to acquire. Often outcomes such as ‘generating some 100 engineers with micro manufacturing skills’ are very open to interpretation, as are measuring the positive effect on UK industry. In particular sentences like ‘the likely financial impact on UK GDP will be in excess of £200 million by 2014 as the technology infrastructure created in this project will underpin the development of the next generation of MST-based products’ (proposal document, p.15) introduce outcomes that are incredibly difficult to measure/ prove.

Table 7.7 Extracts from Mercury's Tender Document Relating to the Outcomes.

p.4	… the proposed service.. will give industry and the UK unrivalled opportunities in the global markets for such products. The capital investments .. will facilitate the efficient manufacture of precision micro-components … enabling companies greatly to extend their product lines and make improvements to existing ones. This will make the products more competitive, stimulate the growth of a new type of manufacturing, generate new opportunities, encourage further inward investment, create new high value companies and jobs and hence assist the regional economic development.
p.14	It is anticipated that over the next five years, *Mercury* will generate some 100 engineers with micro manufacturing skills. In addition, *Mercury* will build upon the existing [university centre] consultancy activities… to provide UK industry with unbiased expert advice on … micro components and the cost effective implementation of micro technology. Over the next five years, *Mercury* is expected to assist some 150 companies in this way.
p.15	The availability of the *Mercury Service* in the UK will underpin the development of next-generation MST-based products with a major commercial impact by 2010. The value for money aspect … readily be assessed from its potential impact compared to the proposed investment: an additional 1% share of the MEMS, Micro-fluidics and Photonics markets to UK PLC as a result of the ability competitively to design, prototype and produce products requiring … microcomponents would be worth at least 100 times the requested DTI funds. By extending the existing range of micro- tooling and fabrication facilities, the [university department] forecasts a £4.9 million net increase in its income over the next decade. The likely financial impact on UK GDP will be in excess of £200 million by 2014 as the technology infrastructure created in this project will underpin the development of the next generation of MST-based products.

7.7 Outcomes – Primary Data

Outcomes in terms of different actors' understandings of success and failure have been discussed using a role-ordered matrix in table 7.3. This section will now provide further understanding of the outcomes of this MNT government intervention from the actors within Mercury. In order to facilitate this, at the end of each interview, the following question was asked:

'Do you think that publicly-funded initiatives such as nanotechnology centres help industry to exploit emerging technologies?'

In answer to the above, Dr. Dickson said '*I think it's patchy [sigh]. The picture I get suggests that some have done very well and others have not'.* He adds the caveat that *'maybe that's true of any portfolio of investments.. you know.. I don't think anyone is good enough to invest in many different centres and expect them all to thrive*'.

Dr. Rubin said yes to the above question:

> '*Especially those companies, who seem to be small companies, that can't afford to develop the capability themselves.. from micro SMEs to medium size SMEs with a few hundred people.. it tends to be only the huge, multinational companies, that have the resources to develop these type of capabilities in house. And they're the ones that keep quiet about it, don't want to give away their knowhow*' (Dr. Rubin).

In reference to Mercury in particular, Dr. Newton took the view that '*they are good and their quality level is good, but potentially the delivery on-time mechanism.. may not be the best.. to some extent you'll sacrifice delivery accuracy for the quality of the machine setting or the quality of parts*'.

Dr. Plunkett said that Mercury was technologically ahead of private companies:

> '*the blunt answer to that is no I do not believe it is. And that's a real damning indictment on the organisation, but I don't believe it is. It might be academically, it might be. So we counter that by saying, yeh it probably has done some quite innovative research papers. But in terms of commercialisation now there are people who have technically commercialised it better than we have'* (Dr. Plunkett).

7.8 Summary

This chapter has presented a number of key findings from the major case, Mercury. Having presented these findings, an adapted version of the MIRP framework was used to organise the data, and provide evidence for these findings.

The perceptions of actors have been shown to differ greatly in terms of actors from a business background in comparison to those with an academic world view. Data from the ‘purpose’ construct enabled a comparison of the generic purpose and local centre purpose to be compared and contrasted amongst the actors. This was found to be particularly important when such perceptions inform an individual actor’s logics, and in turn lead to actions which alter the original intention of – in this case - the government intervention.

In terms of the ‘local context’, building on existing infrastructure is often seen as an advantage for setting up centres or expertise. However, the evidence from Mercury appears to suggest a less favourable outcome. The local context of this MNT centre is that of a university research centre, heavily influenced by professional academic actors. Findings show that the employment of business actors into this environment to steer Mercury toward a commercial footing (as per guidance from the state actor – the TSB), leads to contestation, and competing logics. This is shown to have had an effect on the ultimate action taken by the TSB to withdraw funding, and close the centre early.

In addition, the ‘extra local context’ highlighted issues related to the transfer of one large intervention programme from one government body to another. In particular the purpose was seen to alter during this transition period for the main case. This led to contestation between the local field actors (i.e. those in the MNT centres) and the extra local field actors (i.e. the state actors in the government body- the TSB). The argument from one of the most influential actors within this centre was that the ‘goal posts were moved’ during this handover. In other words, he felt that what the centre had signed up for initially was then altered, although evidence shown displays how this may not necessarily have been the case.

The next chapter introduces the comparative MNT case centres, and analyses them according to the constructs, as this chapter has done. The common themes running across the comparative cases will then be compared with the in-depth findings from this chapter, and discussed.

Chapter 8 – Cross-Case Comparison of the MNT Centres

The presentation and analysis of the main case study data highlighted the relevance of those constructs selected to investigate the MNT government intervention. However, a deeper understanding of the MNT network (and government interventions in general) could be garnered with further data collection. This led me to investigate a number of comparative MNT case centres and associated actors. In turn this will allow the development of the findings from the major case, and generate further understanding of the MNT government intervention.

The findings from the main case were structured according to the constructs used to gather the data. They were used to help explain the social phenomena within the MNT government intervention. These constructs initially consisted of those from the MIRP programme. They were then developed to include a number of others to provide a deeper level of abstraction with which to gather and analyse the MNT field data. Having structured the main case findings around these constructs, I found that equal attention was afforded to each category, which in turn distracted attention from the inductive theory building nature of presenting and understanding the findings. *In order to overcome this* the cross-case comparisons are presented differently, using comparisons of centre characteristics where appropriate. This presents the findings in a more suitable way for addressing contingencies, dynamics, boundaries and conventions.

8.1 Conceptualisation of the MNT Network as a Field

The institutional theory literature has been introduced in the extant literature chapters. Using the concepts discussed, the MNT government intervention can be understood as an organizational field using Scott's notion of field (2001). There are multiple actors in a range of organisations in the MNT field. These include: key suppliers (MNT centres); state agencies (DTI, TSB); resource and product consumers (customers, e.g. UK SMEs and other MNT centres); and other organisations producing similar services or products. Through viewing the MNT case through an institutional theory lens the notion of institutional logics is also introduced, helping to conceive the way actors are able to interact continuously within the field. Institutional logics provide the categories, beliefs and motives – i.e. organizing principles – that inform members of how to conduct themselves in the field (Delbridge and Edwards, 2007; Reay and Hinings, 2005).

Institutional logics provide a way of understanding the MNT case which brings together a wide range of actors with different demands, relating to the actions of others.

To understand the meaning of a field one must understand the actors who establish it and those within it who confer legitimacy. The MNT field presents an opportunity to cast insight on the emergence and legitimation of such a nascent field.

8.1.1 Understanding of the MNT Network as a Field

The MNT network has been understood as an organisational field borrowing concepts outlined in the extant literature. The MNT network is comprised of a number of organizations which comprise the MNT government intervention. Within the organisational field are the actors; three groups were identified during analysis of the main case study. These are *academic, industrial* and *state agents*. Arrows link the actor groups to their individual logics. Put simply, logics inform the actor's actions. Action is mediated through the structure of the network and/or logics that inform the actors. Action is conceived as the outcomes which might be a mix of contestations and pragmatic collaborations. These actions have consequences, and for the case of the MNT government intervention, I have described these in terms of outcomes - particularly in terms of success and failure, from the perspective of different actors, in specific contexts.

8.2 Comparative Case Data

Table 8.1 below lists those additional MNT field stakeholders also interviewed to add further depth to the cross-field analysis. The position of each actor along with the links they have to the individual MNT centres is also provided in this table. Position is included to illustrate the potential an individual actor has to carry out actions upon their centre (or linked centre). For example, Mr Morgan - the MNT Operations Director – is in such a position that he was able to withdraw funding from centres deemed to be failing in their remit. This is evidenced by the early closure of Mercury. An additional example is that of Mr Gillette; he is in a senior decision-making position within his local MNT centre, however in the wider setting of the university within which it is located, he has limited influence on the university procedures.

Links to MNT centres helps to locate the additional field stakeholders within the overall MNT network field. For example, Mr Strauss is the local RDA for a number of MNT centres, however he is not responsible for the direct day-to-day running of the centres, but was involved in the initial setting up and tendering approval processes for the centres.

Table 8.1 - Additional MNT Field Stakeholders Interviewed

Field level	**Interviewee [position]**	**Links to MNT centres**
Government advisor	Prof. Hertz [architect of the MNT manufacturing initiative]	Led the selection panel for the centres
Government body (e.g. TSB, Nano KTN)	Dr. Daimler [a TSB Director]	Part of original selection panel
Government body	Dr. Dickson [a member of TSB steering group]	Linked to Mercury
Government body	Mr. Morgan [MNT operations director]	Oversees all centres for the TSB
Government body	Dr. Teller [Nano KTN senior employee]	Involved in knowledge transfer events and dissemination that the MNT centres are exposed to.
Regional Bodies	Dr Strauss [RDA manager]	RDA link for Mercury and Liber. Member of the UK-RDA-MNT group.
Regional Bodies	Mr. Archimedes [RDA team manager]	RDA link for Concordia. Member of the UK-RDA-MNT group.
Regional Bodies	Mr Neumann	Former RDA Director Member of the UK-RDA-MNT group.
Third-party (e.g. E&Y auditors)	Mr Rubik [Management consultant]	Organises audits of MNT centres for the TSB.

8.2.1 The Actions of the Additional Stakeholders

The additional stakeholders in table 8.1 – *although not physically present in the actual centres* – have had an influence in shaping their associated centre, or in certain cases the wider organisational field. For example, Professor Hertz led a UK trade mission to France and Switzerland in 1999 to observe how other countries were dealing with micro- and nano- technologies. This UK trade mission was a government funded tour to other countries in order to observe their technological progress and compare findings with the UK. He took 20 experts from industry and academia on this trade mission. Professor Hertz described how it '*became very obvious that what [the] French and Swiss [were] doing was far in advance of what [the] UK [was] doing. Little or no commercialization of MNT [was] taking place in the UK at all*' (Professor Hertz). The group of experts then decided to form the 'Micro systems and nano technology Manufacturing Association' (MMA), and lobbied government heavily to get funding for the technology. Chapter 6 outlines the rest of the process which led to the formation of the MNT government intervention; this example illustrates how certain actors have been able to influence the development of the field from the start. Drs Daimler and Strauss, and Mr Neumann were also heavily involved in the tendering process of the MNT centres, and were part of the original selection panel. The inclusion of such additional actors in the data collection was therefore important to provide a fuller understanding of the MNT organisational field.

8.2.2 Comparative MNT Centres and Associated Actors

Table 8.2 provides details of the MNT centres which are compared within this chapter. This table describes each centre, some *basic* background (so not to identify the real centre), along with those interviewed and the centre name. The following narrative builds on the information in the table to help contextualise the centres and the actors in more detail. The origins of the centres are discussed, along with more details of each centre's Director. It became apparent from the interviews that the centres did not interact closely with each other in the field. Mr Gillette (Lucretia) and Dr Tesla (Rhea) did talk of working with other centres, however their comments related to ad-hoc relationships.

8.2.2.1 Mr Gillette, Lucretia – Lucretia was is based on a university campus, much like Mercury, and Minerva. The management team – overseen by Mr Gillette – have all come from the industrial sector. Only one senior employee is from the academic world. Lucretia is in a standalone building within the university setting, and appears separate when you enter it. Again, this is similar to Mercury. Upon visiting the centre, the feeling is of entering company rather than a university. Mr Gillette is responsible for the management of the centre, ultimately reporting to the university (and one specific professor). Lucretia does not take on PhD students/ other research students. Mr Gillette describes how they '*..don't do a lot of research, what we do do is a lot of development. So we would take somebody's research and actually develop it into something else. With some customers that's all they require* (Mr Gillette). Mercury, as a centre which is similar in venue, does cater for research students and PhDs. Lucretia is in a university setting, however clearly acting as a business. Mr Gillette runs the centre as a business, and describes how he manages to work around the slow moving, bureaucratic management highlighted by Lambert's white paper in his review of business-university collaboration (DTI, 2003). When asked how the venue of Lucretia helped or otherwise the purpose of the centre, Mr Gillette said '*It doesn't! It doesn't really help. We have to manage our relationships. The university has a number of different ways of doing things*' (Mr Gillette).

8.2.2.2 Dr Nobel, Liber – As the pseudonym of this centre suggests (Liber meaning 'free'), one of the main aims Dr Nobel had with this centre was to set it up independently of the university, despite the university still having a major financial stake in the host company which was awarded the MNT funding. Having had a poor experience of working within a university environment in terms of developing new commercial technologies, Dr Nobel deliberately sought to move to a Science park as the venue for his centre. He explains how he moved from industry to a university '*specifically to set up a commercial operation; and after two years of that operation it was obvious that actually to run a commercial business operation within an academic building was impractical. So one of the main tenets of our proposal was that we would be a fully autonomous, commercial centre, run commercially and by a commercial organisation*' (Dr Nobel).

8.2.2.3 Dr Alvarez, Bacchus – This was the only centre in the sample set in a global organisation. Upon searching for information about the centre and upon arrival, a visitor would find it difficult to extract the MNT centre from the main host organisation. That is, the MNT centre was not apparent, it was subsumed by the wider organisation. The fact that the centre was in the context of a large host organisation appeared to have hidden the individual centre.

Dr Alvarez described how the centre was formed: '*the [DTI] said, well we have got certain big companies doing stuff but they tend only to do it for themselves, so let's set up some new ones but also don't let that go to waste, let's see if we can, and they called them high impact facilities. Let's see if we can put a little leverage into some of these established facilities with good track records and say, would you work for other people and what would you need to do it? And we said we would need more space to do projects for others. So we extended our clean room to take that into account and the plan was also to hire new people, which we have done to the tune of 2*' (Dr Alvarez).

Out of the sample in this study, Bacchus was unusual in the sense that it was given money to extend their offering outside of their global company. They worked with 11 external customers throughout the life of their centre, which Dr Alvarez explains they were '*heavily criticised over*'. This may however be an effect of the difficulties associated with changing the traditional customers from internal to external customers.

8.2.2.4 Dr Apgar and Professor Pelton, Ulysses – One of the centres based on a science park, Ulysses was set-up for characterisation (i.e. measurement) of micro- and nano- technologies. In line with the DTI's original purpose statements, such centres were expected to be funded after the MNT grant finished, rather than become self-sufficient. However, in this case the centre was run by Dr Apgar – who had both academic and industrial experience. He describes how the '*main objective [of the grant] is to facilitate .. umm.. development in micro and nano technologies for the UK. That's the main objective: that's the Technology Strategy Board's objective*'. However, '*Our objective is obviously that, but my objective is to run a sustainable business*' (Dr Apgar). The manager of Ulysses was clear in his view that the centre should be self-sustaining (even though not a requirement by the TSB), because he had a longer-term view for the centre, and wanted to be able to keep staff in employment and invest in new equipment for the future.

8.2.2.5 Dr Russell, Concordia –Concordia was set-up on a university science park, and owned by the local university. He describes how the centre was initially run by an academic who ran the centre with '*an academic view of what industry needs*'. Dr Russell joined Concordia half way through its funded period to address problems with the direction of the centre: '*The University didn't want to renege on the original TSB* *plan. All the premise was on the plans that had been built [based on an inaccessible big-pharma model]… [They Uni] tried hard to stick with the business plans: [written] by academics (similar to EPSRC bids)….[But there was].. no substance*' (Dr. Russell).

Just as Mercury was forced to employ an external business actor, the same happened for Concordia. Dr Russell was employed as a consultant to improve the direction of Concordia, and in his own words: '*The TSB used emotional black mail on me [to become the CEO, because].. I had been involved in original identification of the centres*'.

In comparison to Ulysses which was also based in a science park, the management in both cases from the beginning clearly differed according to the individual centre directors.

8.2.2.6 Dr Tesla, Rhea – Dr Tesla was another actor who was involved in the original identification of centres. When discussing innovation and the difficulty with putting your resources in the right area, he described how he nearly didn't set-up his MNT centre: '*I actually nearly didn't take the money I have to tell you!. We had to be persuaded..bizarrely. I still sometimes go 'why am I doing this?'* (Dr Tesla). This tone reflected his strong business logics and the need to run a profitable business and stay in business. The local context of his centre takes priority over the extra local context of the MNT network. This is a fundamental observation of an MNT centre run by an existing private SME, demonstrated in the following statement: '*At what point do I start moving my brain to being back more [host company] - oriented [rather] than Rhea-orientated.. and of course the sooner I get even the slightest sniff that they are not interested anymore [i.e. the TSB, and their funding]..my brain will move..*' (Dr Tesla).

In terms of the regional location of Rhea, it is based in a region that has built on a strong history of global chemical companies, and aligns with this expertise. This provides some evidence of the regional context issues that may need further policy consideration when developing such national systems of innovation.

8.2.2.7 Mr Singer, Cardia – Cardia is based in an R&D centre (as part of a regional development agency centre). Mr Singer had a number of senior positions within the host regional development centre. His role (along with his team) was that of brokering relations between MNT suppliers within the area and local companies, in order to help them develop their MNT capabilities. Originally the centre's role was '*to manage some key bits of capital assets which was seen as de-risking and reducing cost of entry for people*' (Mr Singer). This then changed to:

> '*bring in other non-funded people who could help by making available to potential entrants to the nanomaterials world, their technology, albeit on a paid-for basis. And so we've steadily expanded the number of members of the alliance to about 30, 32 … So that anybody coming to us with a query on nanomaterials or a desire to get involved in the use of nanomaterials we can find a partner who can guide and do things for them – whatever*' (Mr Singer).

This centre is interested in a more regional context than some of the aforementioned centres, which focus on the local context.

8.2.2.8 Mr Cole, Minerva – Minerva is based on a university campus, in a similar venue to Mercury and Lucretia. However, Mr Cole described how he measured his centre's success in terms of '*Jobs created and saved, into [the] region..*' Further enforcing his focus on the local regional context, he explains how the centre is focused predominantly on one local global company. He described the driver for his actions as '*Creating more jobs [it's] all about this*'.

Table 8.2 – Descriptions of Comparative Cases

MNT centre	Interviewee(s) [position]	Technologies	Organization type	Ownership	Setting (context)	TSB Grant /Million	Start	Finish
Mercury	Main case (described in chapter 8)	Micro-machining Micro-fabrication	University	University	University campus	£2.5	2005	2010
Lucretia	Mr Gillette [Business Manager]	Microsystems Nanotechnology MEMS devices Bio-nanotechnology Micro-fluidic technology	University	University	University campus	£2.54	2005	2010
Liber	Dr Nobel [Managing Director]	Laser micro machining	R&D centre (e.g. technium)	Private micro SME (new)	Science Park	£1.75	2005	2010
Bacchus	Dr Alvarez [Director]	MEMS devices Micro-fluidic technology	Large firm	Global organization	Existing global organization	0.375	2006	2009
Ulysses	Dr Apgar [Manager] Prof. Pelton [Science park manager]	Characterisation (i.e. measurement)	University	University	University science park	£1.64	2005	2010
Concordia	Dr Russell [CEO]	Nanto-coatings Nanotechnology in food & pharmaceuticals	University	University	Science Park	£3.51	2005	2010
Rhea*	Dr Tesla [Director]	Micro-fluidic technology	Independent firm	Existing SME	Existing SME	£2.0	2006	2011

MNT centre	Interviewee(s) [position]	Technologies	Organization type	Ownership	Setting (context)	TSB Grant /Million	Start	Finish
Cardia	Mr Singer [Director]	Brokerage for MNTs	R&D centre (e.g. technium)	Regional development agency (or other publicly funded body)	Regional development agency centre (e.g. RDA)	£5.8	2006	2011
Minerva	Mr Cole [CEO]	Micro metal layering	University	University	University campus	£5.0	2006	2011

* An organization called ‘Prosperina’ in the Republic of Ireland was interviewed who used Rhea to develop their laboratory instrumentation devices. Details of this in the transcripts addendum.

8.3 Practice versus Praxis of MNT Actors (business, academic and state)

The purpose of the MNT government intervention from the view of the original state actor (DTI) and then the current state regulator (TSB) was introduced when describing the main case Mercury. Through comparing the findings from individual actors in this one case with the state views it became apparent that there are multiple logics being played out within this MNT field. Furthermore, this chapter adds a range of organisational structures into the mix which have a bearing upon individual actors. Hence the title 'practice versus praxis' – this refers to the theoretical purpose (or practice) of the MNT government intervention as per the original DTI description, in relation to the understood purpose through the actors in the field. The understood purpose refers to the 'praxis'; that is, how the purpose of the MNT intervention is actually carried out.

In the main case a number of different categories of actors were identified. These include business actors, academic actors and state actors; all of whom have their own associated institutional logics.

8.3.1 Generic Purpose of the MNT Government Intervention (Practice)

The generic purpose of the MNT government intervention in the eyes of the field actors is generally consistent. The use of the meta-table in the transcript addendum along with non-MNT centre based actors' interview transcripts enabled the development of table 8.3. Within this table a number of important themes emerge which align with the wider views of the field actors. Three themes are presented; firstly, there is the traditional economists' view of the need to address a 'UK market failure'; secondly, the need to 'de-risk' entry for UK businesses into the area of micro- and nano- technologies; and finally the idea that both of these issues can be addressed by creating 'open-access facilities'. These align with the themes found in the government intervention/ NSI literature (refer to table 3.1).

Two particularly influential actors in terms of purpose of the centres - historically, and currently - are Professor Hertz (originator of the GI) and Mr Morgan (TSB operations director), respectively. Professor Hertz instigated the original trade mission and government lobbying which acted as the precursor to the MNT government intervention. As such he has been described as the 'architect' of the centres within this thesis. Mr Morgan represents a more recent actor with the responsibility of overseeing the MNT centres on behalf of the TSB, and as such is a very important stakeholder.

Table 8.3 – Perceptions across the Organisational Field of the MNT Government Intervention Purpose (grouped into themes).

UK Market Failure The Economist view; funding is required for the centres because there is a market failure. ▪ The centres are not research, they are '*purely commercially focused.. research is well looked after'* (Prof. Hertz, architect of centres). ▪ Grant funding is given to fund the capital investment and then the centres are expected to move to sustainable businesses (Mr Morgan). ▪ Competitor organisations to the UK had created impressive centres, which became 'divorced from the needs of industry (e.g. Chalmers, Sweden).. [the UK Government therefore..].. tried to link in the needs of industry better in the UK' (Prof. Hertz). In other words a distributed model was used. ▪ 'Market failure & missed opportunity' (Dr. Tesla, Rhea). ▪ The UK had little MNT resources; therefore leverage those existing facilities and create a 'hub & spoke' network (Mr Neumann, former RDA Director).
De-risk entry into MNTs Entry costs are too high for businesses to exploit MNT technologies, therefore MNT centres provide the opportunity to access these technologies, without having to purchase capex. ▪ Emerging technologies: high risk. People do not want to invest, therefore need to be Government funded (Mr Neumann, former RDA Director). ▪ Funding: it is accepted that it is there to pump money. Costs are higher than a normal company could survive with (Dr Rubin, Mercury). ▪ The MNT centres can reduce the barriers of high entry costs to SMEs (Prof. Hertz). ▪ De-risk entry into nanomaterials and fill supply-chain gaps (Mr Singer, Cardia).
...by creating.. **open-access facilities** ▪ Raison d'être for the TSB.. 'selling to the wider community' (Mr Morgan) ▪ Open-access: Access to the technology for .. the wider community; not 'free' and not open access to walk in and use (Mr Morgan).

The majority of interviewees (and actor categories) viewed the general purpose of the government intervention through commercial eyes. The only actors that differed were the academic actors within Mercury. They were the only ones who felt research was an important part of the generic purpose.

8.3.2 Purpose – Relating to Individual Centres (Praxis)

Actors were asked to explain what they thought the purpose of their individual MNT centre was. The answers to this question offered a way of exploring the underlying organising principles of individuals in different MNT centre contexts.

A review of the resulting data shows how the actors adopted a wide range of interpretations for the purpose of their centre. In theory the centres should all aspire to the aforementioned 'generic purpose'. However, even Mr Daimler - one of the TSB Directors - admitted that '*different centres have different purposes*'. This is not perhaps surprising, but what is really interesting is how the actors assimilated individual meaning within their centres. Table 8.3 displays this data grouped by categories of actors and context.

The findings in table 8.3 reveal that the most significant theme appeared to be one which I will call 'Darwinian bias'. I will use this term to describe how each MNT centre biases their individual purpose according to their context, along with the organising principles of those senior actors who were interviewed. This creates a notable disjuncture across the centres. Reviewing the centres from a university context in table 8.3 it can be seen that the first (Lucretia) has a very strong business logic even though it is based in a university. Conversely, the senior professor running Mercury talks of developing '*true emerging technologies*' which are unlikely to generate much commercial income, i.e. a more typical understanding of university research. It would appear therefore that in the case of Lucretia, the organising principles of the senior actor – Mr Gillette - responsible for the centre appears to have had a bearing on the MNT centre. Mr Gillette fits with the IT description of an 'institutional entrepreneur', as an agent who is able to mobilize resources to transform an existing institution (DiMaggio, 1988).

The three science park-based MNT centres are all overseen by senior actors that I have categorised as business actors. All of whom are driven by business logics, i.e. they talk about '*commercially-led enterprises*', '*focusing on a product*', and being '*driven to cover costs*'. Dr Apgar from Ulysses runs one of the characterisation MNT centres, which means that technically no revenue needs to be generated. However during his interview he described how he had a large amount of both industry and academic career experience, which suggests that he is an actor driven by multiple logics. He has had experience of working within a number of different institutions.

The last two examples in table 8.4 relate to one centre in an SME setting, and another in an RDA environment acting as a brokerage, Rhea and Cardia respectively.

