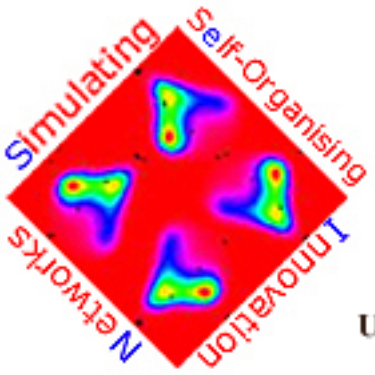

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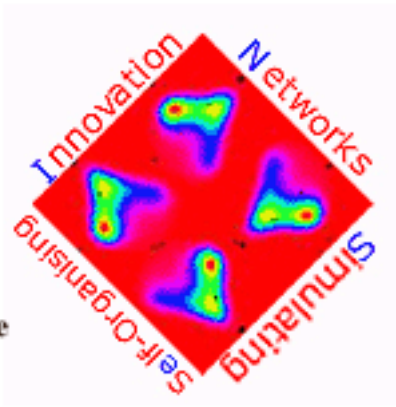

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SEIN - Deliverable / Part II:

Innovation Networks by Design: The case of the mobile VCE

by

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Introduction

This deliverable is supposed to describe the project's progress, that has been made within the first year. This contains the development on the theoretical side, as well as the case-studies final reports. The development of the theoretical design involves different steps. Firstly, the concept of self-organisation has been elaborated in more detail and in specific relation to innovation networks. Secondly, a model of innovation networks has been developed in order to understand their emergence, structure and dynamics. Thirdly, two simulation models have been developed from the case-studies, that are currently being brought together in an integrated simulation model which takes into account the theoretical specifications.

As a part of the SEIN-project, four case studies were being carried out to examine the structure and dynamics of innovation networks. To have a broad perspective on innovation networks these case studies cover different technology areas and follow different approaches. At this point, the final case-study-reports have been completed and are part of the deliverable. The case study on Virtual Centres of Excellence (VCE) studies the nature and effectiveness of deliberately formed innovation networks. The final case-study report includes a description of the development and the likely future trajectory of the network. The case study on biotechnology is essentially about new products (product innovation). The final report being included in this deliverable is presenting results on scope, options and timing of policies aiming at the formation of innovation networks based on model results. The Knowledge Intensive Business Services (KIBS)- case study concentrates on the co-evolution of technology and innovation networks in e-commerce (producer-user-networks). The report highlights critical factors and implications of the case-study's results for policy. The case study on the combined heat and power technology (CHP) is concerned with transforming an old service supply system (both product and service innovations embedded in an architectural innovation). The CHP final case study report could not been finished due to a lack of time. Due to that, this deliverable only contains a summary of the work in this case-study. The final report will be submitted to the scientific officer in mid-february.

INNOVATION NETWORKS BY DESIGN:
CASE STUDY OF THE MOBILE VCE

CONTENTS

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Innovation Networks by Design: the Case of the Mobile VCE

1. Introduction

This case study is a contribution to a broader interdisciplinary project, the SEIN project, which is a study of self-organising innovation networks. The Mobile VCE is distinct among the case studies being addressed by the SEIN project, in that it concerns a research network that was deliberately designed by policy-makers. The case study therefore addresses questions of the effectiveness of deliberately designed networks, as well as exploring the usefulness of the specific mechanism (virtual centres of excellence) deployed in this case. In this paper, I look at the context in which the Mobile VCE was produced, asking in what sense it may be seen as a product or outcome of technology policy, and in what sense it is a product of its industrial context. I ask whether the context of production of the VCE throws any light on its effectiveness and what criteria of success may be appropriate given different available practices of evaluation. Finally, I indicate some issues relevant to incorporating the case study in the broader simulation project being addressed by SEIN.