Table 8.4 – Actor's Perceptions of the Purpose of Individual MNT Centres

Category of actor	**Context**	**Perception of individual MNT centre purpose**
Business	University	▪ host runs the centre within a research department which must generate revenue. ▪ Generate revenue (high margins to recoup this, which may prevent open-access to SMEs) ▪ '*to be a centre of excellence for MNT-scale technology*' (Mr Gillette, Lucretia).
Academic	University	▪ to develop true emerging technologies (rather than those which are commercial ready, and likely to generate more revenue, e.g. *Liber?*) (Prof. Stephenson, Mercury)
Business	Science park	The original private company 'UK-Liber' was created to '*match the requirements of DTI programmes out at the time for <u>commercially-led enterprise</u>*' (Dr. Nobel); i.e. a new organisation to match government calls for tender.
Business	Science park	▪ [Science park/ business] Concordia – Dr Russell describes a '*product focused*' purpose. Does this move away from the generic purpose of open-access. Appears to be ran as more of a commercial business.
Business	Science park	▪ Not to develop technologies but measure/ characterise them. ▪ Less likely to generate revenue as other centres, but not expected to (the original remit suggests measurement centres and medical application centres are likely to require continued funding due to their nature) ▪ Driven to cover costs, and run the centre in a commercial manner (Dr. Apgar, Ulysses).
Business	SME	▪ The MNT centre enabled host to have an enhanced R&D capability (to increase longevity of host business) ▪ '*At what point do I start moving my brain to being back more []Rhea-host]-oriented than Rhea-orientated.. and of course the sooner I get even the slightest sniff that they're not interested anymore ..my brain will move.. But [the TSB] probably won't mind.. because as long as it sustains .. [they'll] probably be happy'* (Rhea). ▪ Investment in R&D/ supply-chain relationships ▪ Focus on emerging market which needs R&D (Rhea).
Business	RDA	▪ [RDA/ business] Cardia* - Brokerage, driven by making business-to-business collaborations, and partnering customers up, in order to push nanomaterials technology.

Rhea provides a very good example of the influence context and a senior actor's organising principles can have on the purpose of an individual MNT centre. Dr Tesla (founder of the host organisation, and director of Rhea) created Rhea as a research and development (R&D) centre which ran as a subsidiary project to the overall host company. In other words Rhea was deliberately decoupled from the host organisation. The centre provided Rhea with an enhanced R&D capability which provided the opportunity for its users to develop their applications further in the host company. Dr Tesla made it clear that this was not an altruistic move on his part; his clear business logic led his actions as company director to tender for the MNT centre. However, he did explain that the running of Rhea did align with the initial open access requirements of the grant. Importantly though, coming to the end of the grant for his centre, he posed the question:

> ‘*At what point do I start moving my brain to being back more host-oriented than Rhea-orientated.. and of course the sooner I get even the slightest sniff that they’re not interested anymore ..my brain will move.. But [the TSB] probably won't mind.. because as long as it sustains .. [they’ll] probably be happy*" (Dr Tesla, Rhea)’.

This is a good example of how the organising principles of a business actor are contingent upon both logics and context.

One of the essential goals of the MNT government intervention was to ‘*provide open access on equitable commercial terms to Microsystems and Nano Technology platforms and associated knowledge*’ (DTI, 2004). This linked to the concept of open labs described in the literature by Hung *et al.* (2004). It is notable that none of the actors placed much emphasis on this aspect of their MNT centre. This provides a further example of how the initial objectives of the MNT government intervention brought a group of field actors together, who then – *via their own institutional logics* – have appeared to push themselves apart. The cross-case analysis shows that the initial identifiable objectives and goals of the MNT government intervention, over time, has led to conflicting interpretations. For example Professor Pascal (Mercury) described how he viewed his MNT centre as being one of the more unbiased centres for open-access because of its positioning within a university. The suggestion was that his centre is able to provide unbiased/ impartial advice as he and his colleagues are not being driven by the same pressures as commercial organisations. Alternatively, Rhea saw an opportunity for signposting open-access customers toward their host organisation, providing the opportunity for future revenue generation. In a similar vein, Dr Russell of Concordia was very much focused along the lines of generating a product portfolio for exploitation. As such the general impression of allowing external actors to come and use the equipment was that it would detract from the business focus. However, Dr Russell *was* keen to get university research staff in to work at Concordia on short-term projects as a route for knowledge sharing, and a way of giving academic researchers industrial experience.

8.4 Roles

Scott's theorisation of institutions as pillars led the way for scholars to further investigate institutions (Scott, 2001). The normative pillar introduced the concepts of values and norms into institutional life. Norms specify how things should be done. However not all values and norms apply to all members of an institution, some apply only to certain actors or positions, i.e. roles[1]. Values and norms apply to all members of an institution, some apply only to certain actors or positions: Roles are the way we understand the goals/ activities that these particular individuals are likely to fulfil. This includes the way they behave, and the expectations from other important actors. The focal actor will also experience external pressure to conform to other actors' perception of their role. Thinking about roles will therefore help us understand more about the actions of the actors.

Roles add to the people construct explored by the MIRP categories by adding an understanding of actors' actions and agency *rather than* taking a more prescriptive view of what they do during the innovation process. Essentially roles help us to understand what people do.

The previous section discussed the way in which organising principles vary amongst a number of identified categories of actors in the cross-case sample (business, academic and state actors). In turn their actions have enabled the production of different MNT centres with different purposes, which I refer to as 'Darwinian bias' (i.e. they have evolved to suit their own purpose). The foundation for this Darwinian bias *appears to be* within centres rather than across centres, which leads to one important aspect of this cross-case analysis, i.e. **how the actors have assimilated individual meaning within their centres, and how these local logics have worked through a centre**. This section will now address this and related questions.

[1] Roles are '*conceptions of appropriate goals and activities for particular individuals or specified social positions… these.. are .. normative expectations.. of how the .. actors are supposed to behave.. the expectations are held by other salient actors in the situation and so are experienced by the focal actor as external pressures*' (Scott, 2001, p.55).

8.4.1 Local Field logics

A recent example of scholars who have investigated change within an organisational field is that of Reay and Hinings (2005). The field they investigated – healthcare - was already established, with a dominant institutional logic in place (physician-centred). However, in the case of the MNT national system of innovation, the field is nascent. Subsequently it had no existing dominant logic/s to begin with. In order to understand how the actors have assimilated individual meaning within their centres there is a need to consider institutional logics on a local level, i.e. the organising principles in the context of individual centres.

The nature of the state intervention under investigation by Reay and Hinings (2005) afforded them a plethora of written, publicly accessible documents with which to characterise the logics for the field's actors. Unfortunately, as discussed in the methodology, very little secondary information exists for the MNT government intervention. As such, greater emphasis had to be placed on the interview transcripts of actors in order to understand the local logics of key actors. A number of methods were used to ensure high quality of the data collected, including interviewing of the most senior members of each MNT centre (see methodology chapter). This process was inductive and carried out in parallel to the IT literature review.

Responses and views from each actor's interview transcript were then used to develop a summary of indicators relating to the belief systems and associated practices/ activities for the local institutional logics of the MNT field actors. Where accessible secondary data was also used to help attribute these logics to an actor (and the centre they represent). Table 8.4 shows the result of this analysis.

Table 8.5 – Comparisons of Institutional Logics for MNT Centres

Logic	**Belief system** (what goals or values are to be pursued within a field?)	**Associated practices/ activities** (means for pursuing the goals and values)
Business / Market	▪ Customer is King ▪ Commercial success ▪ Develop technologies users want ▪ Technical problem-solving ▪ Inward-looking (i.e. Darwinian bias) ▪ Extend supply chains and services.	▪ Business strategy, clear organisational objectives. ▪ Products on shelves, generation of income stream ▪ Market awareness, understanding customers ▪ Enjoyment of problem-solving; technology and product development. ▪ Target driven to reach project goals. ▪ Employing industrially experienced professionals; emphasis on creating the right team with a balance of skills. ▪ Create 'work-arounds' when stifled by a large organisation's bureaucracy ▪ Collaboration through building networks, connections. Some linking of academia to industry. ▪ Motivate staff, and drive forward (keep the highly skilled experts interested)
Professional Academic	▪ Curiosity-driven research ▪ Technology development ▪ Secure funding for future research ▪ Academic publication ▪ Career promotion (i.e. publish or be damned environment of academia)	▪ Develop new technologies ▪ Trying new things, testing and seeing if they work (failure is okay) ▪ Dissemination through writing journal papers; presenting at academic conferences. ▪ Achieve project targets (projects do not have to be profitable to be successful) ▪ Grant applications
State	▪ Linking academia to industry ▪ Safeguard public-spending ▪ Develop economic competitiveness (on a global, state and/ or national level) ▪ Create jobs	▪ NSIs, government interventions ▪ Auditing of NSIs etc. ▪ Promote technology development for the benefit of UK markets and manufacturing.
Management consultant	▪ Driven by meeting targets ▪ Overseeing public spending as a third party	▪ *see business logic* ▪ Treat MNT centres in a similar way to large organisations: i.e. use of typical business measures and audits

In order to investigate the concept of roles further, it is important to harmonise the terms I have used so far for each senior stakeholder within the MNT centres. For each of the centres investigated for this cross-case comparison, the most responsible and senior member of each centre was identified and interviewed. The range of reported job descriptions included: *CEO, Director, Managing Director, Manager,* and *Business Manager*. The majority of these centres were small (tens of employees), and the levels of responsibility of those interviewed were similar in the sense that they were the ones ultimately responsible for running their MNT centre having the most influence in terms of decision-making. As such are all classified as 'Centre Directors'. The comparison of these eight Centre Directors provides a reasonable sample for this role.

In addition to the Centre Director role, a number of others were also interviewed from the field participants which include: an NSI architect (i.e. the man responsible for setting up the MNT intervention); a Science Park Manager; an MNT Operations Director and one Management Consultant.

A role-ordered matrix was created to present and analyse the findings from the cross-field actors, and investigate the aforementioned roles, logics and the assimilation of outcomes for their centre. Table 8.5 displays the first part of this table, and the complete table can be seen in appendix 8a. This table is now discussed.

Remaining actors from a number of other field organisations (e.g. RDAs) have not been included in this table, because they have been considered not to have such direct influence on the decision-making of these centres. The few influential cross-network stakeholders who have been included are considered to be 'decision makers', and their actions have a potential effect on the organisations in the field, which is why they are included. The decision makers include; Professor Hertz (government intervention architect), Mr Morgan[2] (MNT Operations Director) and Mr Rubik[2] (Management Consultant responsible for external auditing of the centres). They are included because their actions are likely to affect (or have affected) the outcomes of the centres, along with the internal actors for the centres.

The concept of whether the type of logics that the actor was following was exclusive or not was deduced referring to the original transcripts. *Exclusive* describes the case where an actor's logics all appear to be toward one coherent set of beliefs, for example Mr Gillette was heavily driven by business logics. Conversely, Dr. Alvarez was considered *not exclusive*, because his over-arching problem-solving logic appeared to be at odds

[2] Note: Mr Morgan and Mr Rubik have been categorised as 'state' actors. Technically they are third-party consultants seconded to work on the MNT government intervention. In the case of Mr Morgan he is seconded full time as the MNT Operations Director for the TSB overseeing the intervention. In the case of Mr Rubik he is a consultant overseeing the Ernst and Young auditing of the centres, contracted to the TSB. As they are both working for the state actor – the TSB – then they have been categorised as 'state agents'.

with his business logics. Clearly he was part of a large commercial OEM, however he described how his R&D centre had to ‘play at business’ in order to satisfy the accountants. These comments alluded to secondary logics competing for adherence to multiple belief systems.

Table 8-6 - Role-Ordered Matrix: Linking Actors, Roles, Logics and Agency (see appendix 8a for full table).

ROLE / Category or actor	**CONTEXT / Centre**	**Assimilation of OUTCOMES for their MNT centre**		**LOGICS** /belief systems /Exclusive or not exclusive	**Examples of associated practices/ activities**
		Success	**Failure**		
Centre Director /Hybrid	University science park /Ulysses	▪ successful companies growing on back of Ulysses' services ▪ Repeat business	▪ lack of clarification of expectations from both the centre & customer: there is a need to *really* understand what is being achieved. ▪ Some customers set out in one direction, then realise no money to be made and change product line accordingly.	▪ Business [Not exclusive]	▪ Collaborations ▪ Target-driven ▪ Employing high skilled individuals ▪ Helping start-up companies ▪ Run the centre to generate an income stream (cover staff costs)
Centre Director /Business	University /Lucretia	▪ Happy customer: ▪ Repeat business ▪ In top two of the Yole review	▪ Don't win business ..or having won it, fail to complete the task. Why? We/ or customer didn't understand it/ scope it properly/ communication breakdown between organisations. ▪ *Caveat*: failure is a valid outcome of research.	▪ Business [Exclusive]	▪ Employs his staff to achieve market targets. Avoid research, that's for the academics. ▪ TSB tried to change objectives; Mr Gillette invited the TSB board in to 'explain' Lucretia's contract to them and how Lucretia did not have to pander to their added requirements. ▪ Example of new business development manager being paid for results, and if he doesn't perform he is out. Uni HR had a different view on performance-related contracts, but Gillette tells them this is the way it is (like industry). ▪ Target-driven ▪ Rebellious

An overview of table 8.5 shows that eight different MNT centres have been included (comprising 9 interviewees). 7 out of the 9 centre actors interviewed were categorised as having a 'business' background. Two of these centres were based in university settings. An example from each centre context has been included; one university science park; two local development agency R&D centres; one university; one existing SME; one RDA; and one large global organization. Although only one actor is interviewed in each case (apart from Ulysses), those interviewed are senior level actors, more often that not qualified to PhD level. Their view is therefore considered to be more experienced, and *of interest*. The predominant role of those interviewed is that of Centre Director.

8.4.2 The Role of Centre Directors – in terms of Outcomes

The majority of Centre Directors in table 8.5 have been categorised as having a business world view. Only one of the Centre Directors was considered to have a hybrid classification (i.e. business and academic backgrounds). The business actors follow the 'commercial' view of the world as do the business actors already outlined in Mercury. For example, Mr Gillette talked about satisfying the needs of customers '*giving our customer what he requires, at a price he can afford, which is commensurate with the task*'. This notion of a happy customer was also emphasised by Dr Alvarez, and Dr Nobel described success in terms of '*serving the needs of industry*'. Further comprehension of success included the launch of successful products (Drs Russell, Tesla and Mr Singer); in Mr Singer's words: success as '*ultimately product on the shelf*'.

Actors such Drs Alvarez and Tesla also talked about advancing the UK technology base, and *uptake of new technologies* into application areas, which aligns with the original MNT purpose.

Nearly all of the Centre Directors were identified as having a *business* logic, which describes how they exhibit characteristics which are: commercially-led; lead to the development of commercial products, and generation of an income stream. Furthermore they are market aware, and are in tune with customer needs (refer to table 8.4). This aligns with the notion of collective identities introduced in institutional theory literature (Tajfel and Turner, 1979; Reay and Hinings, 2005).

8.4.3 The Assimilation of Outcomes by Centre Directors

This section now discusses how actors of the Centre Director role have taken on board individual meanings from their business logics, along with examples of how these have manifested in the associated practices/ activities of themselves or the centre.

Gillette describes how he employed a business development manager on a performance-related contract (unusual in a university). If the employee doesn't reach their commercial targets, they are relieved of their position.

Dr Nobel explains how he facilitated a quick exit plan from the university where Liber was initially based. Having joined the university from industry he explained how it:

> '*was obvious that actually to run a commercial business operation within an academic building was impractical. So one of the main tenets of our proposal was that we would be a fully autonomous, commercial centre, run commercially and by a commercial organisation*'. He added '*I have no doubt that the commercial expansion is not possible within a University environment*' (Dr. Nobel).

Dr Russell describes how within Concordia he had to separate the management from the university; '*i.e. if [you] allow Uni[versity] to make decisions about what we do..[we've] got no chance!'* Included in this was the need to separate Concordia's finances from the university system. Russell further explained how the original business plan for Concordia was unrealistic. He was driven to re-focus the business plan. He talked about his commercial plan to:

> '*make a large amount of money in a short amount of time.. [and his] personal passion .. to sell a product. May sell up to corporates .. (but doesn't benefit UK).. [so why develop?] because you generate thousands every time [you develop an incremental product]*' (Dr. Russell).

Dr Tesla made the point that '*R&D is no use unless [it] results in income generation of some kind.. otherwise we're just messing about aren't we! Just giving Universities loads of money for just messing about*'. In terms of agency, Tesla does continually invest in R&D and collaborations to keep ahead of the game, *but* he is clearly focused on generating income from it. Unlike the other centres, Rhea is run by an established manufacturing host which he set up. He is very open when he describes his bias toward maintaining the sustainability of the host business, when nearing the end of Rhea's grant period.

Cardia was the only centre acting as a brokerage in my sample. Mr Singer was highly driven by enabling 'business to business' (b2b) collaborations, which would result in products on the shelf. His business logic is shown when he actively markets the benefits of MNT for making money.

Industrial Actors not following the Business Logic

As is often the case with data, there were a few anomalies in terms of industrial actors not following the business logic. Mr Cole and Dr Alvarez provided such examples. Mr Cole was driven to create jobs. He said '*It's not about the technology, it's about the people, the softer issues, where they live etc*'.

Dr Alvarez runs the Bacchus MNT centre within a major global organisation. Bacchus itself sits within a research centre with hundreds of employees, and only received a fraction of grant funding in comparison to other centres. Dr Alvarez explained that this was due to the host organisation's existing infrastructure (i.e. this concept links back to the leveraging of existing capabilities in the UK).

Alvarez talks of himself and a senior colleague keeping '*most of the people away from the normal company drudgery that upsets a lot of people and they tend to be in the lab 90% of their time I would say*'. He is driven more by a *problem-solving* reasoning than a business logic. He is dismissive of how the host company accountants treat each unit as a little business which has to generate money. He gives an example of how product x took longer than people thought, and how '*actually things don't need to come in as quickly as people think. We were always told every Christmas on product x, if it doesn't work by the end of this year we have had it..'* but in the end product x became an incredibly important safety product, and is now in a large number of cars.

8.4.4 The Assimilation of Failed Outcomes by Centre Directors

This section discusses how actors of the Centre Director role have taken on board individual meanings of failure from their business logics, along with examples they provide which illustrate their associated practices/ activities. These examples were used to discover a number of themes, which now follow:

8.4.4.1 Communication – Poor communication between organisations; tasks and understanding the deliverables. Mr Gillette firstly describes a failure to win the business, and then having won the business failure to understand the task properly as a centre or as a customer of the centre. This leads to a '*failure to complete the task*' described by Dr. Tesla as a failed outcome. Dr Apgar, having experience of both academia and industry added that this stems from '*a lack of clarification of expectations from both the centre and the customer..Why? issues of expectations, and effort on something that isn't really important*'. There is a need to really *understand* what is trying to be achieved. From a brokerage perspective, Mr Singer describes how failure results from not bringing people together in order to collaborate and increase new technologies.

8.4.4.2 Business not Sustaining (financially) – Dr Nobel describes failure as the '*business doesn't survive beyond 5 years: complete failure*'. Dr Tesla adds a sobering view on the whole purpose of this government intervention when he states 'the r*oute to sustainability might mean: actually forget the UK, and concentrate on overseas sales. The reasons for setting up the MNT Network in the first place – which is market failure and missed opportunity – it would be an acceptance that the market had failed in the UK*'.

8.4.4.3 Lack of Business People Leading/ Working in the Centres – This was a common observation made by industrial actors associated with Mercury. Analysis of the cross-field actors shows that it is also a major concern for them; although, it should be noted that the majority of actors in table 8.5 are categorised as 'industrial', which is likely to bias their view of non-industrialists running or working in the centres.

Mr Gillette is particularly dismissive/ disparaging of academics when it comes to their commercial ability. In terms of his actions he employs one academic out of 31 staff in the whole of his organisation. The academic (a Professor) is the Director of Lucretia, and Mr Gillette is the next in line in terms of responsibility. This centre is based on a university campus. Comments such as describing the university as '*care in the community for the terminally gifted*' – although voiced jovially - give an indication of his underlying beliefs. He presented a paper for the UK Trade and Investment which discussed the interface between commercial organisations and academia. The alternative title he gave it was 'cat-herding for beginners'. An anonymised version of this can be seen in the transcripts addendum.

When asked to elaborate more on his views of employing academics/ researchers within Lucretia, Mr Gillette explained that training was one of the major issues:

> '*In order for us to function we can't take time to train people to that extent. And that's actually what it boils down to. It's people we need to be able to hit the streets at a dead run. We don't have the luxury of... The standard university model is that you employ somebody and then you train them to do the job. That's actually how [our] University works. If you want to be a senior librarian they'll bring you in and then they'll teach you how they want you to be a senior librarian. And therefore they inculcate you with their own culture and their own methodology etc. Here, we take exactly the opposite stance. We go to the marketplace and say 'We need an engineer with background in these processes using this type of equipment with this type of experience'. And that's who we recruit. So on the first day he arrives here he is actually starting to contribute to ... And we are covering his wages frankly*' (Mr Gillette).

When asked about sharing of research projects/ ideas with the university, Gillette gives a recent example:

> *'For example.. we got a nice little research contract last year, and it's not anything the University does per se, but it was something we were interested in, and we took it forward and got some funding. we were accused by one of the academics of stealing his funding! And we said well 'firstly we didn't know about it, and secondly you're not doing that!'.. 'yes but I could have been, if I'd known about that!'. [big laugh]. You can't dispute that logic, so we don't try' (Mr Gillette).*

Dr Russell inherited a number of problems when taking over Concordia. From his account the major issue appears to have been that the original business plans were written by academics. Russell describes how when preparing the business plans '*lots of due diligence took place.. large OEMs [were on-board]..[there was] ..strong.. industry support [and] the reasoning seemed sound*'. The university tried to stick to this plan, even after the original focus on large pharma companies became problematic after a few years. At this point Dr Russell was recruited to address the concerns of the TSB. The TSB was concerned on two accounts; firstly, whether the university would deliver/ would intend to deliver; and secondly if they had no inherent interest. Similarly the TSB imposed an industry-facing CEO on Mercury in order to turn things around to their understood purpose.

Dr Russell described Concordia as a '*bit of a mess*' when he joined. Reasons he gave were that 'academics' were given a free hand when designing the original businesses model. The organisation was subsequently overseen by a science advisory group with 5 university board members on it. '*When I joined they had asked for a machine z tool [based on] an academic view of what industry needs*'. The problem here being that the actual market need was not considered, purchases were against a technical need. *'If a commercial person [saw business plan..they would say] there is nothing to sell, no service, no product.. nothing to sell'.*

He had exhibited a strong example of associated practice in terms of his focus on people, and more specifically recruitment. He addressed some of the above problems with a careful selection of 'capable' people with a balance of commercial and technical skills. Russell appeared to be strongly driven by getting the right people in with strong attitudes to what they do. He didn't rule out academic staff involvement, and actively encouraged university staff to spend time working with Concordia to share expertise, and gain industrial knowledge/ skills. Along with the chief technical officer (CTO) he strongly believed that there was a large potential for new technologies and IP to be developed from within universities.

Mr Singer described how it was important in his brokerage centre to employ those with industrial experience; '*if took young post doc/ young graduate and put in front of British Aerospace, to talk about the commercial value of nanomaterials, you haven't got a hope of getting their attention. If you were previously the Business Development Director for a mineral company and you stand in front of them and tell them that they will listen*'.

A key issue for Mr Cole was employing people and creating jobs. Interestingly his view of academics applying for the MNT grants mirrored his own activities which centred on people; '*you are an academic at uni.. desperately try and pay wage for your team, so you will do anything so you can go to the conference next year. You'll promise anything, fill any piece of paper*'. Mr Morgan – occupying a state role - describes how one of the roles of the TSB is to prevent such hijacking of the government funding: '*Further University investment is not the aim. It is not about subsidising Uni/firm development projects, they <u>need</u> to go out and charge a commercial rate. The <u>aim of the centres</u> is to move to standalone businesses to a greater or lesser degree*'. This demonstrates the clear tension and contestation within the MNT field.

Of the field actors interviewed, the industrialists were quicker to criticise their opposite numbers in universities, than was observed the other way around. However, Professor Hertz makes an important point when asked whether running the university centres with actors with more business acumen would have been better? '*This whole technical area is very complex.. a lot of the technology is at the leading edge.. and the people who understood it and even now understand it are academics… You've got this delicate balance between people who understand the technology and people you want to commercialise it*' (Professor Hertz). Mr. Rubik does also point out that 'In 90% of the centres, they haven't done anything different from what they said they would do' (Mr. Rubik). This perhaps begs the question why the proposals were accepted if the resulting network is felt to be 'notional' according to Mr Morgan.

8.4.5 The Assimilation of Outcomes by Actors with a Hybrid Background

This section discusses Centre Directors as well as other roles occupied by actors with hybrid backgrounds (i.e. those how have worked across multiple institutions). The way they assimilate findings is now discussed to see if any common themes emerge.

Dr Apgar and Prof. Pelton were interviewed concerning their centre Ulysses. They have both worked successfully within academic institutions and industrial institutions. Apgar describes how success for him is helping companies grow through using the services of Ulysses. Pelton concurs by describing success as helping companies get up and running.

When commenting on the more commercial nature of Ulysses in comparison to his experience of university departments, he says: '*as far as delivery goes, it might be the biggest difference is that our deadlines are daily, and research deadlines are yearly!*' Pelton adds:

> '*Market need is what I'm driven by. I don't think that the UK has spent enough money or effort on addressing market needs. I think we put too much funding into basic science and not enough into applied science and engineering. .. unfortunately this is interpreted by ..um .. academic scientists as being 'anti-science'. I'm not, I just don't see why 90% of our budget should go on pure science and 10% on applied'*. He is also referring to his role as the science park manager when he says this. Professor Hertz reinforces this: *'[the UK] always had very good research going on in nanotechnology, but not very much commercialisation…[the MNT programme is] Purely commercially focused. Research is well looked after. For last 10 years.. the equivalent 110Million pounds today is being put into nanotechnology research by the research councils'*.

Apgar and Pelton are both clearly driven by business logics as are the industrial actors. However they don't mention financial issues as much as other actors (bearing in mind each actor was interviewed according to the same interview template). However Apgar did refer to generating revenue in terms of covering staff costs. Ulysses was one of the measurement centres in the MNT network, and as such is less likely to generate large amounts of revenue like those centres able to develop products/technologies for sale/ licensing. Table 8.1 shows how the TSB doesn't require metrology centres to be self-sustaining. However, Apgar does treat the centre as a business, and Ulysses was nearly self-sustaining at the time of interview.

When asked about failure, interestingly both actors said that failure could lead development in other directions. So essentially failure is not a bad thing. Professor Hertz explained that '*Some failed projects can be used as the basis for a different project in a different market*' (Prof. Hertz). This aligns with the academic views found in Mercury.

Prof Hertz was instrumental in setting up the MNT government intervention. His comments refer to the overall government intervention. In terms of success, he referred mainly to the financial leverage the government achieved for the government intervention: '*I give great credit to Government.. if they hadn't put that sort of money up then the other money would never have been leverage*'. He also describes how investment is still continuing in this area, which is a successful outcome for him. When asked about specific examples, Professor Hertz mentions a number of outstanding MNT centres. One of which is *Lucretia*, managed by Mr Gillette; the other was not accessible for this research. In terms of failure, Professor Hertz said he was '*very disappointed that there haven't been more collaborations to date*' between the centres. This is likely linked to the other failure that he mentions: '*The idea was they were going to be co-ordinated [but] with the disintegration of the DTI, and loss of funding in that.. that never happened.. the remnants transferred to TSB*'. Professor Hertz touches on a common finding here across the field; numerous accounts were given of how the MNT network added value to the centres, but when it was dissolved and replaced with the Nano KTN (knowledge transfer network) this co-ordinating role diminished.

8.4.6 The Assimilation of Outcomes by State Actors

The state actors included both Mr Rubik and Mr Morgan, both of whom are employed by the TSB to oversee the MNT government intervention. They have a strong influence on the Centres and it is important to further understand their logics and actions. They are both management consultants recruited to oversee the MNT programme; Mr Morgan is seconded to the TSB, and Mr Rubik works externally for Ernst and Young. They have both been employed to – in their own words – '*look after the public purse*'.

Rubik and Morgan both describe success as the MNT centres within the intervention to be classed as Internationally competitive, and 'World Class' (which is a classic example of business logic). Unfortunately, Mr Morgan describes the reality of this: '*we do not have a network of World class facilities.. [we have] a collection of World Class centres; including technology available to people, which wasn't [there] before and delivering a notional supply chain*'. He explained that '*If [the government] want[ed] to build truly World Class Network of Centres [there was] too little money, too thinly spread to consider something World Class*'. Mr Rubik refers to this 'thin spreading of money' and blames this on the fact that the RDAs became involved in the original planning of the centres, ending up with nearly 4 times as many centres as originally planned: *'[The] original call for 5 or 6 internationally competitive centres..[the] RDAs were why the UK ended up with 23 half-baked [centres]..they might be regionally competitive as small businesses*'. This is an important point when considering the context within which the MNT government intervention developed.

To summarise the failed outcomes of this government intervention, Rubik bluntly states: '*good thinking and policy [led to] a pot of money.. then no longer joined-up thinking*'. This is a very simplistic view of a very complicated government intervention, however Mr Rubik does have access to all of the audit review documents of the centres, and as such has more data than most field actors on which to base his analysis. The same applies to Mr Morgan, although Mr Morgan was more reserved with his answers.

Both management consultants appeared to follow the logic I have called 'state'. That is, they feel driven to manage the risk to public money (i.e. the risk to the state). They see their role as governance of the MNT government intervention. Both act as gatekeepers to the audit data and recent Yole review data concerning the centres.

8.5 Context

A number of important findings in relation to context of the MNT centres have emerged so far in this cross-comparison review. This section will explore this disjuncture in more detail by exploring a number of emergent themes in relation to specific contexts.

A number of general themes emerged when analysing transcripts according to the *context* construct. Table 8.7 presents these along with the findings that help to illustrate them. For completeness, corresponding examples from Mercury and other field actors are included to enable further comparison. Each section of the table is split into themes, and below each theme are the direct quotes or descriptions to illustrate the theme from interviewees. The context each individual comes from is also given to show their framework of reference. In some cases actors such as Professor Hertz, or Mr Archimedes are not given a context as they are not associated with one specific MNT centre. A real tension between contexts is apparent in table 8.7. The main themes from this table are now discussed further.

8.5.1 University Context versus Industry Context

Considering the clear commercial purpose of the MNT government intervention, a number of actors purport that companies would have been a better starting point for them. Dr. Tesla explained why he believes this is the case:

> *'Companies do not start from scratch, they pull on existing resources, and have been working in the field for years..Anyway that's why companies should have done this because if you get a university doing it, although they will have argued that they had the same background as a company, they don't.. you know that's not true, that most universities run on the basis of a clever professor, and then he brings in fresh young PhDs and Post-Docs to do all the work, and somehow it works, but is not as effective as a whole team of people, and that's why universities have struggled and companies have found it easier'* (Dr. Tesla).

Table 8.7 – General Themes Emerging from 'Context' for the Cross-Field Actors

Embedded Centres versus Standalone Centres – *Using the capital facilities grant to leverage the development of existing MNT facilities*		
Context	**Organization pseudonym / actor**	**Illustration/ comment from actor**
Existing SME	Rhea/ Dr. Tesla	▪ additional R&D facilities to compliment the manufacturing facilities
Cost-centre in global organisation	Bacchus/ Dr. Alvarez	▪ more space and facilities provided by the grant, and ability to work with external customers (although they only worked with 10 or 11 during the grant)
University	Lucretia/ Mr Gillette	▪ occasional use of spare university capability.
University	Mercury	▪ wider use of host department's technologies
Commercial Credibility to Customers		
Science park (RDA)	Liber/ Dr. Nobel	▪ Sited on commercial science parks ▪ 'I believe that the commercial expansion is not possible within a university environment' ▪ Universities & research institutes or big organisations: 'inertia, lethargy'
Science park (RDA)	Concordia/ Dr. Russell	▪ Sited on commercial science parks; 'Concordia is in one of the UK's largest bioscience incubators' (Mr Archimedes, local RDA manager) ▪ Importance of being a 'commercial operation' & Universities not being suitable for this
University	Mercury/ Dr. Newton Mercury/ Dr. Dickson	▪ Importance of being a 'commercial operation' & Universities not being suitable for this ▪ Mercury charges too little: industry see universities as 'bargain' places
Existing SME	Rhea/ Dr. Tesla	▪ Importance of being a 'commercial operation' & Universities not being suitable for this
University	Lucretia/ Mr Gillette	▪ Lucretia is on a University campus, but essentially standalone in the way it looks and operates.
N/A	Mr Neumann (former RDA director)	▪ Success: '*those that look & feel like industry…blend & interface: porous walls between industry and research*'

Keep Control Separate from Larger Organizations - Bureaucracy of universities or global companies can restrict the commercial operation required of the MNT centres		
Science park (RDA)	Liber/ Dr. Nobel	▪ As Liber is a private Ltd company and not part of a University, Nobel describes how they can make commercial decisions that are <u>reactive</u>, rather than being delayed by going through finance departments etc. ▪ He can quote, accept orders, invoice, sign non-disclosure agreements (NDAs), and benefit from the financial and operational autonomy that being a Limited company affords them. This improves timeliness, 'which is not possible with the timelines in a university setting' ▪ He describes how universities work on different timelines and deadlines to commercial organisations. It's all about <u>commercial responsiveness</u>.
University	Mercury/ Dr. Rubin Mercury/ Dr. Plunkett	▪ Rubin refers to this as academic style versus industry style. ▪ Plunkett describes HR policies at Universities which prevent re-organisation of staff to a more suitable profile (i.e. can't sack people if not perform)[†]
Science park (university)	Ulysses/ Dr. Apgar	▪ E.g. '*daily deadlines versus yearly deadlines!*'
University	Lucretia/ Mr Gillette	▪ Mr Gillette describes problems with university HR policies – difficulty employing people on a performance-related contract. ▪ However, 'If you manage the environment, it's not too bad'
University Context versus Industrial Context		
Existing SME	Rhea/ Dr. Tesla	▪ '*Companies do not start from scratch, they pull on existing resources, and have been working in the field for years*' ▪ *'Anyway that's why companies should have done this because if you get a* ***University*** *doing it, although they will have argued that I had the same background as a company, they don't.. you know that's not true, that most universities run on the basis of a clever professor, and then he brings in fresh young PhDs and Post-Docs to do all the work, and somehow it works, but is not as effective as a whole team of people, and that's why universities have struggled and companies have found it easier'*.

Cost-centre in global organisation	Bacchus/ Dr. Alvarez	▪ Bacchus was set up in order to leverage existing facilities, client-base etc. However, Dr. Alvarez did say that they did not access as many external customers as they originally thought.
Science park (university)	Ulysses/ Dr. Apgar	▪ '*People in research groups especially high end.. focused on own research: don't look outward. We [in a science park] look outward.. otherwise* <u>*no*</u> *business*'
	Professor Hertz	▪ '*The maturity of the organisation that put money into the first place is a consideration. E.g. Nevlin Nanotechnology.. had money to commercialise existing equipment.. it blossomed.* <u>*Lucretia.. significant organisation to start with*</u>*. Very successful at raising money on the back of the grant (4 x multiplier on the DTI figure) now a significant player in nanotech. world*'.
Centres Should not be Managed by Academics - A number of interviewees expressed this as an important issue.		
N/A	Professor Hertz	▪ '..you need to get the balance right between the 'people who understand the technology and the people you want to commercialise it'.
Note: Examples where academics passed over the reigns (Prosperina, example of a customer of a start-up company of Rhea; and Concordia). The academics did their essential bit and then allowed actors with a stronger business logic to do their bit.		
Clusters/ Locations for Centres?		
N/A	Ulysses/ Professor Pelton	▪ '*Technology should have been kept where the clusters where, rather than politics of RDAs wanting a centre each*'
N/A	RDA Team manager/ Mr Archimedes	▪ Move away from the regional thinking to where best in the nation should the centres be? (AM).
N/A	RDA Senior Manager/ Mr Strauss	▪ '*relationship within Universities changes dramatically from [one] organisation to [next].. So no preconceived ideas.. because wanted as wide an MNT provision as we could to satisfy the needs of UK business'*.
Organisational Schizophrenia – confusion of centre purpose related to its institutional context.		
University	Lucretia	▪ Clearly commercial, but still underwritten by University.

University	Mercury	▪ Doesn't know what it is trying to be. Majority of staff focused on academic careers, only 1 or 2 focused on commercial. ▪ University view: '*hope earn some money from industry*' (Dr. Dickson). ▪ Difficulty of a university starting from scratch, compared to Rhea, for example. ▪ Bureaucracy- Use of academic staff for a commercial centre.

Tesla's comments agree with Professor Hertz's view that the maturity of the organisation you put the money into in the first place is a consideration.

Professor Hertz adds:

> *'What we found.. the organisations that have tended from scratch, tended to be in Universities, and they have had problems and struggled; they have struggled because people in Universities.. the people who ran them in Universities, were initially not commercially aware people. They were sometimes academics. It's been very important to divorce those activities from the research activities within Universities. Though there's a lot to be done still to do that.. about 8 or 10 of the 23 organisations came from those origins'* (Professor Hertz)

Dr. Tesla further questions the financial forecasts made at the beginning of the intervention, and the ramifications of setting up centres in universities:

> *'The reason why there <u>shouldn't have been any universities</u> involved in the MNT network and intention was that there wouldn't be, was that the 40 million was meant to then lever extra money from elsewhere.. so if you got 2 million [from the] government and you say well you really know how to do this don't you [Rhea's host company].. and we say 'kind of' … well if we give you 2 million will you make your expertise available to the rest of the UK? Hmm.. is that a good deal?. interesting offer? So by us accepting it, you have a win-win situation in theory, [Rhea's host company] gets a boost in the arm where it needs it in capital equipment, and in return makes available its existing equipment and all of its know-how available which is the valuable bit.. and government [is] happy that it's got all our expertise …[when the alternative was]...that it would have had to give [the money to] a Greenfield site… the money to develop…[such a site] would probably have cost a darn sight more than 2 million'.*

These comments once again illustrate the movement from Taylor's recommendation for a number of core centres (Taylor, 2004) in the original review, to a number of smaller centres to leverage more value from the limited budget.

In Dr. Apgar's experience of working in both industry and academia '*People in research groups especially high end..[are] focused on own research: [they] don't look outward. We [in a science park] look outward.. otherwise <u>no</u> business*'.

Conversely, if companies, and mature ones at that, are the better place to run MNT centres, then Bacchus presents somewhat of a quandary Bacchus was created on the back of existing micro- and nano- technology facilities within a major global manufacturing company. Compared to the other centres, a relatively smaller investment was made because of the establishment of the existing facilities. The investment bolstered facilities with a view for more collaboration with external customers (typically the host organisation concentrates on internal customers). Dr. Apgar explained that his centre did not access as many customers as they originally thought they would. He talked of working with 10 or 11 external customers over the three year project duration, however he did say that Bacchus had achieved the initial financial targets of the centre.

8.5.2 Commercial Credibility to Customers

One of the significant observations from Table 8.7 is the perception that MNT centres should be commercially credible to entice customers. Mr Neumann (a former RDA director) describes his perception of success as coming from integration: '*those that look and feel like industry.. blend and interface.. [have] porous walls between industry and research*' (Mr Neumann). Dr Dickson (Mercury) made the point that the university charges too little for services, and subsequently industry sees them as 'bargain' places. The business plan for Liber was deliberately created to move the MNT centre away from the university as soon as possible; Dr. Nobel explains: '*I believe that the commercial expansion is not possible within a university environment*'. He believes that universities and research institutes or big organisations exhibit inertia and lethargy. When he describes Liber, he talks of how it benefits from being in science park, and from its flexible, close-knit team.

When Dr. Nobel was asked about the perception that customers may not have seen Liber as being very serious when it was originally in the university, he stated:

> *'It's a <u>big issue</u> for us, and I went to University E from Industry, and I went there specifically to set up a commercial operation; and after two years of that operation it was obvious that actually to run a commercial business operation within an academic building was impractical. So one of the main tenets of our proposal was that we would be a fully autonomous, commercial centre, run commercially and by a commercial organisation*' (Dr. Nobel).

The non-university based centres from my cross-field sample appear to be the most customer-facing, and commercial. Lucretia on the other hand, appears to have been an exception to the rule. It is based on a university campus, in a university building, and a wholly owned subsidiary of the university. In spite of this, Professor Hertz describes Lucretia as 'outstanding', and says it 'is a significant player in nanotechnology in the World now'. Mr Gillette also explains how the recent Yole review placed Lucretia in the top few, when ranking the centres for the most successful (in terms of world class facilities and meeting the DTI/TSB purpose). When Prof. Hertz was asked about which contexts in his experience were the best for the MNT centres, he said '*I wouldn't like to differentiate between those in academia, or real world or large corporations. With hindsight, it depended on the maturity of the organisation that we put money put into in first place*'. Following this thread, he explained how Lucretia '*was relatively large, one of the significant organisations when we started the process. They have been very successful at raising money on the back of the DTI funding. The figure was a 4x multiplier on the figure the DTI gave them* [i.e. the centre generated 4 times the initial grant amount given to them]. *That has had a major boost to their activity on the back of the their DTI funding. 4 times multiplier*'. So the maturity of the contexts to begin with may well have been one of the crucial success factors.

8.5.3 Embedded Centres versus Standalone Centres

The maturity (i.e. whether the centre had an established history in MNT already) of the existing contexts used for the MNT centres ties in with the theme which emerged concerning the leveraging of additional resources. One of the original ideas of creating a larger distributed network of MNT centres stemmed from the idea that more leverage could be achieved by building on existing facilities. Moreover by doing this, the idea was that funding could stretch further, and make a larger impact on the UK micro- and nano- technology industry.

Rhea is an example where funding created an MNT centre to complement an existing SME. The funding afforded Bacchus, albeit relatively small in comparison to other centres, enabled the large global host to build more facilities. The aim of this was to expand their offering to more external customers. For Mercury, the initial intention was to use the host-university's resources to offer a more complete MNT service. However, the TSB altered this by requiring Mercury to be 'ring fenced' as a limited company. One of the reasons being that the boundaries were too blurred between what was university research work and what was Mercury work.

8.5.4 Keep Control Separate from Larger Organizations

Of those MNT centres based in larger organizations, there were many comments concerning how bureaucracy can restrict their operation. These are also illustrated by observing those centres which are not in larger organisations. Actors such as Dr. Nobel with experience of both large and small environments described the advantages of not being part of a large University. Nobel describes how his team can make commercial decisions that are *reactive*, rather than being delayed by going through finance departments. These include quoting, accepting orders, invoicing, and signing non-disclosure agreements. He describes how it is all about 'commercial responsiveness' which is not possible in universities which work in different timelines. Dr. Russell of Concordia describes how there is 'better communication, knowledge, awareness in the company'. He ensures cross fertilisation of teams and R&D staff who also work in production. This appears to avoid the 'lack of respect' he says is often seen from information channels in large organisations.

Those in large organisations such as Mr Gillette of Lucretia, describe how he has problems with the university's HR policies, and employing people on commercial contracts. Although, he does take the view that '*if you manage the environment, it's not too bad*', suggesting that a common path can sometimes be found.

Dr. Alvarez's problem-solving logic surfaces in his description of the issues his centre – Bacchus - has to contend with:

> *'..it is all about business. Or what us cynics would call, playing at business, pretending we are a business. It is a bit silly to say that a research centre within a huge company should be a business, but they are saying it should be. It is the mindless, slice everything down type of approach. The way they sell it to us is, you will be safe as long as you make a profit, nobody is going to say we want to close you down. But you could produce fabulous science but if you are losing money somebody might say, we will close you down because we don't care what the science is like'* (Dr. Alvarez).

8.5.5 Organizational Confusion

The concept of organizational confusion is an important theme in the major case Mercury, and describes how the purpose of a centre can become confused when organising principles of the host institution are taken into account.

In terms of the cross-field centres, Rhea is a good example of where this concept is observed. Dr. Tesla talks of the confusion often caused when customers come to Rhea through their collaborative networks. He talks of '*people coming in and saying 'what's this Rhea thing?' .. are you Rhea's host or Rhea?.. well we'd like to deal with Rhea's* *host, because we know you. Why would I want to deal with Rhea then*'. This was compounded when Tesla had to talk about sub-contracting work to Rhea: '*most companies get concerned when you say you're going to sub-contract.. they go 'what'.. [they] worry about if going to get cowboys to do it. They worry about whether [Rhea is] capable of doing the work..*'. This is one of the difficulties of running a centre within an existing organization. Due to the grant funding and state-aid rules, it would be very difficult to work around this, because money couldn't just be seen to go to a host company to bolster its facilities. Due to the strict state-aid rules, it is sensible that there needs to be a separate, accountable entity.

In sum, a range of different MNT centre contexts clearly bring their own advantages and disadvantages in terms of meeting the purpose of this MNT government intervention. Generally speaking the more commercially focused centres appear to find it easier to meet the commercial purpose of the intervention, whilst the university-based centres are considered to be inappropriate by many cross-field actors. However, Lucretia is clearly an outlier in this respect, and Mr Gillette and his team appear to have created a commercial micro climate within a traditional university setting.

8.5.6 Collaborations

The collaborations construct concerns how the formal and informal relationships among innovation group members; other firms & groups influence the function of the MNT government intervention (and Mercury more specifically).

Needless to say, due to the heterogeneity of the MNT centres, a wide range of collaborations were witnessed, with an equally wide range of actors' views of their usefulness. Those which appeared to be the most common are now described, with examples from relevant cases.

8.5.6.1 Closing of MNT Network and Replacement with Nano KTN

One of the main observations to note is that the co-ordination of this government intervention was lost with the morphing of DTI to TSB and subsequent MNT Network to Nano KTN.

In the main Professor Hertz had an extremely positive view of the MNT government intervention that he spearheaded. However when it came to the overall collaboration and co-ordination of the network he raised a few concerns:

> '*The intention of DTI was that the facilities would all be coordinated and managed. They had to have commercial independence [even though] there are state-aid rules and issues. The idea was they were going to be co-ordinated. But with the disintegration of the DTI, and loss of funding in that.. that never happened. The remnants transferred to TSB. TSB just monitor the public funding that's been put into them. They do that through Ernst and Young… what they don't do is co-ordinate activity.. there is nobody.. Tsar saying.. this company is doing this.. so why don't you do this with them, or try to attract other funding, e.g. venture capital'* (Prof. Hertz).

Hertz continues that he is disappointed that more collaboration hasn't happened to date. Just before Mercury was closed down, he was heavily involved in linking Mercury with another one of the MNT centres, as part of a last ditch attempt to save Mercury. Unfortunately – according to Dr. Rubin - this collaboration was not approved by the TSB.

Hertz further criticises the Nano KTN; he states it is:

> '*there to represent the whole of 'nanotechnolgy'…[however]… it pays lip service to micro systems technology .. they don't feel well represented. [It is] not there to lead the industry, or manage or co-ordinate the industry. It's there [as] an information provider for the whole of industry (not for the network or the 'facilities' as they're called). It has a completely different remit. [The] MNT Network.. was there to create the network.. to fund and create the strategy and all those kind of things…which is what the MNT did and was paid to do*' (Hertz).

Dr. Alvarez (Bacchus) agreed with Hertz's negative view of the Nano KTN;

> '*I mean one of our complaints in this programme was that, it was called the MNT Network was dissolved and morphed into the nano KTN. And the nano KTN virtually ignores the micro side whereas in the MNT Network you had guys who were trying to promote nano and they were trying to get the customers and the facilities together, they were really doing their job but it was in the early days but they were just dissolved. So we didn't get the help from the DTI that we thought we were going to get*' (Dr. Alvarez).

Dr. Tesla described the KTN's as '*rubbish*'.

8.5.6.2 Importance of Collaboration for some Centres

Of the centres, Ulysses and Cardia were particularly active in terms of collaborations. Dr Apgar explains that for his metrology centre:

> '*Collaborations are really, really important, because I don't think we could exist in isolation. If we can collaborate with a company to do research and development that is more.. product orientated than just pure research which would obviously be in the University, then I think those sort of collaborations are really important. And…they have a greater impact on our bottom-line. So all of those.. you can't do it alone, we don't make anything, we examine things here.. well we make some things, but we don't really make; my group doesn't really make things. So we have to collaborate*' (Dr. Algar)..

He also describes how there is a need to have strong industrial collaborations and relationships in order to know what is going on at the cutting edge of industry.

Mr Singer explains how Cardia's initial job:

> *'was to manage some key bits of capital assets which was seen as de-risking and reducing cost of entry for people.. into nanomaterials'. Through this they had their starting partners in an industrial alliance. Following this, their 'role was to bring in other non-funded people who could help by making available to potential entrants to the nanomaterials world, their technology, albeit on a paid-for basis. .. so .. steadily expanded the number of members of the alliance to about 30, 32'* (Mr. Singer).

As such, Cardia must have strong collaborations through its alliances in order to bring customers and suppliers together. Singer explained that at the time of interview they had around 150 business-to-business collaborative business programmes going on.

Collaboration was also an essential part of Dr. Tesla's focus for Rhea and its host company. He describes one European funded network which linked up a number of MNT organisations in order to complete the supply chain. He describes '*Research and Technology Development*' projects (RTDs), which have features known as service actions in them:

> '*the service action on the whole is where you have proven processes.. and offer them to anyone as open access service provisions. RTD is when you don't know the answer yet, it's Research. So the idea of Integral Plus.. is that you have within the same collaborative group of partners.. R&D going on to do the things that you don't know how to do, but as soon as you do know how to do it, it becomes part of the service of the things you do know how to do. So Integral Plus was effectively part of Fluence during that period, because the bits that we didn't know how to do were developed in Integral Plus, once we knew how to do them they were offered*

> *Integral Plus but also offered through Fluence. So, all the time Rhea is also through the projects improving its capability, and its relevance for its capability, and is using both itself and either Integral Plus or other networks to sell*' (Dr. Tesla).

Mr Gillette described a range of collaborations underway with Lucretia, including; membership of the 15 out of the 25 government KTNs; framework 7 programmes (EU funded programmes); work with large companies on developmental programmes; relationships with other universities; and relationships with other MNT centres. Lucretia can also take advantage of spare capacity within the university departments to their benefit; '*It doesn't happen all the time but where there is spare capacity in the university, we can take that up and charge competitive commercial rates*'. Likewise the university can use equipment at Lucretia.

8.6 Reflections on using the MIRP Constructs

Rather than structure the cross-case comparisons around the MIRP constructs as in the main case study chapter, this chapter presented the findings in a more inductive way. In some instances this included the use of comparisons, e.g. university versus industrial contexts, or business actors versus professional academic actors. This approach has enabled the dynamics of the MNT field to be explored in a less constrained fashion. This approach coupled with viewing the MNT field through an institutional theory lens has helped to highlight some of the shortcomings of the MIRP constructs. For example, if the MIRP constructs had been religiously adhered to, then some of the findings such as the assimilation of outcomes from different actors and the importance that logics have on the contestation produced within the MNT field, may not have been realised. The findings from the data collected in this study and those of the MIRP programme are discussed in more depth in the 'Discussion' chapter next.

8.7 Summary

The conceptualisation of the MNT network as an organizational field of actors has been introduced in this chapter. In doing so the theoretical notions of actors having logics which inform their actions (agency) has enabled a deeper investigation of how the MIRP constructs influence the MNT government intervention. Furthermore the interplay between an actor's logics and the context they are in has highlighted some unusual findings. For example, Mr Gillette (of Lucretia) is seen to have a very strong business logic and industrial background, however he is in a university. Compare this to Drs Rubin and Plunkett in Mercury, who were in a similar position. If Mercury was a typical example then one would expect Mr Gillette to have been overcome with the bureaucracy of his university, and the predominance of academic actors with opposing logics. Surprisingly, not only is Lucretia reported to be in the top two successful MNT centres, it is also described as 'outstanding' and 'world experts' by Professor Hertz. Having used the MIRP constructs combined with institutional theory, reasons behind such contradictions emerge. That is, in Lucretia of the 31 staff employed, only one (the Director) is an academic. It would appear that Mr Gillette has created a standalone commercial centre within a university environment.

The following chapter will draw together examples such as these and use the MIRP and institutional logics combination to discuss the implications of this research, and how this approach has been used to understand the MNT government intervention further.

Chapter 9 - Discussion

9.1 Introduction

The reviewed literature spanned a number of disciplines so as to fully comprehend the government intervention under scrutiny and to place it into its proper context. The framework for the MIRP research programme was then adapted and augmented.