The Mobile VCE (or, to give its longer title, Virtual Centre of Excellence in Personal and Mobile Communications) is a research network that is funded by public and industrial money and brings together seven universities and more than 20 companies, including almost all the major players in the mobile phone industry. It was inaugurated in 1997 for a three-year period, having been initially proposed by the Communications Panel of the UK Foresight initiative, and having won funding from the Foresight Challenge Awards. Its initial three-year research programme was set up following discussion among representatives of many of the industrial and academic bodies that later joined the VCE, and the programme is managed by a committee that includes both industrial and academic representatives with the support of a full-time chief executive officer. As a collaborative research network, the Mobile VCE has some innovatory aspects which I shall discuss later in the paper, including a ‘virtual’ network of university researchers, based in different institutions but intended to operate as a single department. I shall also discuss appropriate measures of evaluation later in the paper, but it is worth noting that

the Mobile VCE has been clearly successful on one measure, that is, the enrolment of a sufficient number of industrial members to fund its research programme as originally proposed.[1]

2. Material and methodology

This case study is primarily based on interviews and a reading of texts relevant to the setting up of the Mobile VCE. The present paper provides a description of the Mobile VCE and discusses issues concerning its effectiveness as a policy mechanism. This is based on 30 interviews[2] with academic and industrial members of the Mobile VCE and representatives of some other relevant organisations, including the DTI, EPSRC and the Digital VCE. It is intended to carry the case study forward in the context of an attempt to model the behaviour of innovation networks as self-organising systems. This will involve exploring ways in which this case study may be compared to others within the SEIN project, and also involves issues of using interview-based, discursive material to generate data for an abstract and generalisable model. The SEIN project is interdisciplinary, bringing together researchers with different backgrounds, including economics, technology policy and sociology; and the case studies vary in their approach both to data collection and to analysis. The project uses a broad understanding of self-organising networks as a common starting point; nonetheless, for each case study there are questions of how it relates to the other case studies and to the project as a whole which will be addressed in the next phase of the project.

The present case study is partly informed by recent work in the sociology of science and technology, including the use of some analytic ideas based in ethnography and ethnomethodology that allow discursive (conversational and textual) material to be

[1] In this respect, the Mobile VCE may be contrasted to another VCE in broadcast and digital technologies (Digital VCE) which was set up at about the same time, and with a similar historical background as a recommendation of the Foresight Communications Panel, but which always had problems in recruiting and maintaining industrial members. A comparison between these two VCEs may therefore be expected to assist in understanding one aspect of 'success' or 'effectiveness' of the Mobile VCE, which may lend itself to being understood in terms of self-organising networks.

[2] A further set of about 10 interviews is planned for validating and extending the analysis in forthcoming work.

understood as socially active.[3] In the present paper this approach is used particularly to articulate the relationship between policy discourse and the production and evaluation of the Mobile VCE. By 'policy discourse' I mean a negotiated and open set of ideas and issues evident in policy texts and the academic policy literature which I discuss in section 3. I address some issues of the relationship of the policy discourse both to the aims involved in setting up of the Mobile VCE and to issues of evaluating the VCE mechanism for policy purposes.

3. The policy context

I suggested in the Introduction to this paper that the Mobile VCE may be described as a product or outcome of technology policy. To explore this claim, I begin with a brief sketch of recent technology policy, both as it is represented in academic commentaries and produced in policy documents. The two sets of texts address policy issues relevant to the production of technological innovation, but the academic literature is primarily concerned with commentary and analytic description, while the policy texts are involved directly or indirectly in the setting of policy and are in general performative of policy. White papers, in particular, are performative in a straightforward sense: what they describe as policy thereby is policy. More generally, the policy texts and literature may be said to be performative in the sense that they provide terms of accountability, through which actions may be justified (whether legal measures, policy mechanisms, academic performance, and so on).[4]

Within the academic literature on the subject, most authors agree that the conditions of production of science and technology are changing, with many closer links between academic and industrial research, and that the aims and scope of policy have changed to

[3] By 'socially active' I mean, very broadly, that conversational and textual material may be read as negotiating identities and relationships, including those between the speaker/author and respondent/reader. Examples include the notion of 'translation' in actor network theory (cf Latour, 1987) and the concept of the 'configured user' (cf Woolgar, 1991).

facilitate the economic and social exploitation of science and technology. Gibbons et al (1994)[5] identify three phases of policy: 'policy for science'; 'science in policy'; and 'policy for technological innovation'. The first phase is said to be concerned with the identification of research issues, guided by academic scientists;[6] the second is said to be concerned with adapting science policy to other national policy objectives;[7] and the third phase is said to be concerned specifically with adapting science policy to the requirements of economic growth. This history draws on and reinforces their major argument concerning a structural shift in the conditions of production of knowledge from what they call 'Mode One' which is based in the disciplinary divisions of traditional academic life, to 'Mode Two' which is based in heterogeneous and temporary alliances determined by a context of application. Faulkner and Senker (1995) describe the historical trends in terms of increased industrial-PSR linkages (measured in terms of the amount of money spent by industry on research in academic and government laboratories).[8] They describe the history of UK science and technology policy from the early 1980s (that is, within the 'third phase' for Gibbons et al), and emphasise the dual policy aims of stimulating innovation and growth in high technology industries[9] and the encouragement of the exploitation of publicly funded research.[10] Faulkner and Senker problematise what they call 'knowledge flow', and they deploy a typology of knowledge which emphasises differences between the communication of 'tacit' and 'explicit' knowledge, and implies a need for different forms of linkage (eg, personal communication as well as exchange of learned papers) in order to promote communication. This may be contrasted to the typology suggested by Gibbons et al which is based on distinctions between Mode One and Mode Two contexts of knowledge production, where communication is posited as an achievement of Mode Two and they

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[4] This may be so particularly within an institutionalised context, so that terms of accountability may differ from one discursive community to another, for example: within a corporate setting, in a government department, or in a university (cf the discussion on evaluation in section 7).

[5] Cf pp 158 ff.

[6] The first phase is particularly identified with the writings of Vannevar Bush (1946).

[7] The second phase includes the UK Rothschild Report (1971), the OECD's (1971) Brooks Report and the US RANN (Research Applied to National Needs) programme.

[8] Faulkner and Senker, 1995, pp 11-14.

[9] The examples they give are of two UK initiatives of the early 1980s, the Biotechnology Directorate and the Alvey Programme (Faulkner and Senker, 1995, p 15).

[10] One major example of this is the White Paper *Realising Our Potential* (OST 1993).

suggest that within Mode Two it is appropriate to talk of 'technology interchange' rather than 'technology transfer'. Similar claims are made by Leydesdorff and Etzkowitz (1996) who suggest that, within new collaborative institutional forms, 'knowledge is no longer transferred, but co-developed'.[11]

Whatever their differences, the above texts all broadly agree on a history of changing concerns in technology policy, including an increased value placed on the exploitation of knowledge (based on assumptions about the power of technological innovation to effect economic and social change)[12] and the encouragement of new forms of linking and networking to support increased technological innovation. It seems legitimate to speak of a 'discourse' of technology policy, in the sense of a set of terms and issues recognised and reproduced by 'insiders'. One leading scientist (interviewed in 1998)[13] traced the changes in UK science policy from the early 1980s when 'researchers were encouraged to go and do something useful' to 'a sea-change' in the late 1980s when the Thatcher Government decided that 'the proper place for government funding ... was where there was market failure', that is, in basic science; and finally:

> In the last eight or nine years there has been the recognition that we had to become useful not by doing applied things but by networking and making our basic science available and exploitable. .... [This] means that if you do basic science, maybe in strategic areas, you should make sure than anything that arises from that is exploited and the Intellectual Property Right is fed back.

Networking, in this context, is effectively contrasted to what Gibbons et al call 'the context of application', and is presented as a means of addressing the communication of

[11] Leydesdorff and Etzkowitz, 1996, p 21.

[12] The economic historian Nathan Rosenberg comments at the beginning of his book, *Exploring the Black Box* (1994, p 9): 'It is no longer necessary for an economist to apologise when introducing the subject of technological change. That is, in itself, a (modest) cause for celebration, since the situation was very different as recently as forty years ago. ... Although sympathetic readers of Marx and Schumpeter had learned to attach great importance to technological change as a major impulse - perhaps the major impulse - in generating long-term economic growth, such an awareness had not yet rubbed off on the dominant academic traditions of western economics.'