The objective of this chapter is to open up a dialogue around the study's findings in relation to the academic literature used to investigate the research questions. Furthermore, the academic contributions which result from this study are discussed.

9.2 The Academic Contribution of this Study

A new method that helps us understand the innovation process in a recent government intervention has been developed, by working across disciplines and synthesising different methodologies. To understand innovation it is necessary to see how it is made possible in a meaningful (real world) context which is why the MNT government intervention was conceived using organisational field theorisation, with 'local' and 'extra local' contexts (Hallet and Ventresca, 2006).

In addition, the Minnesota Innovation Research Programme (MIRP) constructs have been used to gather data on a recent UK government intervention. The methodological approach adopted is that of the Interactive Process Perspective (IPP) as described by Slappendel (1996), and also what was effectively used in the MIRP programme. This approach overcomes the limitations of perspectives concentrating solely on individual action or objective structures.

The method used has synthesised the Interactive Process Perspective with an Institutional Theory (IT) approach, and has been used to further explain the complexities of the innovation process by demonstrating the co-operation and contestation between actors from different interest groups.

The Interactive Process Perspective pays attention to the understanding of how action and structure interrelate. The importance of this approach is recognised by others such as Edwards (2001) in assessments of similar government interventions. Table 1 displays a further contribution of this research in relation to Slappendel's findings. That is, the main features of the approach developed in this PhD add another viewpoint to the perspective of researchers investigating innovation at the organisational level.

Table 9.1 – Main Features of the Novel Approach using IPP & IT Theorisation in Comparison with the Interactive Process Perspective

	Interactive Process Perspective	**IPP & IT process (with MIRP constructs)**
Basic Assumptions	Innovation produced by the interaction of structural influences and the actions of individuals	IT theorisation further explains the complexities of the innovation process in terms of structure and action. In particular it demonstrates the co-operation and contestation between different categories of actors (i.e. different interest groups).
Conceptualisation of an innovation	Innovations are subject to reinvention and reconfiguration. Innovations are perceived.	Actors hold different orientations
Conceptualisation of the innovation process	Complex process	Complexity: IT introduces logics which represent interactivity. This explains the complexities of the process by demonstrating the role of co-operation between collective identities.
Core concepts	Shocks; proliferation; innovative capability; **context**.	**Context:** IT also shows the differentiated or contingent nature of social relations within a given context. Local and Extra local contexts.
Research methodology	Case studies; case histories.	Case studies; case histories.
Main authors	Van de Ven *et al.*[MIRP]	-

Source: Author (adapted from Slappendel, 1996, p.109)

9.3 Adding to the Empirical Data Store

Denrell (2003) argues that one of the main barriers associated with developing effective policy interventions is the lack of empirical studies in the literature which concern themselves with *failed* examples. The literature reviewed in this study confirmed an evident reliance on data gathering from successful cases alone. Denrell (2003) argues that this is due to the economic process which means that unsuccessful firms are replaced by individuals and firms with good performance, resulting in a limited sample of firms for research.

The main case study (Mercury) in this study provided evidence of failure in terms of achieving the purpose of the MNT intervention. The main objectives for each centre were to be open-access, and generate commercial revenue in order to be self-sustaining at the end of the grant funding. Coupled with this is the importance of providing a boost for UK manufacturers wishing to develop MNTs. Such an in-depth look at a failed organisation contributes to bridging this identified literature gap by adding a new and useful example of failure to the plethora of successful examples already in the literature.

9.4 Establishing Relationships between the Findings and Initial Research Questions

9.4.1 Findings in relation to Research Question 1

In response to the first research question *(how do government interventions such as the MNT network function?)* a picture of a nascent field was developed using a novel approach combining the interactive process perspective with that of institutional theory, outlined in the previous section. This approach made it possible to understand how the MNT government intervention functioned.

9.4.2 Findings in relation to Research Question 2

In answer to the second research question (*How can we describe stakeholder values and understanding in relation to the role of a nascent government intervention?*), the understanding of the role (in particular what constitutes ‘success’) of a government intervention, has been shown to vary greatly amongst actors and their local environments. This deduction describes the situation which needs to be addressed in national intervention policies (in particular technology policies) where state actors have an understanding of the local environment in which they are trying to achieve objectives. The findings from this study highlight the importance that local environments have on the original purpose of the intervention.

Kelley (1976) describes how the goals (i.e. ‘success’ for the MNT centres) of an organisation or organisational network are not monolithic. They are multiple and contradictory reflecting the dynamics of internal contestation and the interests of organisational actors. '*This process is one of continuous conflict, with goals of programmes constantly in the process of negotiation*' (Kelley, 1976, p.67).

9.4.3 Findings in relation to Research Question 3

In relation to the third research question (*How do the the following aspects of innovation management: purpose, process, people, collaborations, context and outcomes influence the success of emerging technologies in different organisational settings?*) more detailed findings were identified in relation to the MNT cases under investigation. In the main case Mercury, an in-depth analysis has provided particular evidence showing that – *for the MNT intervention studied* - these aspects have a particular affect on the local context and function of organisations which are part of a government intervention.

The study began by using an existing theoretical framework to gather and analyse data for the MNT government intervention; that is, the Minnesota Innovation Research Programme (MIRP). Constructs were used from this framework and more were added to cover the specific nuances of the intervention under investigation.

A gap in the extant literature concerning the links <u>between</u> the MIRP constructs became apparent. The use of an IPP perspective, and IT and IL theorisation enabled this gap to be further explored. This has been achieved by investigating the actions of actors within the local context and extra local context which they inhabit.

This added theoretical insight highlighted the importance that action and structure have on the constructs outlined in the third research question. Those of particular importance for the MNT government intervention were shown to be purpose, people, context and outcomes (success/ failure).

The principal links between individual constructs and institutional theorisation are identified in the following text. Context is discussed first, as the MNT centres in this study highlighted a number of important issues relating to the development of a government intervention comprising of many distributed local contexts.

9.4.3.1 Context

The context within which a centre was based had associated institutional logics which actors could not avoid. Mercury exemplified a centre with deeply-ingrained professional academic logics, which caused internal conflict with the state-actors and actors with business-oriented systems of reasoning.

In the main case, this conflict was a key factor in the centre's failure. Greenwood *et al.* (2010, p.15), described a growing interest in '*why and how organizations interpret and respond differently to their contexts*' in their discussion of the concept of homogeneity and heterogeneity. The MNT centres investigated were viewed as quite heterogeneous. The discussion of competing institutional demands from centres within this MNT government intervention added to this enquiry concerning organisational context. The differing actors, systems of thinking and reasoning, roles and contexts, all impacted significantly on the centres' outcomes.

Context is a large influence on the function of an system of innovation. The distinction between 'local' and 'extra local' contexts introduced by Hallet and Ventresca (2006) has contributed to a far deeper understanding of a contemporary government intervention.

This study provides further empirical evidence of the new and unfamiliar forms of organisational arrangements which result from cross-sectoral interventions as discussed by authors such as Garrett-Jones *et al.* (2005).

9.4.3.2 Purpose

Institutional reasoning has provided an understanding of the competing logics within many of the MNT centres under investigation. Moreover, the dissonance evident between the state actors from the governing body and the main case study, called into question the difficulties of embedded agency when actors have ingrained and opposing organising principles, institutional thinking and reasoning processes.

Authors such as Mass and Tessa (2008) have investigated the different perspectives held by actors within SMEs. They described how '*sometimes, these views show diverging goals among the stakeholders and consequently, contrasting opinions on effective supporting policies*' (Mass and Tessa, 2008, p.393).This PhD has cast new insights into the problems highlighted in this area; in particular, how the views of the actors within a government intervention show diverging goals, and as a result contrasting views on how such intervention should be run in different contexts.

9.4.3.3 People

Institutional logics provided a tool for understanding the organising principles of actors within the MNT field, and insight into why they carried out the actions they did. The concept of 'roles' was also investigated, leading to a cross-case analysis of the 'Centre Director' role.

The linking of the people construct in a more nuanced way with outcomes, illuminated the interaction between actors and structure and the importance that the organising principles of individuals play in a government intervention. The differing actors, systems of thinking and reasoning, roles and contexts all impacted significantly on the centres' outcomes.

A new category has been put forward to categorise those actors with multiple points of reference and frames of meaning, i.e. 'hybrid' actors. Hybrid actors were those observed with experience of working in business and academia. These 'hybrid' actors were able to bring different understandings to their MNT environment, and appeared able to move across institutions. This may indicate the need for such cross-disciplinary experts from a range of sectors, due to the nascent nature of the MNT field. Harvey (2010), raised the associated idea of industries being accountable for their own reasoning and judgements.

The nascent MNT industry may be held accountable for its own system of institutional thinking and reasoning, due to the high mobility of experts required across different institutions who have experienced different institutional thinking and reasoning processes.

9.4.3.4 Outcomes

Examples of successful MNT centres (in terms of the original DTI purpose) were those whose actors were driven by a common purpose and had associated inherent and common business thinking, reasoning and judgement processes.

Conversely, the main case study provides an example of failure. This failure can be linked in part to the differences in the perceptions of objectives and the defining of success for key innovation stakeholders (Mass and Testa, 2008). The existence of very deeply ingrained and different perspectives led to diverging goals and outcomes. This study also builds on the work of Garrett-Jones *et al.* (2005) who investigated the common purpose and divided loyalties observed for academic and government researchers in a government intervention which set up collaborative research centres.

9.5 Reflective Discussion: MIRP Literature and Government Interventions

The framework from the MIRP programme was used in this study to provide important constructs with which to gather data about the MNT government intervention. The findings from the MIRP programme are now discussed and compared with those from the main case and cross-case comparisons.

9.5.1 Contribution to the MIRP Findings

The MIRP framework and key concepts used to guide this study were: *people; context; transactions (collaborations)* and *outcomes (success & failure)*. This section will now discuss how the MNT government intervention data have the potential to contribute to this framework.

The overall findings associated with each construct were discussed by a variety of scholars in Van de Ven *et al.'s* (2000) work. Indubitably, different researchers adopted different methods for their data collection and analysis. For example, in his work concerning 'psychology and organisational innovation' Angle (2000) presented his findings as a number of propositions. In contrast, Dornblaser *et al.* (2000), took a more qualitative approach to presenting their findings in relation to 'innovation outcomes, learning and action loops'. In harmony with this latter approach, my contributions are founded on the qualitative research methods which I adopted.

9.5.2 People and Context

Angle's work (2000) developed a number of propositions when evaluating the data collected across MIRP studies for the *people* and *context* elements of its framework (reproduced in table 9.1). This section now discusses the way in which these propositions relate to the findings from this PhD.

Table 9.2 - Propositions Resulting from Angle's Findings from the MIRP Programme (Angle, 2000).

No.	Angle's Proposition
1	Organizational innovation is a joint function of members' personal attributes and the context for innovation in their organization.
2	Organizational innovation occurs in organizations that have a context containing enabling and motivating conditions for innovation; innovation will not occur where either factor is missing.
3	Innovation effectiveness is positively associated with frequency of communication among persons with dissimilar frames of reference.
4	Innovation effectiveness is positively related to the extent to which the organization integrates creative personalities into the organizational mainstream.

9.5.2.1 Findings in Relation to Angle's First Proposition

This first proposition was found to be important in relation to the findings from my own study. My study contributes further to this proposition with its discussion of institutional theory. This discussion illuminated the importance of the relationship between institutional logics (which linked to personal attributes) and structure (i.e. organisational context) for the MNT government intervention case. Many examples have been provided to reinforce this contribution in Chapters 8 and 9.

For example; in Mercury, it appeared logical for policy makers to build on an existing academic centre-of-excellence in order to offer industry micro technologies. However as my research shows, integrating a university context and associated academic actors with an intervention driven toward commercialisation, led to failure. Specifically, if one observes the professors who wrote the proposition for Mercury and its technologies, they apparently have the skills; however, they lacked the required business acumen. This highlighted how the '*interaction between people and context will result in outcomes not fully accounted for by people and context taken separately*' (Angle, 2000, p.138).

9.5.2.2 Findings in Relation to Angle's Second Proposition

The data from the main case (Mercury) provided in-depth findings which displayed how a context deficient in enabling and motivating conditions led to a failed environment for organisational innovation. As per Angle's second proposition, this demonstrates how innovation will not occur where either enabling or motivating conditions are missing.

The conflict created between industrial and professional academic actors within their local context led to poor innovation conditions:

> *'...In the same respect that organizations can create a de-motivating climate, they can through a number of mechanisms, create systems and structures and an organizational climate that impede the innovation process' (Angle, 2000, p.144).*

Data from centres similar to Mercury do however show that actors can work within the constraints of a '*university's slow moving, bureaucratic management structure*' (Lambert, 2003, p. 64). Examples within the MNT case example included Lucretia, Liber and Ulysses. Ulysses, for example, was created on a Science Park, which '*encourages people in different specialties to interact by location and arrangement of meeting rooms, eating facilities etcetera*' (Lambert, 2003, p.144).

9.5.2.3 Findings in Relation to Angle's Third Proposition

The third proposition Angle put forward (*Innovation effectiveness is positively related to the extent to which the organization integrates creative personalities into the organizational mainstream*) resonated with examples provided from Concordia and Rhea. They suggest that actors with strong viewpoints (and possibly different institutional logics) were beneficial to the innovation development process. However, more important were the findings from Mercury and Bacchus, which showed the possible negative impact on an innovation process when these 'dissimilar frames of reference' were polarised. In both cases, there was an element of the host organisation being "*mechanistic, bureaucratic organizations…the type of organization who may stifle the spontaneity of its members by over-routinizing all aspects of organizational life*' (Angle, 2000, p.145).

In the case of Mercury, the issues were also significantly localised in the subgroup (i.e. the MNT centre).

> *'...If the goals of the subgroup [Mercury] are completely congruent with those of the organization [i.e. the host university], it may not matter which attachment is formed. On the other hand, if the values and goals of the group are antithetical to those of the larger organization, then it matters indeed where loyalty lies'* (Ibid. p.158).

So on the one hand, the professional academic actors were aligned with the goals of the university, i.e. research and teaching; however on the other hand, the goals of the business actors (i.e. revenue generation) were antithetical to those of the university.

However with Lucretia, this did not appear to cause any major problems. Significantly, the explanation for the differences between Mercury and Lucretia may lie in the way that the MNT network was theorised through an institutional lens perspective in this thesis. That is, there were competing logics, with business and academic actors working together in close proximity in Mercury; this was in contrast to Lucretia, which was set up with a majority of business actors and distanced from the host university.

Lucretia’s Director was very clear on what his Centre’s boundaries were:

> *‘Lucretia is a wholly-owned business unit... a 3rd strand activity. Although we are commercially facing, we have a board of management, and people with recognisable job titles outside of academia...we are a School in the faculty...’* (Mr Gillette).

He also demonstrated a more productive working relationship with the multiple values and goals of his MNT Centre and the host University:

> *...the [host] University supports Lucretia…we are an incubator in the University so I am a University employee... they support us. But we have to find our own money…*

To address the balance of being commercially-focused whilst also within a university, he describes how Lucretia’s staff have commercial contracts:

> *...they use a system here, where we have a University-graded salary, but it's based on what a commercial salary is for my function. So I'm paid what my opposite number in BAE systems is paid, effectively...* (Mr Gillette).

Conversely, Mercury appeared to have competing logics amongst its actors. It did not have commercial contracts and this is likely to have added to the confusion of the Centre’s actors: if they are employed as researchers, why then should they do commercial work?

> ‘*Another thing that some people forget about is that Mercury have academic staff who are academically driven, they aren’t just research staff because they want to publish and they have academic careers to work on.*.’ (Mr. Anderson).

Mr Anderson, although in a senior position within Mercury, demonstrates his own professional academic logic by travelling to an academic conference when the CEO explicitly asked him to remain at the centre and carry out commercial work.

9.5.2.4 Findings in Relation to Angle's Fourth Proposition

Concordia provides an illustration of how Angle's fourth proposition (*innovation effectiveness is positively related to the extent to which the organization integrates creative personalities into the organizational mainstream*) is demonstrated in the UK government MNT intervention. The Director described how the original business plan for Concordia had been '*written by academics with a great deal of careful planning (e.g. external OEMs were on board and strong industry support was forthcoming) and with sound reasoning. However, if a commercial person read the plan, they would probably say ...there is nothing to sell...no service...no product...nothing to sell'*.

This plan ran for a number of years, but the TSB eventually became concerned with its direction. Dr. Russell was then brought in to help to rectify the situation as he was considered a key stakeholder in the MNT field. In effect, by bringing a 'creative personality' into the organisation, it was hoped that the Centre's overall performance would improve. Dr. Russell further introduced 'new blood' into the organization, to overcome the issue of 'groupthink' described by Pelz & Andrews (1966, p.104) thus:

> *'...cohesive groups tend to homogenize the frames of reference of their members ... no matter how heterogeneous a research and development team is on its formation, the team will (eventually) become homogeneous...'*

To overcome this issue of homogeneity, Dr Russell consciously ensured that the Concordia's environment was conducive to the flow of arguments. This also related to another of Angle's propositions -that of developing a positive relationship between innovation effectiveness and '*bringing issues into the open and working them out'* (Ibid. p.160).

Conversely, in the example of Mercury, the majority of actors recruited for the MNT centre at the beginning, were simply transferred from existing research positions onto this new 'project'. Such a move demonstrably, only increased the incidence of homogeneity in an organization.

9.5.3 Outcomes

One of the important questions that Dornblaser *et al*. (2000) asked during their interviewing process was the question '*what current criteria are you using to judge the success of this innovation?*' The data from this PhD study asked a number of similar open questions which also addressed this issue with the MNT centres who were carrying out innovation in the form of MNT technology development. These questions are shown in box 9.1.

How would you describe a successful outcome from the development/application of your [nano] technology (and/or expertise)?

Conversely, how would you describe a failed outcome or an outcome that results in elements of success and failure (i.e. positive and negative results)?

Describe examples of either successful or failed outcomes (where participant can disclose).

Your views on the measures that the TSB use to assess your centre - how appropriate are they?

Box 9.1 – Additional open questions used to understand how actors understood outcomes

The findings from this PhD study make a potential contribution to Dornblaser *et al's* (2000) work by investigating outcomes (success/failure/measures) from the point of view of four additional types of situational actors; i.e. professional academics, business actors, state actors and hybrid actors.

9.5.3.1 Management Paradox

Successful outcomes for the MNT government intervention from the perspective of the original DTI remit, described certain revenue-generating centres that develop technologies which are then adopted by UK industry. The findings from this PhD study were in accord with Dornblaser *et al's* (2000) concept that a central problem in innovation management may be the management of a paradox. This was highlighted in cases such as Mercury, where opposing/conflicting organising principles were evidently in existence and which proved difficult to manage. Similar problems occurred in the case of Concordia during its first few years. However, the situation was rectified by the introduction of a new Centre Director who shifted the focus towards revenue-generating activities.

These two examples highlighted one of the major paradoxes observed in terms of perceived outcomes and context for the MNT government intervention. Centres were created using existing MNT facilities (typically in universities) to leverage the relatively small investment for the overall programme[1]. As such, the government created an innovation management paradox from the outset; i.e. developing MNT centres which were meant to be revenue-generating in a context that was typically research-led and run by research-motivated actors. However, Lucretia provided at least one tangible example of where this can be successful.

9.5.3.2 Resource Controllers

Dornblaser *et al.* (2000) also posited the importance of what they called 'resource controllers' and 'innovation managers' in the innovation process. Parallels with these actors could be seen in terms of the TSB and Centre Directors respectively:

> '*...when innovation implementation efforts went awry…and [resource controllers] where disappointed with results, the external resource controllers tended to focus on input criteria... if outcome assessments of resource controllers and innovation mangers did not converge, the assessments that mattered in determining the fate of an innovation were those of the resource controller…'* Dornblaser *et al.* (2000 p.202)

The case of Mercury in this PhD study reinforces these findings, and how the dissatisfaction of the state actors (i.e. TSB, the resource controllers) led to intervention in the centre. That is, an external CEO was firstly required, and then when progress still failed to reach an acceptable level, funding was removed.

However in the example of Lucretia, when the resource controllers requested additional reporting measures which Mr Gillette felt where inappropriate, the decision-making shifted from the state actors to the Centre Director:

> '*...I put our contract in front of her [TSB actor] and I said...you show me anywhere in this contract where I have to follow...I have to provide this [hits folder] level of information?' And she couldn't... So having got that out of the way, what we then said was... now we've established that this is inappropriate for us...we don't want to queer our pitch or your pitch...we will now participate in this...we wanted to say 'we're always going to have a red cross here, until you understand what this business is about'. And since that time we've been fine!'*

Dornblaser *et al*'s (2000) results show how different types and levels of criteria were used at different times in the innovation process, leading to outcome evaluations which became increasingly difficult to judge accurately. The above extract displays evidence

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[1] In comparison to countries such as Taiwan who invested 21.5 billion US dollars over six years (Hung *et al.* (2004), in comparison to the UK intervention of 90 million UK Pounds.

of this, caused by the metamorphosis of the DTI into the TSB and other NDGBs. This also demonstrates how an actor with strong business reasoning and judgement was able to stand up to the state actors from the TSB and deal with this challenge.

Actors reconstructing their views - the data from the MNT intervention also agreed with Dornblaser *et al*. (2000, p.202), in terms of how actors can reconstruct their views at different points in time:

> *[problems such as project slip] led innovation managers to emphasize meeting process criteria of solving these problems, achieving technical milestones, and meeting deadlines and budgets in order to maintain credibility for their innovation development effort...innovation managers tended to reconstruct negative information in a positive frame with assurances that they were in control of problems and with action plans for addressing the problems* (Dornblaser *et al*. 2000, p.202).

Further findings from this PhD study show how Centre Directors reconstructed their views when things were not going to plan. More importantly however, this data set showed how the evaluator/resource controller (i.e. the TSB) actually reconstructed negative information, or prevented it from being published. This conclusion is based on consideration of the following information:

1. There was a scarcity of information available in the public sector concerning the MNT government intervention programme. The most detailed information often amounted only to a list of centres, with associated grant figures.
2. Added to this was the lack of publicly-available targets for the centres by the TSB.
3. A recent third-party review of the centres (The Yole Review) was not published.

9.5.4 Collaborations

Data from this current study was collected using an adaptation of the transactions code, namely the collaborations code. This was to make a distinction from the MIRP programme’s method of capturing and recording each individual transaction. The term ‘collaboration’ is used to emphasise the more macro view of transactions observed in this thesis between the MNT network actors. The relevant findings from the MIRP study are now presented in comparison to the findings from the MNT government intervention.

In Mercury, it was shown that particular actors 're-represented' their Centre's purpose, guided by their underlying world views. As the TSB looked to further commercialise the Centre, these actors opposed this as a result of their sense- making process. This was demonstrated when comparing Mercury's original tender document and its clear requirement for a 'commercial' focus from Professors Stephenson and Pascal. These actors almost tried to 'justify' their manipulation of the original purpose, which appeared to be reinforced through the transactions with TSB actors. This agreed with the MIRP findings that:

> *'…the 'facticity' derived from a process of understanding often changes as a result of experiences in carrying out initial commitments. A mutual agreement that two individuals think they have developed and is operational, may not be in place or may have evaporated' (*Dornblaser *et al.* 2000, p.181).

The concept of a 'mutual agreement' between actors was also described in Ring and Van de Ven's (2000) transactions research. Such mutual agreements were displayed between the governing body and the individual centres in the MNT intervention example. The findings showed how the initial agreement often seemed to have altered over time. This was probably linked to the understanding that grants came with 'conditions and not deliverables' and this could be seen as a loss of the 'shared world' between the parties: *In the course of innovating, an entrepreneurial unit often engages in transactions processes. Innovation processes are inherently uncertain. Parties frequently do not fully appreciate or understand their needs* (Van de Ven, 2000, p.187).

A number of MNT Centre Directors described how a challenging part of the development of emerging technologies was creating an understanding of the customer's needs, and that customer understanding what was possible with the new technologies.

Rhea's Centre Director described how technological innovation was accelerated by engaging in cross-European collaborations; this also provided an opportunity for the Centre to offer a wider supply chain.

9.5.5 Contribution to the Existing MIRP Framework

A detailed discussion of the findings from the MNT government intervention and their relation to MIRP was presented in the Discussion Chapter. Through this analysis and the use of the MIRP constructs for gathering data, a number of useful recommendations for the future are now made: Firstly, a number of additional categories from the data relating to NSIs facilitated a deeper understanding of them. The most beneficial were; purpose (generic, individual); outcomes (success, failure) and sub-groups for people (academic, business, state and hybrid).

The role that individuals (actors) play within a government intervention and how they are informed by their institutional thought processes was investigated. This enabled a deeper analysis of the adapted MIRP constructs and a better understanding of people involved in the innovation process. The linking of this more nuanced people-construct to outcomes (in terms of the intervention's success/failure), further illuminated the organising principles and resulting actions. Such categories also provided insight into other research involving other innovation processes. The sub-groups of the actors may need adapting depending upon the field under investigation and the relevant IT literature provides the necessary background information for this.

Secondly, these adapted MIRP constructs were then incorporated within a logics or reasoning framework (i.e. IPP, IT and IL theory). This coupling of systems of reasoning to the MIRP framework can be used for future investigations of the innovation process, thereby providing a different perspective's findings to the existing MIRP methodology. This method was particularly enlightening when investigating the idea of contested and collaborative systems of reasoning within an organizational field (embedded agency).

Additionally, this study built upon the constructs introduced by the Minnesota Innovation Research Programme (MIRP) which was used to investigate innovation processes (Van de Ven and Poole, 1990). This nascent innovation field's findings (*the micro-and-nanotechnology field*) contribute significantly to bridging the gap that was identified concerning the lack of empirical examples in the literature. Furthermore, the main case investigated provided a detailed and valuable analysis of how actors in a local context interacted with each other and perhaps more importantly, the extra local context.

9.6 Reflective Discussion: Emerging and Disruptive Technology (EDT) Literature

This section relates findings from this study with the literature review on emerging and disruptive technology.

9.6.1 Development Time for New Technologies

The EDT literature discussed a range of challenges faced by organisations developing disruptive technologies. One of these was the long period of time required for the development of such new technologies for commercial application. The UK government only funded MNT centres for a short period of time; between three and five years. Woodside (2005) described how the time taken from successful working prototype to commercialisation is measurable in one to five decades, not one to five years. Many scholars echoed this view, stating that short periods of time are not long enough to develop emerging technologies (Holm 1995: Johnson, & Duberley 2009). The notion of the need to develop disruptive technologies with a long-term view in mind, rather than merely doing it as a 'one off' event, or as a 'nice add-on' was discussed in detail by Battilana (2009). Interviewees within this study reinforce these views (ref. Dr Tesla, Mr Strauss, Professor Pascal, Dr Teller, Dr Alvarez). As such, the need for technology policies – like the MNT intervention – to consider longer timescales appears to be a potentially overlooked factor in the successful development of emerging technologies.