[13] Cited in Henkel et al, 1999

basic science to industry. A similar emphasis is also evident in a remark by William Waldegrave, the minister responsible for instigating the Foresight Initiative:[14]

> "[I] started with a belief that the alternative to a slightly naive linear model of how science works was a more complex interactive picture which had needs, users, ideas, creativity working in a much more complex inter-relationship and I had always therefore firmly believed that the main role of the state, apart from funding the areas which the markets won't fund, is to try to create the structure that a good university creates, only on a national basis .... The state could usefully build networks – sometimes physical networks ... but also the interactions between people."

Within the policy literature, and especially in texts written by or for a policy-making audience, ideas of the importance of foresight became increasingly common during the 1980s and (in the UK) the 1990s. These concerns were articulated in two publications by Ben Martin and John Irvine the first commissioned by the Advisory Council on Applied Research and Development (ACARD 1986)[15], the second by the Dutch government (Martine and Irvine, 1989). Martin and Irvine represented UK policy as failing in comparison with other countries at attempting a systematic 'forward look' at technological innovations. The idea of 'foresight' was distinguished from earlier ideas of picking strategic technologies,[16] which was recognised as too determinist and too linear, and was intended to incorporate perceptions of both technological and social trends, as a guide for policymakers in setting priorities.

The UK Foresight initiative was announced in the 1993 White Paper *Realising Our Potential* which was the first major science policy document for twenty years (since the *Rothschild Report* in 1971). This document brought together science and industry policy, and echoes of *ROP* may be found in a subsequent series of industrial policy

[14] Interview quoted in Henkel et al, 1999

[15] This report was presented to ACARD by 1984, but not published till 1986.

[16] The Foresight Steering Committee Report (OST, 1995a, para 3.2), for example, commented 'The Foresight processes … have not been about picking winners but about generating a flexible, well-informed science, engineering and technology base, able to respond rapidly to our needs in future.'

documents, the *Competitiveness* white papers.[17] The convergence between these policy areas is apparent in the opening paragraph of *ROP* (para1.1):

> The understanding and application of science are fundamental to the fortunes of modern nations. Science, technology and engineering are intimately linked with progress across the whole range of human endeavour: educational, intellectual, medical, environmental, social, economic and cultural.

A similar convergence is suggested by this message from the *Competitiveness* White Paper of 1995:

> Innovation is essential for competitiveness ... Innovation is the successful exploitation of new ideas. ... Innovation depends on people's ability to embrace new thinking. It is stimulated by education, training and experience.

In its arguments for Technology Foresight, *ROP* mentioned both a need to properly utilise the UK's strength in science and technology[18] and a desire to 'get maximum value for money' from public expenditure on science and technology.[19] In its announcement of Foresight, the White Paper stated:

> Technology foresight, jointly conducted by industry and the science and engineering communities, will be used to inform Government's decisions and priorities. The process will be carefully designed to tap into the expertise of people closest to emerging scientific, technological and market developments. The aim is to achieve a key cultural change: better communication, interaction and mutual understanding between the scientific community, industry and Government Departments.

The Foresight Programme was structured to bring these groups together in its own committees and panels. It was implemented initially, in 1993, by the setting up of a Steering Group of industrialists, academics and government officials, and the Steering Group in turn instigated 15 sector panels, which again brought together industrialists,

[17] The *Competitiveness* White Papers were published annually from 1994 to 1996 (cf DTI 1994; 1995; 1996a).
[18] Cf para 1,16
[19] The White Paper estimated the annual expenditure as about £6 billion. Cf para1.18.

academics and government officials. The broad remit of the Foresight Programme was to address such broad questions as:[20]

- What are the likely social, economic, environmental and market trends over the next 10-20 years?
- Which areas of R&D and underpinning science, engineering and technology best address those future trends?
- How best can public funds be used to sustain an innovative science base to support future national prosperity and quality of life?
- To what extent should regulation, skills, educational facilities, and other factors be taken into account?