9.6.2 Curiosity-Driven Research

A number of academics interviewed across the MNT field described the need for 'curiosity-driven research', which may have alluded to the idea of development being more of an idealistic activity. Foster (1986) described the concept of scientists/ technologists (or academics) as being 'limit-breakers'. That is, they seek novel approaches to the norm, rather than just building on standard methods. The very nature of a university as an institution for education, learning and discovery fully aligns with these observations and aspirations.

Carlsson and Jacobson (1994) describe the importance that researchers place on the need for basic research to be allowed to evolve, leading to new avenues for applied research and technical solutions. The argument continues that science plays an important part in modern democracy by providing independent knowledge allowing important political decisions to be made in an open, transparent and representative way.

As such, it was unsurprising that institutionalised professional academic actors were less driven by commercial incentives. However, the MNT government intervention funding was always clearly intended for development with a commercial application in mind. One way in which the DTI and then TSB tried to overcome this hurdle was to 'monetize the technology' (Palumbo, 2001). That is, the development of the technology alone was not the goal for the MNT centres. Through developing a technological policy that leveraged existing facilities, a consequence was an attempt to turn scientists into entrepreneurs. As the examples from the study and literature by Khilji (2006) that '*scientists-turned-entrepreneurs… lack commercialization knowledge and are ill prepared to convert invention into innovation*' (p.536). Jones-Evans and Klofsten (1997) illustrate this further when they describe how:

> '*studies of academic-based technical entrepreneurs frequently demonstrated that they had very little exposure to management skills such as marketing of finance, and had very little concept of business*' (p.12, 1997). Again, this highlights how '*technological innovation may influence a variety of economic actors in a variety of ways*' (Abernathy and Clark, 1985, p.4).

The investigation of state, academic, business and hybrid actors in this PhD study provides further evidence of the significance of differing actor views in relation to policy interventions.

9.6.3 Newness of the Technology

The renowned writer Kaplan (1999) described a number of strategies for developing discontinuous technologies. He described the most challenging strategy as that of 'industry genesis' (Kaplan, 1999, p.16). This referred to the development of wholly-new technologies, which were largely unknown in nature. When organisations intruded into such unfamiliar territory, they had little or no knowledge of who the competitors were or may have been, or those customers who may have valued the technology, until it actually existed. The MNT government intervention would seem to have fitted into this 'industry genesis' category.

A review of the centres investigated suggested that the level of 'newness' of technologies varied, with some centres being said to have developed 'close-to-market' technologies (e.g. Liber) and others developing 'blue-sky' technologies (e.g. Mercury). Holmes and Glass (2004) recommended the development of a portfolio of opportunities as a way of dealing with this anomaly. The DTI attempted to do this by having a distributed network of centres, rather than the two main centres initially recommended by the Taylor Report. Amongst those MNT centres investigated, Concordia demonstrated a deliberate strategy to develop a portfolio of products. The Centre

Director described the plan as then being enabled to spread their risk over a number of technologies, rather than bet only on a single one.

Another important theme in the literature was how organisations use resources, knowledge and ability to learn in order to better focus their efforts. In a number of cases, examples were given of organisations that were resistant to abandoning incumbent investments in order to move forward in the direction of new technologies (Assink, 2006; Tellis, 2006). The MNT centre ‘Concordia’ provided an example of how the Centre Director joined the company after 2 years in order to rectify a Centre which was considered as moving in the wrong direction by the TSB. Dr Russell (the Centre Director) described how he had to abandon existing investments in capital equipment (capex) in order to turn the centre around and to focus on revenue-generating business streams. He described how the capex had originally been purchased by academic actors without there being a real business case for these purchases.

9.6.4 Roles

The idea of actors having roles evolved while discussing the cross-case comparisons. Garrett-Jones *et al.* (2005) investigated how actors deal with their dual roles as part of an industry-collaborative research centre. The first emphasis of their role is either as a government researcher or academic, and their second as a committed participant in an industry-collaborative research centre. Parallels can be drawn from this study in relation to the findings from the MNT government intervention. Both studies are focused on interventions which go beyond pure research to develop immediately useful knowledge; more so in the case of the MNT government intervention which clearly describes the focus on commercialisation of technologies. Garret-Jones *et al.* (2005) describe how the reward systems for academic researchers misalign with the goals of the intervention: the academics are measured on ‘discovery’, in terms of their research. Conversely, the industry-collaboration research centres they are involved in measure ‘application’.

Findings from this PhD study echo these; however, whereas Garrett-Jones *et al.* (2005) suggest that academics might be deflected by the goals of the centres, the study of the main case Mercury suggests that the over-riding institutional logic of the academic actors interviewed remained focused on ‘discovery’, and as such was not deflected.

Herrmann *et al.* (2006), and Loutfy and Belkhir (2001), discussed the importance that key stakeholders – termed *promoters* - had within an organisation in the sense of bringing new product ideas to fruition. The role of Centre Director was akin to such influential promoters; the Centre Director was seen as having sufficient levels of importance and power to promote new technologies within a centre.

Robeson (2007) described the gap in research which needed to identify and evaluate the motives behind senior leaders' behaviour and designing organizational mechanisms that help guide the appropriate degree of their involvement. This study's analysis adds to this by viewing such promoters through an institutional logics lens perspective, and discovered that such actors did not always have a positive effect on commercialising technologies. The case of Mercury was a good example of how such key promoters – in this case Professor Stephenson - can actually impede development through contestation and procrastination.

Many of the EDT scholars focused on large global organisations for their research data, with a view to learning from their success. A number of authors described how large organisations (e.g. Hewlett-Packard) made use of cross-linking departments and a high level of engagement with the technology/product management teams across business functions, in order to be successful in developing disruptive technologies (Collins, 2004; Hermann *et al.* 2006).

9.6.5 Cross-linking between Actors

Although not on the scale of those firms reviewed in the literature, a number of MNT centres in this current study discussed the use of cross-linking between their staff. Garrett-Jones *et al.* (2005) studied a number of cross-disciplinary research centres in Australia, which were created with national, social, and economic objectives in mind. Parallels can be seen with such centres and the MNT centres. They concluded in their study that:

> '*…[Cross-disciplinary Research Centres] appear to be hybrid organisations, drawing upon the practices and cultures of all their participants.. [developing into] .. organisational styles, perspectives, approaches and mechanisms that are substantially different from the sum of their constituent parts… This CRC 'culture' reflects, first … the need for a consensual approach to marshalling the*

> *resources of the CRC towards common objectives. Second, concurrently, it requires the CRC to somehow accommodate the disparate 'cultures' of the participants, comprising the individual researchers, their research units or scientific disciplines and their 'host' organisations*' (Garrett-Jones *et al.* 2005, p.543-544).

Concordia provided an example of such an MNT centre; Dr Russell described how he purposely employed a mixture of people in terms of their perspectives, approaches, and organisational styles. He did this to create an environment where constructive debates could be had, in order to develop their products further. Dr Russell reported success in terms of marshalling the resources towards common objectives, and accommodating the disparate cultures of participants.

Rhea was another example where the Centre Director described the complementary types of staff who were either focused on problem-solving or manufacturing; both of which were required to make their centre successful. In order to overcome issues of merely being a small SME, Rhea had strong links throughout various European networks, serving the purpose of stimulating innovation, promoting their services, and extending their supply chain. This allowed Rhea to provide services nearer those of a larger organisation. Lucretia also talked of being linked to over half of the UK's knowledge transfer networks (KTNs).

9.6.6 Incumbent Firms and the MNT Network

One of the contributions that this study makes to the EDT literature is the focus on smaller organisations rather than larger organisations.

Incumbent firms and the way in which their bureaucratic structures can stifle innovation was a prevalent theme in the EDT literature review (Abernathy and Clark, 1985; Tellis, 2006; Assink, 2006; and Danneels, 2006). The ways in which MNT centres in larger incumbent organisations managed to deal (or otherwise) with such bureaucratic structures, was further understand in this study. In order to overcome these structures and engage in innovative activities, centres such as Lucretia and Liber developed their positions of autonomy in the larger host organisations. This autonomy was essential in order to make sound business decisions and commercial agreements (e.g. confidentiality agreements and so on).

The IT literature also introduced the concept of decoupling as a:

'rational response to demands for organizational adaptation that are inconsistent or harmful to the organization; by decoupling, organizations achieve legitimacy through espoused action, but remain efficient or consistent through actual action, which enhances their survival prospects' (Boxenbaum & Jonsson, 2010, p.81).

MNT centres such as Liber and Lucretia provided some good examples of this decoupling strategy.

Lucretia and Liber were clearly able to 'break from the routines and processes' of the incumbent organisations, as recommended by Govindarajin and Kopalle (2006). Furthermore, they exhibited a number of common observations put forward by Holmes and Glass (2004), as to why some incumbents were more successful than others (in this case, universities):

1. Disconnecting innovation efforts from the corporate bureaucracy allowed them to flourish and to adapt a more entrepreneurial spirit.
2. Use of interdisciplinary expertise was advocated.
3. Striving for revolutionary inventions was promoted.
4. Considering IP as currency (both had specific strategies for successfully dealing with/ licensing IP) was an enabling factor.
5. Innovation was not just a 'nice to-do', but also a real priority. Great technology was the only thing that allowed one to protect the profit margins.
6. Internal profit sharing helped to spark creativity in firms (in Liber the Directors had a significant stake in shares).

By comparing Rhea to the above list, it was interesting to note that Rhea also exhibited all of these criteria. The current study's findings from these MNT centres contribute to the extant literature by providing an alternative view to the development of EDTs from that of large OEMs/ global companies which predominated in the existing relevant literature.

9.7 Reflective Discussion: Systems of Innovation (NSI) Literature

Using the principles from institutional theory, this PhD study framed the MNT government intervention as an organizational field - the MNT field. This aligned well with the description put forward by Rampersad *et al.* (2010), of systems of innovation networks:

'*Innovation networks are defined as a relatively loosely tied group of organisations that may comprise of members from government, university and industry continuously collaborating to achieve common intervention goals*' (p.794).

This thesis showed how such a network was envisaged at the start of the MNT Capital Facilities Programme through the establishment of the MNT centres, and subsequent MNT field. Further theorisation from institutional logics showed how the reality of this failed to be realised, due to the complications of competing field logics. These observations accorded well with the findings from other relevant literature in the field.

In addition, the findings from this study add to the gap outlined by Edquist (2005, p.201) in understanding the institutional rules that influence organisations in carrying out activities associated with systems of innovation. In particular the combination of the IIP and IT literature with the SI literature further illuminates this gap.

9.7.1 Effective Technology Policy Interventions

This study provided further empirical evidence of how governments tried to drive new technology into commercial use and for public good (i.e. demand creation). Scholars such as Fri (2003) described how creating this demand was hard to achieve. My study's findings subsequently confirmed this.

The researchers suggested that a clearer understanding of the obstacles of policies needed to be further promoted in order to develop effective policy interventions (Fri, 2003; Harvey, 2010). Quere (2004), identified that there was a dearth of detailed empirical data of NSIs. The findings from my study will help in addressing this identified literature deficit.

Harvey (2010), described how NSIs were often set in motion and then the state hoped that the market would do the rest. Perhaps this was the case with the MNT government intervention. Initially, the DTI created the 'UK MNT Network' which acted as a conduit between the MNT centres/suppliers and potential MNT clients/users throughout the UK. This was a discernable direct effort to stimulate the MNT market in the UK.

A number of interviewees described how this was a very useful part of the MNT Programme, which helped to raise awareness of the new technologies.

9.7.2 Metamorphosis of MNT Network to KTN Network

In 2007, the UK MNT Network was closed, and replaced by a Nanotechnology Knowledge Transfer Network (KTN). The 'MNT Network' in this sense refers to the body responsible for raising general awareness of the centres and their technological opportunities in the UK. Activities included trade missions (i.e. activities where key technologists from the UK were funded to benchmark the UK MNT technologies with global competitors); the creation and publication of databases of services offered to UK industry in the MNT sector; and wider dissemination activities such as seminars and conferences. The transition occurred in order to bring the MNT Network in line with other KTNs which were currently representing UK industry. The NanoKTN's role was similar to the previous network; that is, to be a knowledge-based network for MNTs.

Unfortunately a number of MNT actors described their disappointment with this new incarnation:

> *'It [the MNT network] became more generic and more structured..it had less staff and concentrated on nano[technology]'* (Dr Alvarez, Bacchus Centre Director).

> '*...since its formation, the nanotechnology KTN emerged and overlaps with a lot of activity that we do, but I'm a little bit cynical about the KTN, I don't think they work as well as [the RDA MNT group]. Yeh, I'm pretty negative about this...I think the KTN is based in the North East, I think it serves that area very well. They don't come to [our area] and talk to [our] centres'* (Mr Strauss, RDA Manager).

> *'...the MNT Network metamorphed into the nanotechnology KTN. But without sufficient resources to undertake a coordinating role for the Centres as part of the UKMNT Network...The MNT Network was more equipped than the current KTN - its function is not truly embraced in the KTN. It was a hybrid, and only one like it at the time...The MNT network had contacts with a range of facilities...[The]MNT Network .. was there to create the network .. to fund and create the strategy...which is what the MNT did and was paid to do.'(*Prof. Hertz, MNT architect).

These latter comments suggested that the MNT network originally set up to help to stimulate market demand for MNTs was removed and not replaced.

How well the technological system works is, in part, dependent on how well its constituent parts are connected, according to Carllson and Jacobsson (1994). They describe how:

> *'…one of the most important functions of technological systems is to facilitate the sharing of knowledge among actors… government policy may play an important role by improving the connectivity of the technological system and thereby enhancing the information and knowledge sharing within the system*' (Carllson and Jacobsson, 1994, p.244).

Swan and Scarbrough (2005) investigated three cases of networked innovation, each of which involved the development of new technologies. Their research showed that the co-ordination of networks, rather than simply their formation, is found to play a particularly crucial role.

> *'…analysis highlights the need to recognize the importance of the institutional context and the role of technology as important influences on networked innovation processes. This suggests a need for multi-level analyses, embracing not only the politics of the immediate innovation process but also the environing constellations of power invoked by technology and institutions'* (Swan and Scarbrough, 2005, p.940).

Considering the findings from this study along with the aforementioned literature, it would appear that by replacing a well-recognised and received MNT Network (which provided a central focus for the MNT government strategy) with one perceived as 'generic' with limited resources, the government may have inadvertently reduced the general awareness of the technological opportunity for UK industry.

9.7.3 Relation to Institutional Model

Groenewegen and Steen (2006) introduced an institutional model in his research work, in which a number of layers were presented to help understand the layers and dynamics of systems of innovation for future policy learning. Key elements of this model were described which needed further understanding; the data from this PhD study contributes to this identified gap:

Table 9.3 - Relationship of Study's findings with Groenewegen and Steen's (2006) model.

Layer description	**Findings from MNT Cases in University Institutions**
Layer 1 describes the informal institution (i.e. culture: values and norms) and technology.	Understanding of the university institution as domain for learning and carrying out research. The recent policy focus of commercialising university research for socio-economic benefit has brought contestation between traditional academic actors and external funding bodies (e.g. state actors).
Layer 2 deals with the political system.	Mercury displayed contestation between leading actors with different business logic. The 'politics' involved between actors with business logics and those with professional academic logics were clear in Lucretia and Mercury.
Layer 3 refers to the formal rules of the game (laws, regulations, and policies).	The MNT intervention showed how regulations such as 'state-aid' have a bearing on the running of NSIs where commercialisation is the motivation for the intervention.

Layer description	Findings from MNT Cases in University Institutions
Layer 4 shows the institutional arrangements (public and private organizations, contracts, and hybrids like networks)	Mercury displays how running research centres as private organisations can conflict with the traditional university research values and norms. Creating commercial contracts for NSIs can prove problematic in a university institution. Liber provides an example of an MNT centre where the university is the main shareholder of the company. Liber started initially in the university context, but the centre director deliberately moved them to a non-university environment.
Layer 5 displays creative, innovative learning that is embedded in habits and routines, which includes strategic behavior and the power base of actors, which can block innovative developments.	Classification of actors as professional academic, business, state and hybrid link to the concept of norms, and roles. Contestation between actors is shown using institutional logics, which can effects innovative learning, strategic behaviour, and block innovative developments.

Charles (2006), believed that '*there is no standard recipe or package that can be recommended for an appropriate mechanism for universities in their specific and individual regional innovation systems'* (p.128). This current study's findings did not specifically highlight regional contexts as a major issue for the centres developing MNTs. The TSB (2011) published this statement on their website: '*We are encouraging the establishment of links between a number of the facilities so that they will be genuinely seen as national capabilities rather than providing a limited regional role*'. This suggests that the centres were more focused on their local regional context, rather than the extra local context. However, further research is needed to confirm this.

9.8 Reflective Discussion: Institutional Theory (IT) Literature

This section compared the results of the current study with the institutional theory literature. Key papers in this field were introduced in order to view the MNT field and related findings through an institutional theory lens. This section built on the most important findings from my research and demonstrated how it had the potential to link with IT's theoretical underpinnings and literature. This PhD study added to the cross-category area of study described in the literature. Tracey *et al.* (2010) observed how researching across categories remained largely an unsolved problem within IT. This study used the MNT case in an attempt to help to fill this gap, by presenting a comparison of cross-category actors including state agencies, commercial organizations, and academic institutions. This added to the evaluation process of all types of organisations, as proposed by scholars such as Zucker (1977) and Powell (1991).

9.8.1 MNT Centres and Isomorphism

The notion of isomorphism put forward by DiMaggio and Powell (1983), described how pressure was put on organizations to adopt similar structures and forms, resulting in them becoming similar. The very nature of the MNT centres belonging to a range of institutions and variety of contexts brought into question whether isomorphism was possible with such an intervention. Findings across the MNT field showed that isomorphism was not applicable to the MNT centres. However, some of the mechanisms which aided isomorphism may be applicable to the results of this present study. For example, coercive isomorphism appeared to have been used by the main case (Mercury) in the sense that the University was able to adopt specific practices to be eligible for state aid grants, and to tender for and to win the grant. It was also displayed by state actors placing demands on Mercury (and Concordia to a lesser extent), when they make it a requirement for the centres to either employ new staff or face sanctions. Furthermore with Mercury, they had to make the company a Limited Company.

This new research work adds to Fombrun's (1989) criticism of isomorphism that '*if isomorphism obtains, how then are we to explain the apparent variety of organizations that nonetheless co-exist within industries?'* (p.439). In addition, the MNT field data agrees with the ideas from Meyer and Rowan (1977), that organizations meet institutional contexts containing multiple and inconsistent myths that allow for multiple yet equally legitimate responses. In Mercury's case, the professional academic actors believed that their organising principles were quite legitimate, citing core principles of the academic institution within which they were based, i.e. research, development and being driven by curiosity. Conversely, the 'business' actors believed their motivation and rationales were legitimate, citing the purpose of the MNT government intervention as being commercially focused, and revenue-generating.

The MNT centres also provided examples of Fligstein's (1985) complex organisational organisations, where groups competed for power and selectively appealed to institutional pressures to legitimate their claims. This PhD study thus disagrees with the notion that organisations eventually become aligned with their institutional contexts, in accordance with the concept of isomorphism.

9.8.2 Institutional Logics and the Local Context

The concept of institutional pillars, and associated norms, values and roles was observed particularly in the main MNT case, with wider MNT field actors reinforcing the concept of different institutional logics - i.e. professional academic, business, state and hybrid – which informed institutions. The roles of the MNT Centre Directors were in theory meant to be the same, i.e. to develop emerging MNT technologies for the UK's benefit, whilst generating revenue and being open-access. Through understanding institutional norms and their associated reasoning and judgements, the actions of individual Centre Directors were explored, and reasons given as to why the intervention's purpose became contested.

An important observation from the MNT field actors was that many actors exhibiting a range of reasoning strategies. Such actors were described as having a hybrid of business and academic institutional experience and were able to live across institutions, having been exposed to different societal ideas and ways of thinking. This particularly important finding showed how these actors had multiple identities and systems of reasoning and decision-making. This may be a particular characteristic of a nascent field developing complex emergent technologies, which requires a range of actors from different sectors with different skill sets. Further research is needed to investigate this aspect in more detail.

9.8.3 Legitimacy

The complexity of the relationship between legitimacy and performance was demonstrated by several authors. The perceived legitimacy of each MNT centre by their actors and other stakeholders may have had a bearing on how successful they were in achieving the state's goal of becoming revenue generating and commercially successful. Zimmerman and Zeitz (2002) described how being part of a larger institution was important in gaining other resources which are crucial for growth.

In the case of Bacchus and Mercury, the linking to larger organisations, somewhat surprisingly, did not appear to have actually enabled them to become successful MNT centres. In the case of Lucretia, being part of a large university did not appear to add legitimacy to their operations. Success seemed to be a result of the Centre Director's business logic and the commercial focus of the centre, rather than being able to access resources from a larger host organisation.

Conversely, for Rhea, legitimacy was clearly important for the Centre Director, and Rhea built on the reputation of the host SME. Often, the Centre Director described how it was easier to call the MNT centre by the host organisation's name to remove confusion.

Zimmerman and Zeitz (2002, p.423) put forward four strategies for acquiring legitimacy. Of these, 'conformance' was one, and was clearly illustrated by Mercury: Mercury conformed to the University as an institution and its associated practice. However the contested logics within the centre meant that doing so added to its failure as an MNT centre.

Within Chapter 4 the concept of embedded agency was introduced. This idea arose from the difficulty of trying to isolate the impact of agency from other factors. Holm (1995) asked '*how can actors change institutions, if their actions, intentions, and rationality are all conditioned by the very institution they wish to change?'* (Holm, 1995, p.398). Di Maggio (1988) also outlined a number of ways this could be addressed. The key findings from this study in relation to these types of embedded agency are now discussed.

9.8.3.1 Institutional Entrepreneurs

Mr Gillette (Lucretia) is a good example of an institutional entrepreneur, along with Dr Nobel (Liber). Mr Gillette established an MNT centre as a separate organisation within a larger university institution. He mobilised resources in terms of only employing actors with business logics/ commercial experience, and ensured that the MNT centre, although underwritten by the university, acted like a typical commercial business. Dr Nobel went even further by making the concerted effort to decouple Liber from the university which is the main stakeholder of the MNT centre. Through moving to a science park, and focus on business outputs, Dr Nobel presented a clearly different organisation from that typically involved with university institutions. Institutional entrepreneurs do not always achieve their goal in transforming their organisation. Mercury is a good example of this; the traditional, incumbent professional academic logics held through in this centre. This is despite attempts by actors with business logics, and those from the state funder (TSB) trying to change things.

9.8.3.2 Structural Overlap

Greenwood and Suddaby (2006) described how elite organizations are more likely to come into contact with competing and contradictory logics because they bridge different organizational fields. The MNT field conceptualised within this PhD displays an equally specialist area that covers a wide-ranging area of technological applications. The actors interviewed across the MNT field displayed a range of backgrounds, and in a number of cases hybrid logics (i.e. actors with experiences of understanding and having worked with a number of organising principles).

9.8.3.3 Competing Institutional Logics

Evidence of competing logics between field actors according to their individual organising principles, relates to Reay and Hinings (2005) observations of how contested and collaborative logics are enacted within an organisational field. Different Centre Directors exhibit different interpretations of purpose across the centres, as well as outcomes (i.e. conflicting interpretations). In some cases, for example Mercury, there are also differences of purpose within the MNT centre amongst actors.

Greenwood and Suddaby (2006), argued that contact with institutional logical reasoning and judgements in multiple and different organizational fields increased the awareness of and experiences with contradictions in institutional reasoning. This in turn, lowered constraints and embeddedness of actors and enabled central actors to become institutional entrepreneurs. *The evidence from the main case (Mercury) did not support this understanding.* This may be because the majority of actors within Mercury exhibited institutional thinking which was highly conditioned by the university's environment. Jones (2000) describes how the '*variety of norms apparent from the empirical data provide an indication of how industry and universities adopt very different sets of values which inevitably have a considerable influence on their ability to co-operate successfully*' (2000, p.171). With a majority of professional academics in the MNT centre, the experiences of the business way of reasoning may have been overpowered, resulting in the termination of the centre by the state (and before this, the resignation of one of the key business actors). Or as Styhre puts it, '*Institutional actors* *then [in relation to other non-science activities of the organisation] impose ideologies, beliefs, and modes of thinking on their co-workers, thereby reinforcing certain behaviours and beliefs*' (Styhre, 2005, p.198).

The discussion of embedded agency led to a deeper understanding of institutional reasoning and judgement within this MNT government intervention. The key logics observed were those of professional academic, business, state and multiple-logics (or hybrid). These organising principles did not appear to be specific to the context within which the MNT centre was established. The important factor appeared to be the organising principles of the Centres' Directors and actors, which led to either agreement or disagreement on purpose. Actors with similar logics appeared to follow similar actions and organising principles within the MNT field studied. Where a number of logics were observed, then conflicting logics were noted, which led (particularly in the main case) to failures in terms of a centre meeting the original DTI purpose of the intervention. Paradoxically, the initial purpose brought the actors together to set up the MNT field as part of the government intervention. However, the reality of individual institutional logics pushed them apart. Olsen (2007) described the need to understand such conflicts and counterproductive processes based on stakeholder interests in technology development, in order to design innovation processes with complementary roles and interests. This study suggests a number of propositions/ policy recommendations to address this in the following chapter.

The data presented from the MNT government intervention provided an additional case example, which can add to work by authors such as Reay and Hinings (2005) in their discussion of a related healthcare field.

9.9 Summary

This section opened up a wide ranging discussion around the findings from the MNT government intervention examined in this PhD study and in relation to literature used as the building blocks for this study. The research questions were addressed, along with an understanding of how the data collected has the potential to add to or build on existing literature gaps. Throughout this process a number of propositions were formed, which are put forward as contributions to practice. These are discussed in the Conclusions chapter, along with the limitations of this study.

Chapter 10 - Conclusions

10.1 Introduction

This study set out to explore a recent UK government intervention which was established to develop micro-and-nanotechnologies for optimum technology-based economic growth (i.e. stimulation of new industries from emerging technologies). While the need for such technology policies is well recognised (Carlsson and Jacobsson, 1994) there is also however, a need to understand the key challenges that governments face in developing effective policy interventions for the innovation process that will create sound economic leverage (Harvey, 2010).