The panels, more specifically, were expected to consider 'how their sectors might best compete in the harsh global environment of the twenty-first century'.[21] The Steering Committee Report commented at the conclusion of the first round of panel meetings in 1995:[22]

> The Technology Foresight approach has been to seek the broad areas in which it is considered that an international competence will be required in the UK, whether scientific, technological or managerial, and to commend these for translation into action programmes to the appropriate stakeholders and funding groups – private industry, Government departments, Research Councils, Higher Education Funding Councils, the Charities and others.

The mechanism of 'recommendation', as I shall discuss in the following section, was an important one in the history of the Mobile VCE, since it originated in a recommendation by the Foresight Communications Panel. As important to its history, however, are the values, aims and assumptions that were construed in and through the policy discourse, and to which the Mobile VCE could be produced as an answer.

[20] OST 1995a, para 2.2
[21] OST, 1995a, para 3.2

4. The Mobile VCE as an outcome of policy.

In this section I look at the origins of the Mobile VCE in the context of the Foresight Programme and surrounding policy practices, to the time of its winning Foresight Challenge funds in 1996, identifying ways in which the political environment supported the coming together of the VCE as a network.

Shortly after the announcement of the Foresight Programme in the 1993 White Paper, an ACOST[23] working group chaired by Professor Michael Brady completed a report[24] on possible foresight mechanisms which included overviews of three previous foresight exercises[25] in Biotechnology, Catalysis, and Telecommunications. The report on Telecommunications turned out to be a report on optoelectronics (ACOST, 1988), then regarded as one of the principle applicable technologies in the field as it underlay what was expected to be the next major commercial development, the supply of a range of entertainment services over the phone lines which would be enabled by the use of fibre-optic local networks. The ACOST working group, in its 1994 report, pondered the question why 'despite its technical competence as a piece of foresight, the report had little effect'. In particular, the market had 'not materialised' which, they observed, was put down by 'many in the industry' to the Government's regulatory policy.[26] In the early 1990s, however, the mobile communications market was beginning to materialise. One effect of this was an increasing demand for radio frequency engineers, a field of training which had become neglected in universities since the 1960s. The DTI had therefore organised a LINK project, called the Radio Frequency Engineers Education Initiative which brought together a consortium of industrial members and researchers at three universities – Bradford, Bristol and Surrey. Individuals associated with the LINK project were members of the Foresight Communications panel, and this contributed to identifying mobile communications as an area relevant to Foresight.

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[22] OST, 1995a, para 3.2

[23] ACOST, the Advisory Council on Science and Technology, replaced ACARD (cf p 8 above) in 1987.

[24] The ACOST report was published in 1994.

[25] These exercises, which were retrospectively described as 'foresight', were reports of three Task Forces set up by ACARD/ACOST in the late 1980s.

[26] The complaint, which was made particularly by BT during the early 1990s, was that UK operators were restrained from providing entertainment services for ten years, in order to encourage competition from cable companies.

The plan to set up virtual centres of excellence in two of four possible key technology areas was recommended in the report of the Foresight Communications Panel (para 4.29; cf Box below).

The Development of Virtual Centres of Excellence in Selected Technologies

Rationale:
In an increasingly competitive, well-educated and global market it is essential that we plan at macro rather than at micro level. Although there is a significant place for small dedicated research teams in particular niche technologies, the scale of effort and rate of progress needed to compete internationally in mainstream technologies necessitates that we develop ways of harnessing the academic research effort of distributed teams and, where possible, linking these to industrial enterprises both large and small. Each team would have a SuperJANET connection. The term 'virtual' is used to denote the geographically distributed character of what is proposed as it would be extremely difficult to co-locate the work of such a centre.

Funding should be earmarked for the formation of a number of Virtual Centres of Excellence, which would act as foci for interdisciplinary study, each typically spanning computer science, electrical engineering and other departments and involving more than one university, pursuing a managed programme driven by the centre's core funding to reduce the waste of resources inherent in the present and growing fragmentation of the sector (see section 3.34). These could include the key areas of:

- Telecommunications software.
- Broadband network architecture and design.
- Mobile and personal communications systems.
- Multi-media and digital signal processing.