This chapter discusses how the findings from this study make a practice-orientated contribution. To begin with a number of the key findings are presented. These are preceded by a number of practice-orientated recommendations in the form of seven propositions. Evidence from this study is used to support each of these propositions.

The chapter concludes by discussing the limitations of this study along with avenues for future research.

10.2 Key Findings

A number of key findings in terms of practice have been made from the analysis of the MNT government intervention. As a recap, those of particular importance are now listed:

1. The MNT government intervention failed. Furthermore there is no evidence that the DTI considered the issues of local context and organising principles of actors when developing this technology policy. The main focus appeared to be on how much 'leverage' could be achieved by building on existing MNT infrastructure.

2. There was a central problem of 'management paradox' for this intervention. That is, within the organisational field conflicting logics were observed, along with a mixture of contested/ collaborative organising principles. The central problem in innovation management may be the management of such a paradox. For example, Mercury provided many examples of conflicting organising principles, and in particular examples of actors reconstructing their views.

3. Successful centres were those were actors were driven by a common purpose, and had associated inherent and common business thinking, reasoning and judgement processes.

4. The notion of conflicted interpretation has been shown to be extremely important for government interventions and a significant predictor of eventual outcomes.

5. Context - The associated institutional logics of local and extra local contexts could not be avoided when trying to achieve a successful MNT technology policy.

10.3 Contributions for Practice

A number of practice-orientated contributions in the form of propositions were developed as part of the analysis of this study. These are now introduced with accompanying evidence from the data supporting them.

10.3.1 MNT Centre Context

A number of venues were considered by the DTI's expert selection panel when selecting which organisation would enter the tendering process. These venues - described as 'local contexts' - proved to be an important factor in the success of individual centres within the distributed network that resulted.

This study's data showed that there were no specific requirements (in terms of venue) for applicants to fulfil in order to enter this competition. Decisions were ultimately made on a case-by-case basis, and according to the amount of leverage that could be achieved from an applicant (i.e. if they had existing facilities or customers from whom more value-for-money could be obtained). In turn, this is a key factor in explaining the mixed settings of the 24 MNT centres selected which make up the MNT network organisational field. These include: university science parks, existing global organisations, regional science parks, existing SMEs and University settings.

Equally important to this discussion of the mechanisms used as part of a national system of innovation, are the *local contexts* of those mechanisms; i.e. this study's data demonstrated how different MNT centres exhibit different characteristics related to their venue and specific actors. These actors evidently bring their own institutional logics, belief systems and associated practices to their centres. Subsequently, success in terms of the initial purpose of a government intervention, varies greatly amongst actors and their local environments. Examples from this study which highlight this include:

(i) Dr. Tesla (Director of an SME-based centre) clearly stated that his concern was for his SME – i.e. the local context. He emphasised that his business must continue to make profit before, during and after the MNT centre has finished.

(ii) Mr. Cole (Director of a university-based centre) stressed the importance of generating jobs for the local region and described how his centre's main customer is a large global manufacturing company in the local region.

(iii) Dr Nobel (Director of a Science park-based centre) highlighted the necessity of moving out of a university venue in order to deliver commercial services.

The above findings led to the first proposition for practice:

Proposition 1 - *Different MNT centres exhibit different characteristics relating to their venue and the specific actors populating them. These actors bring their own institutional logics, belief systems and associated practices to their centres.*

Moreover, the contested understanding of purpose of a centre leads to another Proposition 2 from this study:

Proposition 2 - *The view of success in terms of the initial purpose of a government intervention, varies greatly amongst actors and their local environments*.

Olsen (2007) describes how *'…bureaucrats, politicians, industrialists, and scientists regard technological development as tools for quite different purposes*' (2007, p.465). Proposition 2 describes the situation which needs to be addressed in national intervention policies where state actors have an understanding of the *extra local* environment they are trying to achieve (e.g. a distributed network of MNT facilities to help UK SMEs gain access to emerging technologies in the MNT example); however, they have not considered the realities of the local environments that have a major bearing on the original purpose of the intervention. This PhD study adds further empirical evidence to understanding how actors regard technological development policies for quite different purposes.

10.3.2 Longevity and Retrospection of Technology Policies

Proposition 3 – *Innovation policy-makers should consider the benefits from having a longer-term strategy and funding in place for government interventions, in order to nurture the best chance of technological success in terms of application*.

Interviewees described how emerging technologies take decades to develop rather than 3-5 years as in the case of the MNT intervention (ref. Dr Tesla, Mr Strauss, Professor Pascal, Dr Teller, Dr Alvarez). When nations invest such large sums and resources for innovation systems, then a long-term strategy is needed. In the case of the MNT network, rather than continue the existing MNT Programme, the TSB set out a new strategy for developing Nanoscale technologies (TSB, 2009b). This strategy only mentions the MNT Programme and Centres a few times, with very little detail. From investigations as part of this study, it was discovered that a benchmarking review of the Centres was carried out prior to the creation of this new strategy. It is unclear from reading the 2009-2011 Nanoscale Technologies Strategy, what has been learnt from the MNT network that led to the formation of this new way forward.

The findings from my data and a review of the 2009-2011 Strategy reinforces the need for policy-makers to follow-through long-term strategies, rather than replace them with related policies which do not draw clear conclusions on how they build on previous interventions. This leads into my fourth proposition:

Proposition 4 - *Policy makers would benefit from the investigation of previous interventions.*

In the words of one senior interviewee in the TSB, the MNT programme was regarded as a '*hot potato*', and nobody wanted to take responsibility for it (Dr Dickson). This might explain the revised strategy for this area. Garrett-Jones *et al.* (2005) in their investigation of industry-collaborative research centres, purport a number of important learning point from such collaborations which would benefit future innovation policies:

> *'This [collaborative research centre] 'culture' reflects, first … the need for a consensual approach to marshalling the resources of the CRC towards common objectives. Second, concurrently, it requires the CRC to somehow accommodate the disparate 'cultures' of the* participants, comprising the individual researchers, *their research units or scientific disciplines and their 'host' organisations*' (Garrett-Jones *et al.* 2005, p.544).

The findings from centres such as Rhea and Concordia - which accommodate a mixture of actors and cultures - highlighted in this thesis, may provide useful learning points for those developing technology policies.

10.3.3 Reconstruction

Proposition 5 - *The ingrained institutional reasoning of certain actors can be hard to change for the intended purpose of an intervention, once funding has been awarded.*

An example of this was shown in the case of Mercury's Professor Stephenson; despite writing a tender document clearly emphasising the commercial requirements of this centre, he then appeared to change his position in relation to this official document. When asked about TSB judging the centre on commercial measures, he said '*From the start- it was not this, there was a lot of other indicators, but in reality they [the TSB] are interested in the bottom line which is…the commercial income'*.

The TSB actors (Mr Rubik and Mr Morgan) attempted to redirect Mercury toward the commercial purpose the state sought. However, even the threat of withdrawing funding if an external CEO was not appointed, demonstrates how resistant the Centre Director was to change.

10.3.4 Organisational Size

Proposition 6 - *Small organisations developing EDTs benefit from strong cross-linking (collaboration) between actors, coupled with an environment where constructive debates can occur*.

In the case of Mercury, the strong contestation between the actors with opposing logics meant that debates were no longer constructive, and often ended up in '*stand-up rows*' in the words of the Business Development Manager. Proposition 6 may only apply when actors follow a similar organisational purpose, as in the example of Rhea.

A common finding from the focus on large incumbent organisations was that bureaucracy was a definite barrier to disruptive innovation in many cases. Researchers recommended that those firms wishing to overcome bureaucracy should decouple the more innovative business units from the main organisation. Many of the MNT centres investigated in this current study were hosted by larger, incumbent institutions; namely, Lucretia, Mercury, Minerva and Bacchus. Of these, the first three were hosted by established universities, whereas Bacchus was hosted by a global OEM. Of these, Lucretia and Bacchus were estimated by their Centre Directors as becoming self-funding by the end of the grant period, and hence, successful in terms of one of the key TSB criteria. Minerva, although part of a university, was described by its Director as dealing predominantly with one large aerospace OEM. However, the Centre's open-access nature was perhaps questionable in this case, but further data are needed to confirm this.

Bacchus, in the global context, was described by its Centre Director as reaching its financial targets by the end of its life-span. However, only a few of the originally estimated 'new' customers were reached. The Director cited the problem as not having a large enough grant to employ business development managers.

Lucretia and Mercury were both hosted by universities; however, Lucretia was described as one of the most successful MNT centres by Professor Hertz (the architect of the whole MNT intervention). There was also a strong indication from Mr Gillette that it was in the top two for world-class ranking, in comparison with the other centres. Conversely, Mercury was also hosted in a university and became a failure in terms of not generating revenue and also being terminated by the TSB. The question of why these centres were poles apart in achievement is fascinating, considering they were both research centres in large universities.

The findings discussed in the main case and comparative case Chapters suggested a number of reasons why Lucretia was more successful than Mercury and these are briefly analysed now.

10.3.5 Success versus Failure (Lucretia versus Mercury)

Firstly, the Centre Director of Lucretia (Mr Gillette) was driven by a strong business ethic. He employed staff from industry who had business experience and who were able to '*hit the ground running*'. Mr Gillette ran his centre using a traditional business matrix structure; i.e. he had sections for *facilities, quality, engineering* and *finance*. He described how it looked like '*a standard commercial structure*'. There was a clear revenue-generating, commercial ethos within Lucretia. Furthermore, Lucretia – although on a university campus – was set up in its own annex, separate from the other faculties. On visiting it, one would have considered it to be a stand-alone business operation.

Surprisingly, Mercury was also in a separate annex to the main university. Although it was physically part of an existing research centre-of-excellence, the lines between where Mercury began and the research department finished were blurred. Walking into the research department did however, provide more of a commercial feel than most other university departments. So the contexts of the two centres were not worlds apart. The obvious differences come with the comparison between the Centres' Directors and staffing. Professor Stephenson's strong professional academic motivation and the internal conflict resulting between himself and business actors within Mercury and the TSB, have been discussed already. The staffing of the Centre with like-minded academic researchers also added to the commercial tensions between the centre and the state actors (TSB).

Proposition 7 - *If the need for a government intervention is premised on a high-technology based economic growth strategy (i.e. stimulating new industries from emerging technologies), then the selected actors must be driven by appropriate business logics*.

Conversely, if the intervention is to develop a nation's research base (i.e. science policy), then those actors selected to manage any ventures are more likely to be driven by professional academic logics. A case of decoupling was exhibited by the MNT Centre - Liber. Dr Nobel (Centre Director) described how he went to the associated University originally to set up a commercial business:

> '*...after two years of that operation it was obvious that actually to run a commercial business operation within an academic building was impractical. So one of the main tenets of our proposal was that we would be a fully autonomous, commercial centre, run commercially and by a commercial organisation'.*

This neatly summed up the strong business logic driving actors such as Dr Nobel and Mr Gillette. In addition, Liber was set-up in a Science Park; the University having nearly half the shareholding of the company, and the rest was split between the Directors. This autonomy was essential in order to make sound business decisions and commercial agreements (e.g. confidentiality agreements and so on).

10.4 Recommendations to Practice in the Field

The study's findings have implications for the development of technology policy in the associated field. It helps to work toward addressing the gap identified by Fagerberg

(2005) '…among policy makers who have been constrained in their ability to act by a lack of sufficiently developed framework to the design and evaluation of policy' (2005, p.20). Some important points have been raised concerning the governance of the UK MNT government intervention. Firstly and perhaps most importantly, the intended purpose of the MNT government intervention was shown to evolve across MNT centres; the key influential actors of each centre (the Centres' Directors) demonstrably followed different institutional systems of reasoning, which in some cases resulted in internal conflicts. *Paradoxically, it was the MNT intervention's original purpose that brought these actors together, but their internal logics pushed them apart*.

There was no evidence that the DTI took into account the type of actor or the site's appropriateness. The main factor appeared to be leveraging the small amount of funding provided by the UK government by building on existing facilities, wherever and whenever possible. This conflict of purpose between the state actors (i.e. the TSB) and the centres caused a particular problem when the state measured the centres' success. This study's findings highlighted the need for state actors to be completely clear concerning their purpose when embarking on NSIs or government interventions. The metamorphosis of the DTI to the TSB and associated passing of governance for the MNT intervention, added to this confusion of purpose. Actors from the DTI who originally set-up the MNT intervention were no longer involved in the TSB, and as such, understanding of the original purpose was altered through the introduction of new actors and their associated logics. This is potentially one of the problems with the cyclical nature of government funding, and how policies change when governments change. Without this clarity, it was premised that the effectiveness of such NSIs was inevitably bound to be diminished.

Three main policy recommendations for national systems of innovation or intervention are proposed as a result of this research work:

(i) The purpose and required outcomes of a government intervention should be clarified from the outset, so that all stakeholders (actors) understand the purpose of any funding they receive.

(ii) There may still be differences in the perception from actors across an intervention, but clearer goals will help to reduce conflict and difficulty. This should be coupled with a tender and selection process which takes into account the environment within which innovation will be developed. Furthermore, an understanding of the key actors involved in the intervention, using recognized institutional theory, has the potential to enhance any interventions and reduce potential disagreement.

(iii) Issues of regional politics may also need to be considered, in terms of funding allocation and support systems.

In practitioner terms, the novelty value of this research is that it provides new empirical evidence that strongly suggests that future innovation policies need to purposely consider the economic benefit when developing a national system of innovation. In addition and perhaps more importantly, the local and extra-local contexts where the perceived technologies evolve, as well as the actors themselves, were shown as appreciably important. As demonstrated in this study, the ingrained institutional thinking and reasoning of certain actors can be difficult to change for the intended purpose of an intervention, once funding has already been awarded.

Although generalisation should not be made from the sample size obtained, the use of purposive case sampling (i.e. similar cases) and the resulting findings offer new avenues to explore for academics, policy makers and practitioners.

The influence that actors/practitioners have on the purpose of an NSI, and how their organising principles (and those of the wider institution) can affect this purpose, should be part of the process of developing future innovation policies. In addition, the short-term nature of the MNT programme appeared at odds with the findings from participants, who recommended that policy-makers should consider the benefits from having a longer-term strategy and funding in place for government interventions. The reason for this was to nurture the best chance of technological success in terms of application; the newest technologies were reported to take between 10-12 years to develop.

10.5 Limitations of this Study

Overall, this research work, albeit inherently interesting and ultimately rewarding, proved to be both a complex and challenging process for this researcher. In addition and in common with all such research, there were a number of limitations for the researcher to identify and to consider. This particular section reflects on the research methodology utilised and how it might be improved if the study were carried out again, with however, the incalculable benefit of hindsight.

10.5.1 Difficulty in Deconstruction

The development of emerging technologies as part of the MNT network was a dynamic and complex process and a framework was used to deconstruct the key aspects influencing the function of a government intervention. The majority of these were chosen using the example of the well-established MIRP programme, with a number of supporting aspects (constructs) included. Whether the right balance of constructs were used to understand the MNT government intervention is a question that should be asked. The researcher's belief was that those selected were suitable for developing data gathering instruments, which then facilitated thematic analysis to develop the findings. Innovation is a complex process, and no doubt a multitude of other aspects could have been investigated. However any more would have made the data too unwieldy for one researcher to handle. More importantly, those constructs selected were complemented by institutional theory, in order to develop a fuller framework for the investigation of NSIs.

10.5.2 Suitability of the Research Methodology

The methodology section presented the researcher's ontological and epistemological views, along with rationales for the choice of research methods. The question of whether this was the right approach for this study's research questions may well be asked. On reflection, the researcher's answer to this question is an unequivocal '*yes'*. The focus on just one government intervention in one technology area, proved useful for making cross-case comparisons across a range of contexts. This focus on one area of technology was in contrast to the common approach in the literature, which often discussed multiple organisations developing a range of technologies across different sectors. The purposive sampling strategy used meant that although it was impossible to control all variables in such a study, at least each organisation was developing technologies within the same sector, in a nascent field, for a common purpose and within a common field.

The use of institutional theory allowed a number of interesting themes to naturally emerge. It highlighted the importance of actors within the MNT field and in particular, how organising principles coupled with action and structure (in terms of context), had an important influence on the success of government interventions. Somewhat surprisingly, these factors did not appear to have been taken into consideration when the

DTI carried out the tender and selection process for the MNT centres. Overall, the approach used supported the examination of a government intervention and brought together a number of different areas of literature to build on the MIRP research framework.

10.5.3 Sampling of Data and Access

This research project's goal was never to make wide-reaching generalisations, but to help develop a method of understanding a contemporary example of a government intervention. Access was gained to nine MNT centres out of the possible twenty-four MNT established centres. The researcher would have preferred to have gained access to more, if that was possible. However, as previously discussed in the Methodology Section, gaining access to just nine centres was requiring considerable and repeated effort in the face of initial resistance.

One example of this is where *Liber's* Centre Director was contacted early in the research process, and access was denied. Despite further e-mail contact, access was still continuously denied. However, after interviewing another Centre Director who was known to *Liber's* Director, a recommendation was then made which paved the way to the desired interview.

The Centre *Bacchus,* which was located in a large global OEM, was also an interesting case concerning access. Once again, perseverance on the part of the researcher was rewarded by eventually meeting with this Centre's Director. These examples were typical of the response from many of the centres. They appeared to be a result of 'audit fatigue' due to the intensive auditing the centres had recently received from the TSB; i.e. the actors did not wish to spend any more time being researched or analysed.

Another conclusion that could be drawn from this was that perhaps the centres were not rigorously following the purpose of the MNT government intervention. However, this is merely speculation and without any real evidence or information on those centres. With this in mind, the purposive sampling strategy ensured that centres covering a range of constructs were examined. If time and access had allowed, then the interviews would have been repeated six months after the original interviews, to allow for some longitudinal data to be collected.

In the case of *Mercury*, interviews with a number of key individuals were carried out at different points in time. However, due to limited resources and issues of access, the interviews were kept to one, with any ambiguities clarified through follow-up phone conversations or email correspondence.

The researcher might be criticised for only interviewing actors at one particular point in time. The researcher’s response here would be that it was a valid and reasonable method for researching this sensitive area. A senior and influential member of one university described the MNT intervention as a *‘political hot potato’*. Considering these access difficulties, the researcher was pleased to achieve a ‘snapshot’ of each individual’s experiences and views at a particular time, situation and context.

Coupled with the interview data from additional MNT field actors, the total number of interview participants totalled twenty-six. However, several more were involved in the data collection process. In reality, if further access had been granted by additional centres, then the amount of qualitative data would perhaps have been too great to analyse for one researcher in the limited time period provided. This is illustrated by Pettigrew (1990) in the following descriptive text:

> ‘*Anyone who has used the comparative case study method will know that the central problem is dealing with complexity; first of all, capturing the complexities of the real world and then making sense of it. For some, there is no release from the overwhelming weight of information, from the task of structuring and clarifying, from the requirement for inductive conceptualization. The result is death by data asphyxiation-the slow and inexorable sinking into the swimming pool which started so cool, clear and inviting, now has become a clinging mass of maple syrup*’ (p.281).

In summary, a purposive, heterogeneous sample (in terms of range of contexts) was used, with specific selection criteria. Follow-on telephone interviews and e-mail correspondence were also carried out to resolve any ambiguities. The findings from the actors were triangulated, when descriptions of similar centres or the MNT intervention as a whole, were carried out.

10.6 Future Research

The government intervention selected for this study was based only in the UK. It would be beneficial to carry out a further study of government interventions which were developing MNTs in other European or even global environments. This would be likely to add not only the context of different cultures and practices to other research work, but would provide a wider comparison from which to compare this current UK intervention.

If further research work was to build upon the work in this particular study, then a number of suggestions are presented here by this researcher:

i. More professional academic Centre Directors should be interviewed, along with further in-depth university MNT centres, to build on the rich data from Mercury.

ii. Once the MNT government intervention is complete in the near future, it is likely that centre reports and findings which are currently considered ‘commercial-in-confidence’ will be released, or could be obtained using Freedom of Information requests. Through gathering such secondary documents, further triangulation of data and the characteristics of professional groups as documented in public-documents, would add to the findings from this present study. Reay and Hining’s (2005) research paper on the healthcare field in Alberta would provide a good methodological direction for this.

iii. Interviews from customers of the MNT centres would add another view of the success of the centres in terms of the DTI purpose. This would help with measuring the penetration of the centres into the UK economy (something the state actors have admitted struggling with). Users of the centres may highlight different organising principles which may inform future policy making.

iv. The Foster Report suggested that two large centres should have been created, rather than a number of distributed centres. Data were collected from a large MNT centre in Leuven, called ‘*IMEC’*, which would be an example of the larger centre originally proposed. This data could be reviewed along with other larger centres to make valid comparisons between the two models.

It is important to note that the research questions asked in this study concerned a government intervention that was initiated to develop a nascent technology for the commercial benefit for the UK economy. If however the grants awarded had been allocated for research, then the findings concerning outcomes would have been different. For example, university contexts with their predominance of professional academics were likely to have been a better setting for ‘blue-sky’ research, whereas business contexts might well not have been. This illuminates the way forward for potential studies concerning interventions which are focused on research evidence. Such studies might however, present the business actors in a less favourable light in terms of achieving the research purpose.

A major conclusion from this study is that the government created an innovation management paradox from the outset; i.e. developing MNT centres which were meant to be revenue-generating in a context that was typically research-led and run by actors with professional research motivation.

The ramifications of getting it wrong are exhibited in the main case study (*Mercury*) which had £3 million invested in it, and then had the final few funding payments withdrawn just months before the end. The majority of this funding had already been invested in capital equipment, which remains in the university department, and is under-utilised. Recently the TSB produced a '*Nanotechnology Strategy*' document for 2009-2012 (TSB, 2009). However, they only briefly mentioned the previous Centres in any degree of a positive light. From a rather sceptical point of view, it would appear that they were presenting only positive information they were happy to share, and concealing the information that they deemed as being negative. This suggested the deliberate reconstruction of their information into a more positive frame, perhaps to maintain credibility with the NDGB. This was also implied by a number of interviewees. Future research investigating this new nanotechnology strategy using the same methodology would provide valuable data to build on this current PhD study.

10.7 Summary

Practice and policy recommendations have been drawn from the case of a recent UK government intervention designed to stimulate the nascent sector of micro-and-nanotechnologies. This research has concentrated on one field only rather than multiple sectors, in order to make comparisons across a number of organisations developing emerging technologies. The novel method used has synthesised a number of disciplines, to inform a different approach in setting up future government interventions. This method has helped us understand the implications of the context in which interventions are situated. Furthermore the notion of conflicted interpretation has been shown to be extremely important for government interventions and a significant predictor of eventual outcomes.

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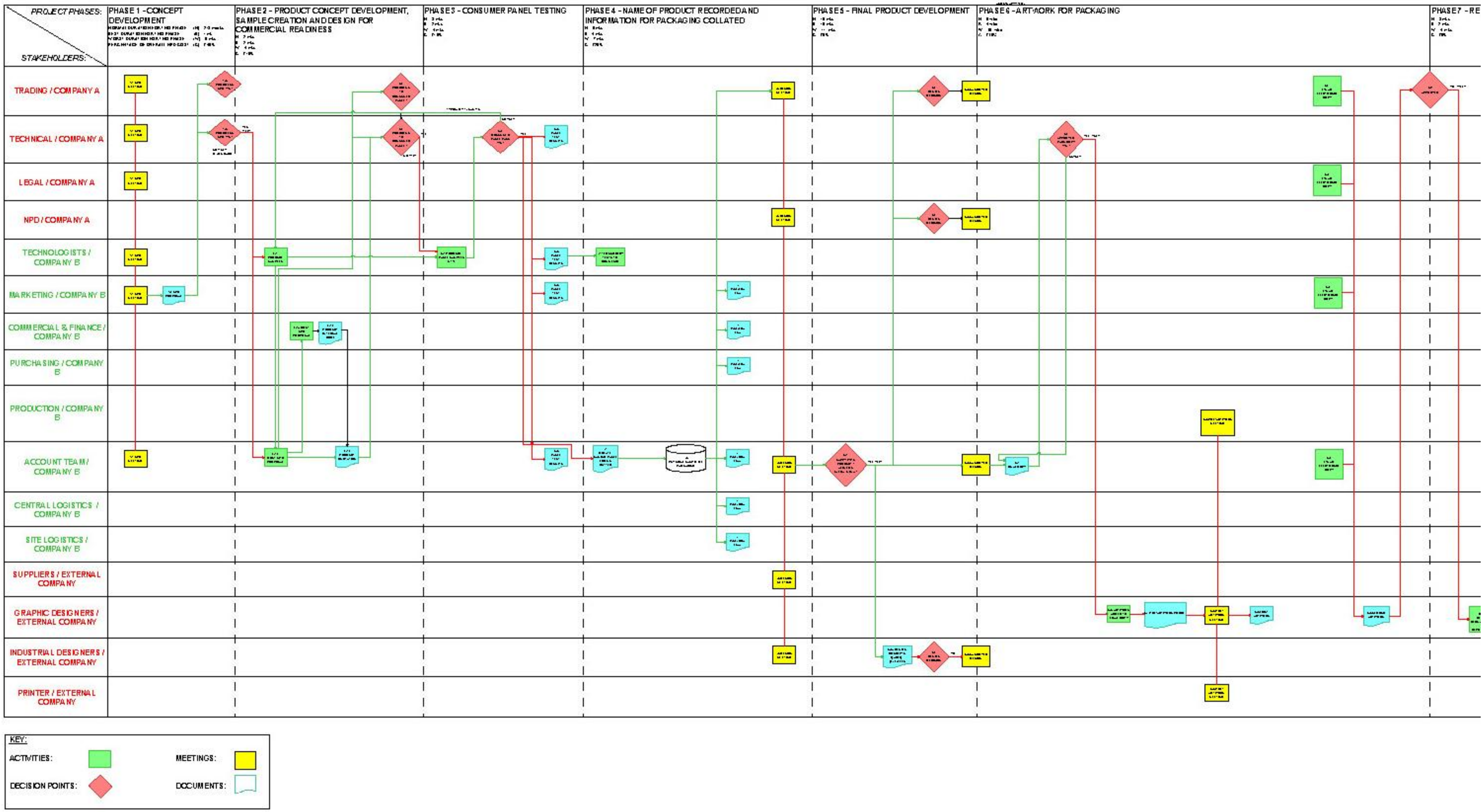
Appendix 5a – Anonymised Example Map from Pilot 1



Appendix 5b – Pilot Interview Template

Introduction [5mins-slides]

Transactions [10mins]
As part of your innovation management process, what relationships/collaborations do you have with other organisations /companies/groups? (these can include formal and informal links).
How were these forged? Any particular drivers?
How do such relationships help to advance nanotechnology within the UK.
Are nanotechnology centres –such as this one- technologically ahead of industrial research?
Do you think that publicly-funded initiatives such as these help industry to exploit emerging technologies, such as micro- and nano- technologies?

Industry involvement [10mins]

- Do you think that government-funded programmes, such as this one, are technologically ahead of industrial research?

Technology success [time]

- How would you describe a successful outcome from the application of your nanotechnology (and/or expertise)?
- Can you describe a recent successful application of your micro technology?
- Was this process formally managed? (i.e. a formal process has been followed to develop these technologies) Yes/No
  - ✓ Can you discuss this? Were there key milestones?
  - ✓ What were the key activities that enabled this success? What were the key activities that created "value" for the customer?
  - ✓ Who were the people or groups involved in these key activities (incidents). What important roles and activities did they perform?
  - ✓ Could any activities have been left out, in hindsight (i.e. "waste activities").
  - ✓ What would have you done differently?
- If not, do you think this would have helped?

Technology failure [time]

- Can you give an example where the application of your technology (or expertise) was unsuccessful? OR an example with elements of success *and* failure?
  - ≡ Why do you think this failed? Were there any key activities that potentially led to this?
  - ≡ If so, were any particular groups or people involved?
  - ≡ What would you have done differently?

Closing questions [time]

- Can you suggest any other potential interviewees?
- Are there any other issues that you have experienced when developing nanotechnologies? *In particular*, focussing on the innovation management side of things.

Table 5c – Additional Research Strategies and their Suitability for this Research Study

Strategy	Form of Research Question	How suitable is this strategy for… ?			
		The Research Questions and/or objectives?	**The existing body of knowledge/ literature?**	**The resources & time?**	**The researcher's world view/ and comments on this**
Experiment	How, why?	RQs are context specific, and the organisational environments too complex for this strategy.	Atypical	Too intensive, and would oversimplify the representation of the innovation management process.	Organisations are extremely complex environments, unrealistic to attempt to isolate variables for study and run a controlled environment study.
Survey	Who, what, where, how many, how much?	Suitable. Visual Analogue Scales and attitudinal scales may be of interest. For the complex area under investigation a survey will only capture information on the variables included. Limited depth of information, but good if large population surveyed.	Good.	Once a comprehensive survey instrument had been created, depending upon response-rate, this would be far quicker than interviewing people, and any travel this may incur. Generally far easier to manage.	Surveys can only provide information on the questions asked; there is very little scope for open questioning. Controls over security - there is no question over who is involved in the discussion, and the session is secure. Again, how do you know the boss isn't filling in a respondent's survey? Also, you don't have the persons full attention, whereas with interviewing or other methods, you do Greenbaum (Moderating Focus Groups)

Strategy	Form of Research Question	How suitable is this strategy for… ?			
		The Research Questions and/or objectives?	**The existing body of knowledge/ literature?**	**The resources & time?**	**The researcher's world view/ and comments on this**
Archival analysis	Who, what, where, how many, how much?	Often organisations developing emerging technologies are at an early point in their lifecycle, and as such quite small. Consequently they are unlikely to have standardised documentation procedures of the innovation management process in place.	If the appropriate records could be found this may be useful when analysing large organisations (e.g. OEMs). Such organisations are not the focus of this research.	Desk-based, so low on resources, but a large amount of time could be used in filtering through archives of day-to-day company records.	More interested in contemporary events, and such events, like the development of new technologies remain undocumented to the level required by archival analysis.
Case study	How, why?	Innovation management is a complex process; combining this with organisations carrying out innovation management in different contexts, the nature of the complexity increases. Case studies are concerned with investigation such complexity, they allow deep and rich analysis of single organisations. External validity can be questioned when investigating single cases, however triangulation	A robust case study strategy would add to the existing body of knowledge. Often cases within the EDT literature area are published in more anecdotal/ narrative forms, lacking true case study rigour.	Triangulation is one way to increase external validity, but takes more time and resources.	The rich, contextual data gathered from case studies appeals to the researchers world view of positive realism. By using multiple cases more generalisable results can be achieved – whilst understanding the limitations of smaller sample sizes. Case studies also allow for a more pragmatic route to data collection; i.e. quantitative and qualitative research methods can be used to compliment each other.

Strategy	Form of Research Question	How suitable is this strategy for… ?			
		The Research Questions and/or objectives?	**The existing body of knowledge/ literature?**	**The resources & time?**	**The researcher's world view/ and comments on this**
		using multiple case studies can overcome this.			
Action Research	How?	If the author was positioned within an organisation developing emerging technologies, this strategy could provide in-depth analysis of one case. The research questions are interested in generating a framework for successful development of EDTs by organisations; a multiple case study approach would provide contemporary examples of existing frameworks for analysis.	This strategy could provide in-depth examples, which would contribute to the existing literature.	Due to the nature of organisations developing EDTs, often access is difficult due to issues of confidentiality and non-disclosure. Such immersed action research access would proved difficult.	Issues of any generalisability if only one case is used, and when the researcher is immersed in a setting, they are often having to deal with their own agenda and that of the sponsor; so pure research would be hard to negotiate.
Grounded Theory	how, why?	Would be suitable.	Not typically seen in the literature for EDTs.	Organisations prefer to have an outline of what the research access is for, therefore a truly grounded theory approach might be off-putting (e.g. participant observation).	The author prefers a more structured approach to data gathering, again displayed by his leaning towards positive realism.
Ethnography	How, why?	The research questions are interested in generating a framework for successful development of EDTs by	In-depth examples would be of benefit to the literature. Very specific though.	Very time consuming. Naturalism in the sense of being in the environment, lots of participant	This strategy is too focussed on the individual for the researcher.

Strategy	Form of Research Question	How suitable is this strategy for… ?			
		The Research Questions and/or objectives?	**The existing body of knowledge/ literature?**	**The resources & time?**	**The researcher's world view/ and comments on this**
		organisations; as such only addressing the individual would not achieve this.		observation, and not simplifying the complex world.	
Processual Research	What, why, how?	Suited to the investigation of processes within a range of different contexts, addressing a number of different outcomes (Pettigrew, 1997). Highly relevant to the RQs.		Authors such as Van de Ven *et al.* (2000) offer a more formulaic approach for process research; i.e. recording events and actions over a long duration of time, for the observed organisational process. Such an approach generates vast amount of data in order to overcome some of the difficulties of generalisation which can occur with the smaller sample sizes typical of organisational research. This approach is very resource hungry*.	Approach appeals to researcher's world view, with the acknowledgement that an adapted method without the highly prescriptive recording of temporal event data. This PhD study does not attempt to emulate such a depth of data collection.

* e.g. in the Minnesota Innovation Research Programme (MIRP) reported by Van de Ven *et al.* (2000) 14 studies were carried out, with different research teams. The teams comprised 34 people (15 faculty and 19 doctoral students) from eight different academic departments and five schools in Minnesota.

Appendix 5d – Meta-Table of Results

[Table not included in electronic version of Thesis due to formatting limitations]

Appendix 5e – Ethical Approval Process

Procedure for obtaining approval from Cardiff Business School's ethics committee:

1. Complete your proposal, questionnaires, consent and debrief forms.
2. Complete Cardiff Business School ethical approval form (Appendix A).
3. Submit two copies of parts 1 and 2 above to Laney Clayton (Secretary to the Ethics Committee) by the 15th of the month.
4. Await comments, and hopefully approval.

Note: for PhD Research, the following statement is made (see Bragg, 2006).
'It is the responsibility of the supervisor .. to ensure that a student's project is ethically sound. If the project supervisor is satisfied that the proposal raises no ethical issues, the project may go ahead. However, if the project supervisor believes that there are ethical issues, the proposal must be referred to the ethics committee. Similarly all research involving participants recruited independently of the Business School must be referred to the Ethics Committee'

References:
Bragg, S. (2006). *Research Ethics Committee.* [WWW]
<URL: http://www.cardiff.ac.uk/carbs/research/ethcommittee.html> [Accessed 22 January 2007].

Further information for the proposal, questionnaire, consent and debrief forms can be seen at:

Bragg, S. (2006). *Research Ethics Guidelines for Applications*. [WWW]
<URL: http://www.cardiff.ac.uk/carbs/research/ethguide.html> [Accessed 22 January 2007].

The main code of ethics for management research that I will use can be found at the following location:
http://www.aomonline.org/Membership/Governance/AOMCodeOfEthics.pdf

Appendix 5f – Approved Ethics Form

CARDIFF BUSINESS SCHOOL ETHICAL APPROVAL FORM:
PHD THESIS RESEARCH
(For guidance on how to complete this form, please see http://www.cf.ac.uk/carbs/research/ethics.html)

For Office Use: Ref **Meeting**

Does your research involve human participants? Yes ☒ No ☐
If you have answered 'No' to this question you do not need to complete the rest of this form, otherwise please proceed to the next question

Does your research have any involvement with the NHS? Yes ☐ No ☒
If you have answered **Yes** to this question, then your project should firstly be submitted to the NHS National Research Ethics Service. Online applications are available on http://www.nres.npsa.nhs.uk/applicants/ . It could be that you may have to deal directly with the NHS Ethics Service and bypass the Business School's Research Ethics Committee.

Name of Student: Peter Dorrington

Student Number: 971060513

Section: LOM

Email: DorringtonP1@cf.ac.uk

Names of Supervisors: Professor Peter Hines & Dr. Mark Francis

APPLICATION APPROVED RESEARCH ETHICS COMMITTEE CARDIFF BUSINESS SCHOOL CARDIFF UNIVERSITY

Supervisors' Email Addresses: peterhines@hotmail.com, markfrancis@sky.com

Title of Thesis: Commercialisation and Technology Management Challenges for Emerging and Potentially Disruptive Manufacturing Technologies

Start and Estimated End Date of Research: Sept 2007-Sept 2010

Please indicate any sources of funding for this research: DTG (from the EPSRC)

1. Describe the Methodology to be applied in the research

This PhD topic crosses the boundaries of engineering and business research. As such, I will adopt a cross-disciplinary approach. This approach will be qualitative, and consist of in-depth case studies, with semi-structured interviews and focus groups.

2. Describe the participant sample who will be contacted for this Research Project. You need to consider the number of participants, their age, gender, recruitment methods and exclusion/inclusion criteria

The selected cases (access permitting) are envisaged to consist of a number of research organisations, along with a number of commercial organisations, which are developing emerging micro technologies. This access will require semi-structured interviewing of key personnel, with a view to arrange focus groups - where access is granted – to investigate identified issues further.

It is hoped that 10 participants (5 from industry and 5 from research organisations) will be interviewed for the first part of this research.

Phd_ethicsform_PD-v4 Version: 09/10/2008

Any access will require participants to give up their time, and so contact time will need to be used efficiently, such that the participant(s) are not questioned longer than necessary.

Participants will be those people who have been instrumental in developing the emerging/new technology. Within a research organisation they might include; researchers, principle investigators and commercial managers. Within commercial organisations they might include; researchers, company directors, venture capitalists, engineers and marketing managers. This research does not focus on a particular age or gender of employees, the focus is on the innovation management process itself.

In the first instance, access is required for one interview. However, if a company is willing to concentrate on any particular issues that they might have, linked to this research, then an interactive focus group session will be offered. This would require 2-3 people to discuss the highlighted issues further, and may include mapping sessions*.

Recruitment will either be through direct contact (in the case of interviewing), or via an organisational stakeholder (where more than one participant is involved). Case selection criteria will guide the choice of organisations to contact (for example: size, type of innovation, industry sector etc.).

* 'mapping sessions' - in this context - describe a group of key stakeholders working together (facilitated by the researcher), in order to identify key process stages, decision points, activities, issues and concerns within the organisation's technology development process. They are interactive sessions, which facilitate discussion whilst capturing key process data.

3. Describe the consent and participant information arrangements you will make, as well as the methods of debriefing. If you are conducting interviews, you must attach a copy of the consent form you will be using.

I will contact potential participants via email and/or follow up phone calls. I will reply to any interested parties by email or telephone, and arrange a suitable time for the interview. I will email them a debriefing document and consent form (refer to 'Debriefing-v1.doc' and 'Consent-v1.doc') prior to the interview, and provide them with my contact details for any questions that they may have.

When I meet the interviewees I will present them with a few power-point slides to reiterate the background and motivation for my research. This will also remind the participant that the interview will be recorded, all data will be anonymous and confidential, and that they are free to withdraw at any stage. They will be informed that the interview will be transcribed afterwards, and a copy provided for them to confirm for accuracy, make changes, or omit anything. This revised copy will also be sent to them.

The information within the transcripts will be kept anonymous, and any data confidential. Again, they will be informed of this in the initial documentation, and introductory power-point presentation.

Once the results have been analysed, a report summarising the findings will be sent to the participants. Following this report the participants will be able to comment and make suggestions. If the findings are reported in any conference papers or other written form, then the respondents will be informed.

4. Please make a clear and concise statement of the ethical considerations raised by the research and how you intend to deal with them throughout the duration of the project

Due to the nature of research in the area of new technologies, there may be issues of confidentiality and moratorium periods for publishing data. RACD have been contacted, and where further confidentiality agreements are required they will be happy to assist.

Unlike historical data or published statistics, I will need to negotiate direct access to organisations, their processes, individuals and teams; as well as taking up their valuable time. As such, I will offer a report analysing the results and summarising the findings from my research, in order that they are remunerated in some way.

PLEASE NOTE that you should include a copy of your questionnaire

NB: Copies of your signed and approved Research Ethics Application Form together with accompanying documentation must be bound into your Dissertation or Thesis.

PhD_ethicsform_PD Version: 20/02/201208

5. Please complete the following in relation to your research:

		Yes	No	n/a
(a)	Will you describe the main details of the research process to participants in advance, so that they are informed about what to expect?	☒	☐	☐
(b)	Will you tell participants that their participation is voluntary?	☒	☐	☐
(c)	Will you obtain written consent for participation?	☒	☐	☐
(d)	Will you tell participants that they may withdraw from the research at any time and for any reason?	☒	☐	☐
(e)	If you are using a questionnaire, will you give participants the option of omitting questions they do not want to answer?	☐	☐	☒
(f)	Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	☒	☐	☐
(g)	Will you offer to send participants findings from the research (e.g. copies of publications arising from the research)?	☒	☐	☐

PLEASE NOTE:
If you have ticked **No** to any of 5(a) to 5(g), please give an explanation on a separate sheet.
(Note: N/A = not applicable)
There is an obligation on the lead researcher to bring to the attention of Cardiff Business School Ethics Committee any issues with ethical implications not clearly covered by the above checklist.

Two copies of this form (and attachments) should be submitted to Ms Lainey Clayton, Room F09, Cardiff Business School.

Signed [illegible]
Print Name PETER DORRINGTON
Date 09/10/08.

SUPERVISOR'S DECLARATION
As the supervisor for this research I confirm that I believe that all research ethical issues have been dealt with in accordance with University policy and the research ethics guidelines of the relevant professional organisation.

X Signed [illegible] (Primary supervisor)
Print Name PETER HINES
Date 10/10/8

APPLICATION APPROVED RESEARCH ETHICS COMMITTEE CARDIFF BUSINESS SCHOOL CARDIFF UNIVERSITY

STATEMENT OF ETHICAL APPROVAL
This project has been considered using agreed School procedures and is now approved.

Signed [illegible] (Chair, School Research Ethics Committee)
Print Name [illegible]
Date 11/11/2008.

Phd_ethicsform_PD-v4 Version: 09/10/2008

Cardiff Business School
ETHICAL CONSENT FORM

I understand that taking part in this research will include participation in individual interviews regarding my experience of innovation management processes for micro manufacturing technologies/products.

My identity will be kept confidential at all times and any identifying data will be made anonymous.

I understand that I can withdraw from the research at any time prior to the submission of the thesis (September 2010) and no reasons need to be given for my withdrawal.

The data held can only be traced back to me by the researcher, Peter Dorrington, and in line with the Data protection Act I can access my information at any time or ask for it to be destroyed.

I understand that at the end of the study I will be entitled to receive a summary of the findings of the research.

I agree to the interview being recorded.

I have read and understood the above terms and agree to participate in the research undertaken by Peter Dorrington, of Cardiff Business School, under the supervision of Prof. Peter Hines & Dr. Mark Francis.

Company ....

APPLICATION APPROVED RESEARCH ETHICS COMMITTEE CARDIFF BUSINESS SCHOOL CARDIFF UNIVERSITY

Signed ....

Date ....

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Appendix 5g –Interview Ethical Consent form

Cardiff Business School
ETHICAL CONSENT FORM

I understand that taking part in this research will include participation in individual interviews regarding my experience of innovation management processes for micro manufacturing technologies/products.

My identity will be kept confidential at all times and any identifying data will be made anonymous.

I understand that I can withdraw from the research at any time prior to the submission of the thesis (September 2010) and no reasons need to be given for my withdrawal.

The data held can only be traced back to me by the researcher, Peter Dorrington, and in line with the Data protection Act I can access my information at any time or ask for it to be destroyed.

I understand that at the end of the study I will be entitled to receive a summary of the findings of the research.

I agree to the interview being recorded.

I have read and understood the above terms and agree to participate in the research undertaken by Peter Dorrington, of Cardiff Business School, under the supervision of Prof. Peter Hines & Dr. Mark Francis.

Company ……………………………

Signed ……………………………

Date …………………….

Appendix 5h –MNT Centre Data Recorded Quarterly by the TSB

The following data are recorded from each centre by the third-party monitors on behalf of the TSB. These are taken quarterly.

- Risk: H, M, L
- Performanc: H, M, L
- On-track/ Variance/ Critical
  - Forecast revenue, variance
  - Number of orders, which sectors
  - Number of enquiries (resulting from which types of marketing?)
- **Performance** - Risk
  - Supplier/ partnership relationships
  - Financial risk
  - Commercial and market risks
  - HR
  - Facilities and Infrastructure
  - MSL/MEC (CU) Relationship
  - Technology and IPR
- Performance - Activities
  - Operating Agreements
  - Office/work space identity
  - Business and technology development plans
  - Technological issues (e.g. software development)
  - Website development
  - Accreditations
  - Staff
  - Equipment purchase
  - Strategic Review
- Industrial Advisory Boards?
- Performance - Financials:
  - TSB grant claimable
  - RDA grant income
  - Contributions in kind (proposers)
  - Contributions in kind (suppliers)
  - Revenue
  - Total
  - [Total Budget/Forecast to date/ actual to date/ variance £ & %]
- Performance - Expenditure
- MATURITY – Vision and Direction

Appendix 6a – Archive documents outlining the assessment criteria used for selecting suitable recipients of funding for this capital facilities programme.

Source:

http://web.archive.org/web/20050212110814/www.mntnetwork.com/assessment.html

Assessment Criteria

All applicants are required to submit a Second Call Application Proposal, which should provide detailed responses to the Assessment Criteria shown below.

For information, and in the interests of openness, guidance notes for referees allocated for each question is also provided.

1. Strategic Fit with MNT Network
2. Provision of Open Access
3. Potential Economic Impact
4. Quality of Business Proposition - Market Analysis
5. Quality of Business Proposition - Business Model
6. Quality of Business Proposition - Implementation Plan
7. Contribution from Partners
8. Quality of Technical Proposal
9. Quality of Risk Management
10. Appropriateness of the Organisation that is Applying
11. Quality of Management
12. Demonstration of Value-Added Support
13. Additionality to UK MNT Network
14. Forward Vision
15. Value for Money

Referee Scoring Process

Each proposal will be allocated to 5 **referees** by the management team (**TTP**).

The referees will be individually asked to assess the strength of the case presented by the application for each of the above criteria and to allocate a score for each criterion on the following basis:

4	a very strong case has been made
3	a strong case has been made
2	a weak case has been made
1	a very weak case has been made.

The referees are also invited to provide detailed comments alongside each score. These comments should include their views as to why the proposal is considered to be valuable and to describe anything that is missing from the proposed activity. Referees will also be asked to highlight any key areas of risk or uncertainty that should be the subject of particular scrutiny during the detailed evaluation in **Stage 2**. These comments should be constructive, as (unless the referee specifically requests otherwise) they will be fed back to the applicant as well as to the **Executive Panel**.

The results and comments from the 5 referees will be passed on to the Executive Panel for guidance and information. The Executive Panel will make the final decision as to whether the application passes the criteria for questions **1 and 2**, which are **mandatory**.

The scores for questions 3-15 inclusive, will be collated and aggregated by the management team. Where there is a significant anomaly, the referee(s) will be contacted for clarification and if necessary, will be asked to reconcile any significant differences among themselves. The overall assessment will be used to rank proposals and this information will be presented to the Executive Panel, for consideration and selection of proposals to progress to **Stage 2**.

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1. Strategic Fit with MNT Network

Tests supporting the objectives of the Capital Projects fund and the wider objectives of the MNT Network.

Information Requirements	Guidance for referees
Applicants are required to explain how	Does the proposal align with the

the proposed project: ▪ Aligns with the objectives of the MNT Network as articulated in "**What is the UK MNT Network?**". ▪ Aligns with the **UK MNT Strategic Priorities**.	objectives of the UK MNT Network? Does the proposal fit with the objectives of the Capital Projects fund as described in **section 3**?

^top

2. Provision of Open-Access

Tests whether the facility is able to provide open-access of its equipment and expertise to the UK MNT community

Information Requirements	Guidance for referees
Applicants are required to demonstrate that their proposal will provide **open-access** of equipment and expertise to the UK MNT community.	▪ How does the applicant propose to provide open-access? ▪ How will the facility allocate resource between competing demands? ▪ What steps are proposed to market the facilities to the wider community? ▪ Is there a clear interface with customers? ▪ Can the service described be delivered within the timescales required of industry or their proposed customer base? ▪ Does the applicant have the commercial expertise to operate an industry-facing facility? ▪ Are there competing demands on expertise and infrastructure that may have a significant impact within

	the facility? ▪ Has the applicant clearly demonstrated how they will manage competing demands?

^top

3. Potential Economic Impact

Assesses the extent to which the proposal demonstrates supporting commercialisation of MNT and the anticipated scale of economic impact which will result.

Information Requirements	Guidance for referees
Applicants are required to explain how the proposed project: ▪ Supports the commercialisation of MNT ▪ Has a positive economic impact on the UK and Region it is located in ▪ Supports industry in achieving a competitive advantage for the UK.	The focus of the Fund is to increase economic activity in the UK. ▪ How does the applicant propose to deliver this successfully? ▪ Does the proposal demonstrate how it will support industry in achieving a competitive advantage for the UK?

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4. Quality of Business Proposition - MARKET ANALYSIS

Tests the robustness and appropriateness of the market analysis.

Information Requirements	Guidance for referees

Applicants are requested to provide details of the following in sufficient detail to demonstrate the quality of the business proposition: ▪ Details of market analysis to demonstrate existing demand and future demand, in the specific sector that the applicant is targeting.	▪ Does the proposal identify a genuine market demand? ▪ And if so will the project be effective in accessing and meeting this demand? ▪ Does the applicant understand and explain what their **specific** target market is, and how they will address this customer base, or do they just provide generic market data? ▪ Is the business case product and/or application-driven?

^top

5. Quality of Business Proposition - BUSINESS MODEL

Tests the robustness and appropriateness of the business plan.

Information Requirements	Guidance for referees
Applicants are requested to provide details of the following in sufficient detail to demonstrate the quality of the business proposition: ▪ Business model, in particular explaining access and intellectual property (IP) provisions.	▪ How complete is the Business Plan? ▪ Is the proposal financially viable based on the requested level of support through the Capital Projects fund? ▪ Do capex and opex profiles look realistic? ▪ Does the revenue profile look realistic and link to expected technology outputs? ▪ Does the Business Plan recognise the need to be flexible should demand not meet expectations? ▪ Does the Business Plan recognise risk and link to a

	Risk Management Plan? ▪ When does the facility expect to break-even? ▪ Is this consistent with the rest of the application? ▪ Does the cost model correspond adequately to the rest of the business model and to future plans? ▪ Does the proposal articulate a convincing model for IP development, ownership and access?

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6. Quality of Business Proposition - IMPLEMENTATION PLAN

Tests the robustness and appropriateness of the implementation plan.

Information Requirements	Guidance for referees
Applicants are requested to provide details of the following in sufficient detail to demonstrate the quality of the business proposition: ▪ Implementation plan, clearly illustrating the treatment of risk and key implementation and output milestones.	▪ Are the implementation plans complete and feasible? ▪ Have the necessary planning, environmental and other consents been identified and are they being progressed? ▪ Does the plan include sufficient (stage gate) controls? ▪ Does it identify implementation risks and adequately address their management?

^top

7. Contribution from partners

Explores which organisations (including RDA/DAs) are prepared to make a financial or strategic contribution to the project.

Information Requirements	Guidance for referees
Applicants are required to demonstrate evidence of the level of financial contribution from all partners. The financial breakdown of contributions must be provided on the proforma, with any accompanying explanation on the free-form application document. If partners bring non-financial benefits, then this should be clearly demonstrated too.	▪ Which organisations will make a financial contribution to the project? ▪ How far advanced are the approvals procedures? ▪ Will they impose operational constraints on the project? ▪ Are there any non-paying partners who bring strategic benefits to the project? ▪ Has the applicant consulted or partnered with the UK leaders in this field?

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8. Quality of Technical Proposal

Assesses the technical feasibility of the proposal and its exploitation potential

Information Requirements	Guidance for referees
Applicants are requested to provide details of the following in sufficient detail to demonstrate the quality of the technical proposal: ▪ Technical feasibility of the proposition ▪ The management of technical risks ▪ Staffing requirements	▪ Are the proposals technically feasible? (e.g. access to technology, support facilities, relevant expertise and will it deliver?) ▪ Are the **technical risks** identified and how are they being managed? ▪ Is open-access realistic for the equipment proposed

▪ Exploitation potential.	(e.g. is set-up time feasible)? ▪ Are there any potential contamination issues? ▪ If so, which equipment falls into that category and how is this addressed by the applicant? ▪ Does the delivery of technical outputs look feasible? ▪ Are there sufficient technical resources allocated? ▪ Does the proposal articulate the exploitation potential of the technology and the projected scale of this impact?