We recommend that each such Centre of Excellence should have a Steering Committee on which the major collaborating companies are represented and a full-time co-ordinator/promoter to aid in the programme formulation and to provide rapid and direct HEI-industry contact.

Recommendation
At least two Virtual Centres of Excellence on specific areas should be established with joint funding from industry and the Research Councils.

Source: Report of the Foresight Communications Panel (OST, 1995b)

The rationale for this recommendation, the need for world-class research teams, addressed a perceived problem of the fragmentation of research in the UK (paras 3.34-

3.36). The suggested solution, a virtual centre, was a way of bringing the fragments together without actually moving researchers from their institutions.[27] This, it was felt , would avoid the financial and other costs of a bricks and mortar institution. As a representative of the DTI put it:

> Our experience of bricks and mortar institutions are not all that good. What tends to happen is you invest a lot of money in setting up a new building and within a short time the academics who really are the centre of expertise move on elsewhere, and you are left with maintaining an institution which is second rate.

One important point of novelty, from the academics' point of view, was the construction of a research team from among institutions that had been used to competing with each other for research council and other funding, as well as in the various modern mechanisms of accountability, such as the Research Assessment Exercise. One obvious issue (to which I return later) was, given the geographical distribution of the research teams, how well did they operate as a community of researchers.

In the history of the Mobile VCE, being mentioned in a Foresight panel recommendation was a crucial step towards its eventual implementation. It was intended (OST, 1994, para4.2) that each panel would develop a 'prioritised list' of technologies, and that the Steering Committee would then identify 'generic' technologies across the panels. However, the prioritised lists made by each panel also became important, not simply as the source of 'generic' technologies, but as a basis for implementing Foresight, which was a task for Foresight Phase II.[28] As an element of a panel recommendation, the successful setting up of such a VCE would count as an implementation of Foresight. When the Foresight Challenge award was announced, bids were invited based on the recommendations either of panel or steering group reports.[29] Facilitating the setting up

[27] At the time of proposing these virtual centres, they were thought to be unique. But some comparable institutions did already exist in North America.

[28] Phase I of Foresight lasted from 1993 to 1995 when the steering group and the first round panels reported (OST 1995). Phase II included some reorganisation of the panels, including the merging of the Communications panel and the IT and Electronics panel into a single panel called IT, electronics and Communication. Phase II ran from 1995 to April 1997. Phase III, which began in 1997, was intended to spread awareness of Foresight throughout UK business (cf POST, 1997, para 4).

[29] Foresight Challenge was one of the first major instruments of implementation of Foresight. It was launched in May 1995 with £40 million to spend over three years.

of the VCE became one way of implementing Foresight for those with an institutional responsibility for carrying out technology policy. Indeed the DTI began to explore the possibility of a VCE in the field of mobile communications as soon as the Foresight report (OST, 1995a) published its list of priorities. A series of meetings was organised for the DTI by Professor John Gardiner of the University of Bradford. The initial meetings, to which industrial companies were invited, specified a number of target areas of research. Universities were then invited to a separate meeting and, Gardiner recalls,

> Surprisingly, or perhaps not so surprisingly, the same sort of consensus about research areas emerged among the university types.

Gardiner therefore wrote a funding proposal (DTI 1996b)[30], which eventually went forward as a successful bid to the Foresight Challenge awards (winning £1.5 million). This specified the four research areas that remained the 'core areas' of the first three-year research programme of the Mobile VCE. Networks; Services and Service Metrics; Radio Environment; and Terminals.

To summarise, there are a number of slightly different respects in which the Mobile VCE was outcome of policy. In the previous section, I suggested that the values and aims of policy discourse enabled the VCE to be produced as a solution. In this section, the work of policy-making institutions has become apparent – both the work of temporary groups such as the Foresight Communications Panel, and the activity of civil servants charged with implementing policy in general and Foresight in particular. In particular, the importance of the meetings set up by the DTI were so important in bringing together the relevant industrial and academic representatives that more than one interviewee commented that 'Without the DTI it would not have happened'.