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9. Quality of Risk Management

Assesses the robustness of the proposals risk management plans through implementation and operation for dealing with technical and business risks and liabilities.

Information Requirements	Guidance for referees
Applicants are requested to provide details of the following in sufficient detail to demonstrate the quality risk management proposals: ▪ Identification of potential risks ▪ The proposed management strategy for each risk ▪ Identification and plan relating to the management of liabilities.	▪ Are key technical, business and other risks (e.g. statutory) identified? ▪ Is the proposed management of these risks robust with clear roles/responsibilities and mitigation strategies? ▪ Are key potential liabilities identified and is there a plan to manage them?

^top

10. Appropriateness of the organisation that is applying

Assesses the technical, commercial and financial credibility of the applicant(s) / consortium.

Information Requirements	Guidance for referees
Applicants are requested to provide details of the following in sufficient detail to demonstrate the quality of the applicant organisation(s): ▪ Technical and commercial expertise ▪ Financial stability of applicant(s) ▪ Robustness of contractual arrangements between applicant(s)	▪ Does the proposal demonstrate that the applicants have the right expertise to deliver the project? ▪ If not, where will they source this from, and is this realistic? ▪ Do they have credible size to manage an open-access facility of national significance? ▪ If this is not the organisation's usual core business, then have they produced a convincing explanation to confirm the reason for diversification into this area? ▪ Is the applicant financially stable? ▪ If the proposal is from a consortium, are all consortia members appropriately contractually bound?

^top

11. Quality of Management

Assesses the competency of the management team, process and controls to ensure efficient operation.

Information Requirements	Guidance for referees

Applicants are requested to provide details of the following in sufficient detail to demonstrate the quality of the proposed management team: ▪ Qualifications and experience of team ▪ Adequacy of resourcing - ability/experience of working together ▪ Robustness of management and operational efficiency controls	▪ Does the proposal demonstrate that management team is competent, experienced and adequately resourced, both technically and commercially? ▪ Are proposed management and operating controls and processes adequate? ▪ Does the proposal address how they will monitor achievement against a plan? ▪ Do they have quality assurance plans in place?

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12. Demonstration of Value-Added Support

Assesses the extent to which the proposal provides value-added support to industry through training, consultancy, etc.

Information Requirements	Guidance for referees
Please explain how the project will seek to support transfer of technology and knowledge into the UK's MNT community, in addition to the direct provision of open access technical facilities. Where appropriate, please include comment on the provision of: ▪ awareness raising ▪ technical training ▪ educational courses including CPD ▪ access to background IP and ▪ support for the creation of new business ventures.	Does the proposal demonstrate value-added support to industry and users? (e.g. through training, learning, consultancy, etc.)

^top

13. Additionality to UK MNT Network

To assess whether the proposal adds to existing UK MNT assets and where it overlaps or provides additionality to the UK MNT asset base.

Information Requirements	Guidance for referees
To assess whether the proposal adds to existing UK MNT assets and where it overlaps or provides additionality to the UK MNT asset base. Applicants are encouraged to adopt a collaborative mindset and to build critical mass, where appropriate, to deliver an open-access facility of national significance. Applicants should thus provide their own assessment of whether the proposal adds to or duplicates elements of the existing UK MNT asset base. If necessary, how would applicants work with other players in the MNT community?	Does the proposal demonstrate how it will add to the national (not just regional) UK MNT capability in ▪ prototyping, ▪ development and ▪ manufacturing facilities?

^top

14. Forward Vision

Assesses the sustainability, flexibility and adaptability of the facility's functionality to meet long-term and changing market requirements

Information Requirements	Guidance for referees
Applicants are required to demonstrate the sustainability of the proposal and how flexible and adaptable the proposal is with regard to responding to changing	▪ Does the proposal describe how the project will evolve, beyond the first 3 years, to deliver to the developing UK

or increasing market demands and how the business model supports such requirements.	MNT requirements? ▪ Does the business model demonstrate sustainability, and support flexibility and adaptability? ▪ Is there potential within the proposal to add breadth to its proposed functionality? ▪ Does the proposal address the potential need for physical expansion and adaptation?

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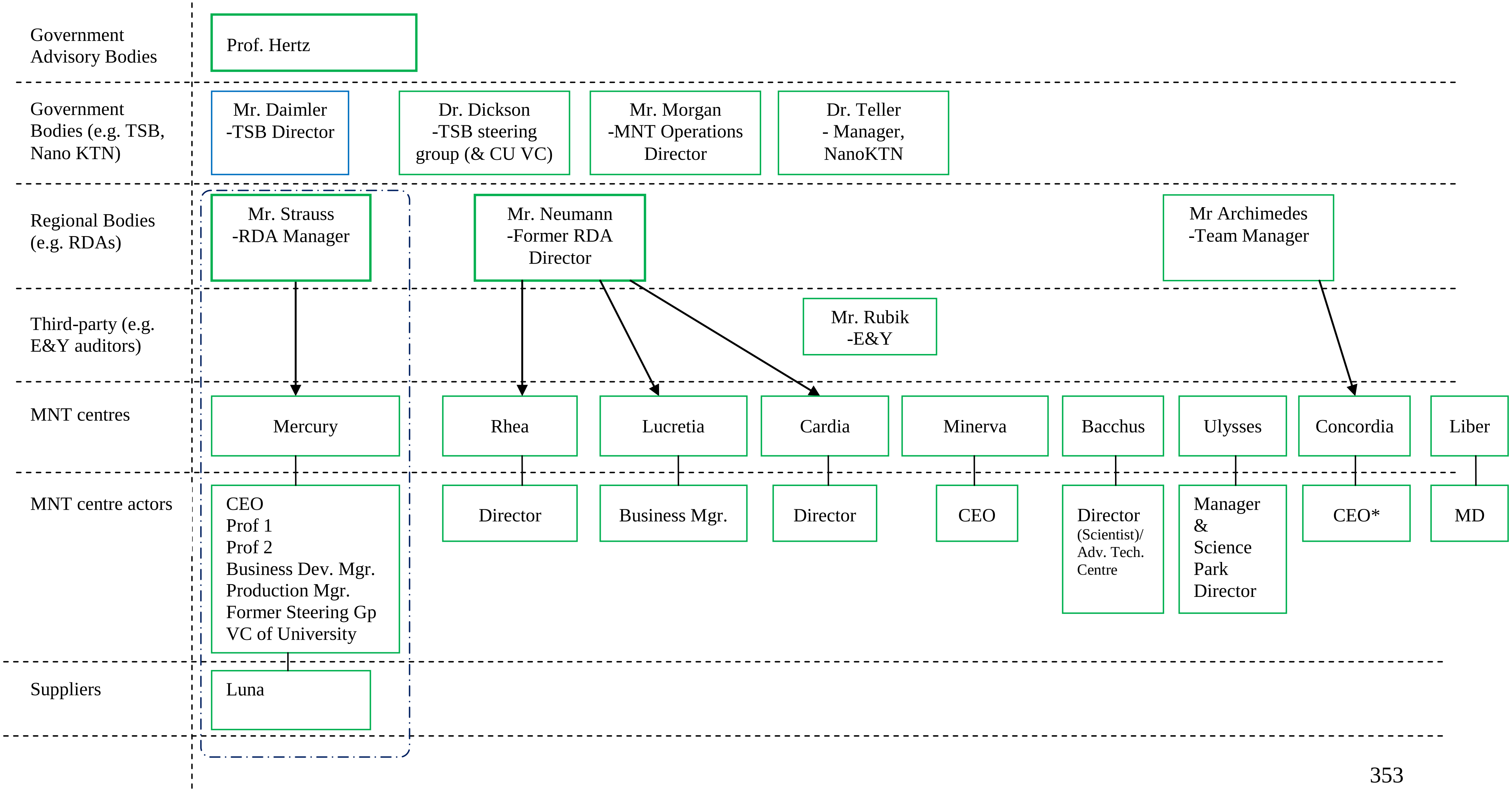
15. Value for Money

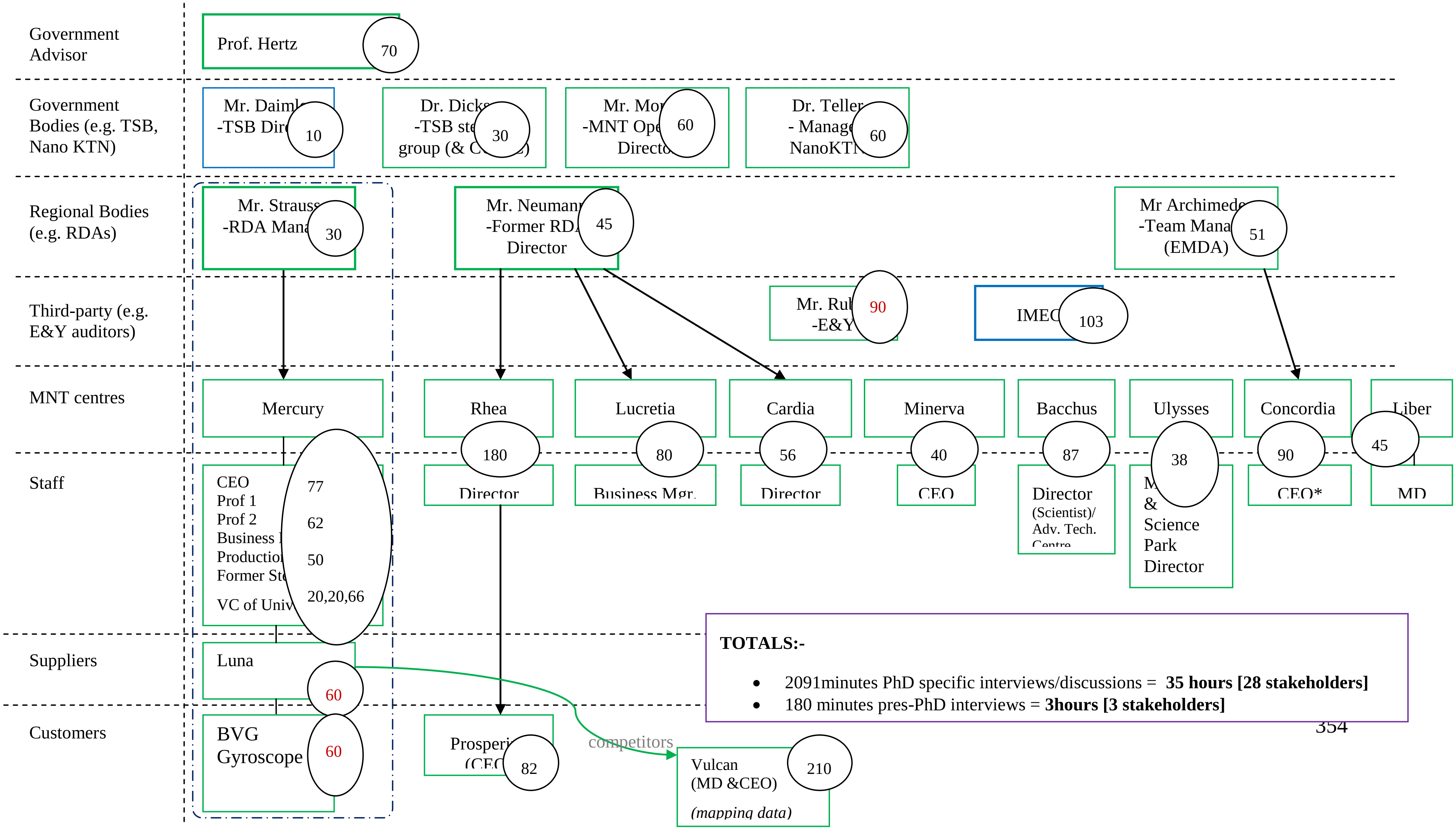
Assesses value for money offered by the proposal from the evidence provided by the Applicant.

Information Requirements	Guidance for referees
Applicants are asked to provide evidence to demonstrate value for money in terms of delivery outputs, throughout the length of the proposed project, through benchmarking or comparator cost models.	▪ Does the proposal provide adequate evidence to demonstrate value for money in terms of delivery of outputs? ▪ Do all major purchases and infrastructure costs demonstrate value for money?

Appendix 6b - A graphical overview of the MNT centres accessed, along with the cross-field actors.



Appendix 6c - A Graphical Overview of the MNT Centres Accessed, along with the Cross-Field Actors, <u>and</u> with Details of the Data Collected (duration shown in circles, in minutes).



TOTALS:-

- 2091minutes PhD specific interviews/discussions = **35 hours [28 stakeholders]**
- 180 minutes pres-PhD interviews = **3hours [3 stakeholders]**

APPENDIX 7a

Extract from one of the TSB's 'micro- and nano- technology centres communications documents'

2. Updates on the Centres Monitoring process

The Technology Strategy Board's Oversight group believes there is a need confirm the Monitoring Process so that Centres understand better how they will be reviewed by their Monitoring Officer.

In the future the Monitoring review process will be tailored according to where Centres sit in the 9-box model, according to the following table of scenarios. The Monitoring Officer (MO) will take the following actions:

Previous Review	Most Recent Review	Resulting actions from most recent review
1	1	• Maturity questions at the MO's discretion • Consider remote review if appropriate
2, 3, 4; 5, 6, 7, 8	1	• Maturity questions at the MO's discretion • On site review
9	1	• Full monitor review to include all Maturity questions • On site review
1	2, 3, 4	• Full monitor review to include all Maturity questions • On site review
2, 3, 4	2, 3, 4	• Full monitor review to include all Maturity questions • On site review • Strongly consider an Amber/Red rating
5, 6, 7, 8; 9	2, 3, 4	• Full monitor review to include all Maturity questions • On site review
2, 3, 4	5, 6, 7, 8	• Full monitor review to include all Maturity questions • On site review • Consider a Red rating
5, 6, 7, 8	5, 6, 7, 8	• Full monitor review to include all Maturity questions • On site review • Strongly consider a Red rating • Discuss with the Technology Strategy Board
9	5, 6, 7, 8	• Full monitor review to include all Maturity questions • On site review
1; 2, 3, 4; 5, 6, 7, 8	9	• Full monitor review to include all Maturity questions • On site review • Discuss with the Technology Strategy Board
9	9	• Full monitor review to include all Maturity questions • On site review • Intervention by the Technology Strategy Board

APPENDIX 7b

- TABLE OF ADDITIONAL SUPPLIER/ CUSTOMER INTERVIEWS

Table 7c – Descriptions of Mercury's customers and suppliers interviewed

Organization [supplier/ customer]	**Organization type [staff]**	**Organisation size**	**Nature of business**	**Interviewee (s) [role]**	**Date of UK Incorporation [turnover]**
Company A [Customer of Mercury]	Part of global group [180]	Private Limited Company (global group)	Medical diagnostics Manufacture medical, orthopaedic equipment	Mr. Slash [Senior Materials Analyst] Mr Burns [Engineer]	1989 [?]
Lunar [Supplier for Mercury]	Small SME [<50]	Private Limited Company (global group)	Laser micromachining systems and imaging systems	Founder	1977 [<10M Euro]
BVG Airflo Group [Customer of Mercury]	Small SME [<50 local site]	(now sold off?)	Manufacture & sales of sports goods	Production Director	1997 (that is BVG Airflo Group) [No longer trading]

APPENDIX 7c

Extracts from Mercury's tender document relating to context.

p.2	The [university host department] has its own purpose-built facilities, which were part funded by [the] University with match funding from [other government exploitation funding], managed by the [local] regional development agency. These include office space for all commercial staff, a reception area and a meeting room for presentations and discussions with customers.
p.7	By setting up the proposed facility alongside the existing micro-tooling and fabrication capabilities at [Venus] the proposed programme will dovetail into the existing ISO 9000 infrastructure… This *reduces significantly the operational risk associated with this capital project* [emphasis added].
p.12	[the university host] has unique and dedicated facilities for the machining of micro-tools in … materials and has managed and participated in National and European projects with a total value in excess of £25M. ...the [university host] has the experience and infrastructure to provide a development-manufacturing-prototyping service and a route to commercial exploitation.
p.13	*Mercury* … will draw on the expertise of the [university department's] business development team..
p.13	The existing approach for managing open access manufacturing facilities, outlined in Section 2, will be adopted in delivering the *Mercury* service. This management approach is a result of a 10-years continuous improvement programme at the [University department]. A Quality Management System (ISO 9001:2000 accredited) is in place to guaranty the consistency of micro-manufacture services to industry.
p.15	The Mercury service will build upon the university's recognised expertise in micro-machining and microtoolmaking and is a natural evolution of the already established open-access MNT facilities at the Centre… The service will dovetail into an existing ISO 9000 business infrastructure that reduces significantly the operational risk and the required initial funding to create such a service provision within the UK MNT Network. Thus, the project represents very good value for money when considering the additional investment and time required to start the proposed *Mercury* service.

Appendix 8a – Table 8-5 - Role-ordered matrix: linking actors, roles, logics and agency (complete version)

ROLE / Category or actor	**CONTEXT / Centre**	**Assimilation of OUTCOMES for their MNT centre**		**LOGICS** /belief systems /Exclusive or not exclusive	**Examples of associated practices/ activities**
		Success	**Failure**		
Centre Director /Hybrid	University science park /Ulysses	▪ successful companies growing on back of Ulysses' services ▪ Repeat business	▪ lack of clarification of expectations from both the centre & customer: there is a need to *really* understand what is being achieved. ▪ Some customers set out in one direction, then realise no money to be made and change product line accordingly.	▪ Business [Not exclusive]	▪ Collaborations ▪ Target-driven ▪ Employing high skilled individuals ▪ Helping start-up companies ▪ Run the centre to generate an income stream (cover staff costs)

Centre Director /Business	University /Lucretia	▪ Happy customer: ▪ Repeat business ▪ In top two of the Yole review	▪ Don't win business ..or having won it, fail to complete the task. Why? We/ or customer didn't understand it/ scope it properly/ communication breakdown between organisations. ▪ *Caveat*: failure is a valid outcome of research.	▪ Business [Exclusive]	▪ Employs his staff to achieve market targets. Avoid research, that's for the academics. ▪ TSB tried to change objectives; Mr Gillette invited the TSB board in to '<u>explain</u>' Lucretia's contract to them and how Lucretia did not have to pander to their added requirements. ▪ Example of new business development manager being paid for results, and if he doesn't perform he is out. Uni HR had a different view on performance-related contracts, but Gillette tells them this is the way it is (like industry). ▪ Target-driven ▪ Rebellious
Centre Director /Business	Science Park /Liber	▪ Viable, profitable business; serve needs of industry; add value to MNT void. ▪ advance UK technology-base ▪ 'we're world leaders'	▪ Business doesn't survive beyond 5 years: complete failure.	▪ Business ▪ [Exclusive]	▪ Separate from university ▪ Facilitated quick exit plan from university environment ▪ Core staff, closely-knit ▪ Flexibility, responsiveness ▪ Problem solving

Centre Director /Business	Global organisation /Bacchus	▪ Happy customer when devices reach proof-of-principle. ▪ Uptake of technologies into application areas.	▪ Not working with external customers in non-allied industries. ▪ Some developments too difficult, or technology inappropriate. ▪ Some items can cost too much (i.e. '*you mustn't underestimate the power of an incumbent technology and making things cheap. Some items you get for £1000 to £2000 are really very complex and making them cheaper in micro systems can be very difficult*') ▪ Not achieved similar examples as seen on trade missions in other countries.	Business.. (but leanings toward pure research for industry) **[Not exclusive]**	▪ Increased internal capacity (doubled floorspace). ▪ Resistance to large hosts' bureaucracy where it may stifle innovation. ▪ Optimism: when iteration fails, *'it is not the end of the world, you go, right we need to iterate something, what was wrong with it? But you have to believe that what you are doing is right at the time*'. ▪ Patriotic ▪ Problem-solving: '*Ours is not always to understand, just to do it*'. Scientific/Technology development logic coming through… ▪ Comfort resulting from being in such a large host: organisation. ▪ Darwinian

Centre Director /Business	Science park /Concordia	▪ Examples of commercial products launched. ▪ Demonstrator and pilot plants built to supply [i.e. production]. ▪ Using skills of academic actors and giving them knowledge of production.	▪ Getting products to market in pharmaceutical sector (as an SME).	▪ Business [Exclusive]	▪ <u>Part of original DTI selection panel</u> ▪ Re-focussed business plan from pharma to another sector with lower entry barriers. ▪ Cross-fertilisation of team: e.g. academics placed in Concordia for a short placement, share knowledge. ▪ Careful selection of capable people (balance of commercial and technical skills) ▪ R&D people have to engage in production and have to deliver. ▪ '*Rebuilt pilot plant to be separate entity. The scientists cannot wander in [and fiddle]*'. ▪ Brought in industry people, and sales people (previously academics) ▪ Separate management from university ▪ This includes separating finances from the university system. ▪ Target-driven ▪ People: (keep expertise inside). Use of 'do-all' people. Everyone is in the same space. Lot of arguments!..very particular people..with strong *attitudes* to what they do. Get a balanced team'. ▪ Motivator (of staff, keep them achieving something all the time). ▪ Problem-solving

Centre Director / Business	Existing SME /Rhea	▪ Success in the marketplace ▪ Benefits for existing SME: enhanced reputation; bring in more business; benefits by association (University); case histories. ▪ Successful components developed for company *Prosperina*, using Rhea's services. Led to repeat business for Rhea, and successful products for Prosperina.	▪ Fail to complete task. ▪ High casualty rate '*some ideas won't make it and some will.. difficult.. no [way]..to bet on sure-fire winners..so if Rhea is not sustainable…[we] have bet on the wrong horses..this is the biggest downside to innovation*'. ▪ Supply-chain example, given where a collaborator let Rhea down.	▪ Business. [Exclusive]	▪ <u>Part of original committee with Taylor report</u> (which recommended a number of major centres) ▪ Continual investment in R&D and collaborations: to keep ahead of the game. ▪ Patriotic: (examples of overseas buy-outs where only the R&D offices remain in UK) ▪ Darwinian ▪ Problem-solving ▪ Collaborations

Centre Director /Business	RDA centre /Cardia	▪ Ultimately product on the shelf. ▪ As an intermediate, success is the amount of work businesses do together (including R&D). ▪ Getting to functional prototype – to enable the uptake of new technology. ▪ Being able to demonstrate to potential MNT users that money can be made out of the technology.	▪ ‘nobody bothers to get together, and after some years no increase in the amount of nano enabled materials coming into the market - difficult to measure’	▪ Business: ‘market-pull’ & awareness of technology push; ‘*cash is king*’. [Exclusive]	▪ Active marketing; role is to champion the cause. ▪ *‘E.g. there are these technologies around.. these features, functions, characteristics that you can exploit. which is why the conference is about exploitation. How do you exploit the properties to give you money. "We're constantly evangelising the benefits" for getting involved with - particularly - nanomaterials, and trying to widen peoples eyes’*. ▪ Set-up conferences to build collaborations & network events. ▪ People: industrial experience required to gain credibility from organisations. ▪ Target-driven: (e.g. number of business to business collaborations) ▪ Collaboration: Cardia acts as a brokerage
Centre Director / Business	University /Minerva	▪ Jobs created ▪ *Cover wage for your team.*	▪ Don’t Know [DK]	▪ State (job creation) [Exclusive]	▪ Patriotic ▪ Darwinian: one major OEM as the customer. Appeared to be the focus of Minerva’s efforts

Science park manager /Hybrid	University science park /Ulysses	▪ Assisting companies to get up and running ▪ Then getting them to IPO and beyond.	▪ Project not meet expectations ▪ If company goes broke ▪ Failure= also valid (can be used elsewhere)	▪ Business ▪ [not exclusive]	▪ Example given from a company he set up that started off along the technology push route, but learnt that market need is essential to be successful. ▪ Open-minded *'I think it doesn't matter what peoples' education, background of position is every person is capable of a good idea.. so we should listen'.* ▪ Problem-solving ▪ Patriotic *'I'm not a person that wants to become wealthy.. [about] creation of jobs*'. ▪ *'job creation within the UK is my main driver'* ▪ Collaboration
Architect of NSI / Hybrid	NA	▪ Having leveraged £233M out of £40M for the MNT programme. ▪ Investment still continuing. ▪ 'Lucretia I think is outstanding'. ▪ Having the technology and ideas coming through to industry.	▪ The centres were meant to be co-ordinated. Nobody is co-ordinating them anymore. ▪ ' We did lose a lot through the demise of the DTI'. ▪ '..very disappointed that there haven't been more collaborations to date'.	▪ Business: ▪ /beliefs: good research but not much commercialisation. Hence the need for the programme. MNT programme is purely commercially focussed. Research is well looked after) ▪ [Exclusive]	▪ Led selection committee ▪ Chair of the MNT network ▪ Trade mission 1999 ▪ Formed the Micro systems and nano technology Manufacturing Association (MMA) ▪ Lobbied government ▪ Taylor Report resulted. This said the UK was slipping dangerously behind all its competitors in the World in Microsystems technology and nanotechnology. ▪ Patriotic

MNT Operations Director /State	NDGB / TSB	▪ Self-sustaining ▪ Leg-up to UK industry ▪ Open-access ▪ Technology has reached a certain level that it is going somewhere. ▪ [to be World class like a Fraunhofer or a Leti]	▪ Referring to the TSB's purpose (see Table 8.1): [we are] a long way from that'. ▪ No collection of World Class facilities.	▪ Business ▪ State ▪ Management consultant [Exclusive]	▪ Mercury closed early: governance structures must be created and jurisdictional claims defended – often with the aid of the state – if professional power is to be realised (Scott, p.129). Show the TSB serious. ▪ Patriotic ▪ Community reach ▪ Target-driven (sets targets & evolved strategy)
Management Consultant /State	NDGB / TSB	▪ To be Internationally competitive facilities: put UK on the map as a destination for nanotechnology work. ▪ If the centres are true to the vision and providing a service, then 'Income + orders + revenue = should be equal', i.e. break even. '<u>But</u> if hybrid, centres look to develop own product, then there is the difference of commercial revenue	▪ 'Good thinking and policy [led to] pot of money…then no longer 'joined up thinking'	▪ Management consultant (i.e. project management/ consultant; dismissive/ superior view over the centres) ▪ State [Exclusive]	▪ Is this the common view of the other E&Y auditors? Would explain some of the concerns about auditing from other centres (i.e. too business like?, too frequent). ▪ to manage the risk to public money ▪ when discussing monitoring of centres: *'[E&Y] are helping them justify their existence*' Rubik views the centres as open-access research development service providers: in terms of ROI, they should not be developing technology to exploit themselves.