[30] The Foresight Challenge proposal was the basis of the prospectus (DTI, 1996b) which was circulated to companies interested in membership.

5. Structure and management of the Mobile VCE

The Mobile VCE was incorporated as a private company limited by guarantee (having no share capital)[31] to provide a legal entity for the management of the project and the holding of IPR. It was funded collaboratively by industrial subscription and public (Foresight Challenge) money at a ratio of about 60:40. An Executive Director was hired in November 1996, to be in charge of co-ordinating the project and to manage the Mobile VCE in collaboration with an Executive Committee, made up of representatives of the industrial and academic membership. In the following sections I discuss some of the main characteristics of the structure and management of the Mobile VCE, including the different conditions of membership for industrial and academic member; the Core Programme and its distribution among the academic members; the provisions for IPR; and some issues of accountability within in the Mobile VCE which have implications for a study of communications within the consortium.

5.1 Membership

Membership of the Mobile VCE is open to companies on payment of a membership subscription available in 'shares' of £25,000[32], and to universities through a process of selection. These two types of membership might warrant speaking of two networks, at least for some analytic purposes: an industrial network, which needs to be enrolled and maintained in order for the VCE to survive; and a research network that might be claimed to provide an example of innovatory cross-institutional research links. In this section I provide a description of the two types of membership and indicate some of the issues that might be further explored.

[31] The 'shares' which companies buy to join the VCE are membership subscriptions.
[32] £25,000 was the original price per share; it has since been increased to £30,000.

Industrial membership[33] is open to any organisation that supports the objectives of the Centre, is established within the European Union and pays it annual subscription.[34] A single share cost £25,000 and organisations might take up to three shares , with appropriate voting rights. An Associate membership, at a rate of £5,000, was also offered in an attempt to attract small and medium-sized enterprises (SMEs), but no SME took advantage of this. The industrial membership has been 20-plus since the beginning of the research programme, with some coming and going partly due to acquisitions and de-mergers. The membership as of December 1999 was:

- BT
- Cellnet
- Dolphin
- Ericsson
- Fujitsu
- Lucent Technologies
- Motorola
- Mobile Systems International (MSI)
- NEC
- Nokia
- Nortel
- NTL
- One2One
- Orange
- Panasonic
- Philips
- Racal
- Radiocommunications Agency
- Simoco
- Sony
- Texas Instruments
- Vodafone

This level of membership meant that the proposed research programme could be supported.

[33] The descriptions of conditions of membership are drawn from the VCE's prospectus (DTI, 1996b).
[34] Provision was also made for membership by companies based outside the European Union, with the agreement of the Board.

Academic membership, which involved the allocation of research funds, was decided by selection. Three universities were involved in the initial bid for Foresight Challenge Funding and were effectively selected by the Challenge Award review process, which was run by a specially appointed OST panel[35]. However, the prospectus also points out that these three universities had previously been successful in a competitive bid for the DTI's 'shortage of RF Engineers' funds, that this research partnership had proved successful in the view of the industrial consortium involved, and:

> Since one of the purposes of the proposed Centre is to provide a collective means for industry to address advanced skills needs it would make sense to build upon this existing basis of co-operation. The DTI has taken soundings with industry and there was overwhelming support for proceeding in this manner. It has the incidental benefit of providing three universities to lead the bid under the Foresight Challenge.[36]

At the time of the bid, it was proposed that a further two academic institutions might be selected to participate. Once the VCE's Board had been constituted, invitations to submit details of interests and abilities were circulated and a selection board received 30 or 40 proposals. In the event, four more universities were selected, two of them on an Associate basis. The university members were:

- King's College, London
- Strathclyde University
- University of Bradford
- University of Bristol
- University of Edinburgh (Associate)
- University of Southampton (Associate)
- University of Surrey

As a select club of those UK academic institutions recognised as being at the forefront of research in the field, it may be there are concomitant issues of exclusivity.[37]

[35] The Challenge Award review process placed greater weight on industrial relevance than is usual in a research council review process.
[36] DTI, 1996b, p10.
[37] One interviewee contrasted the VCE selection process with the situation in the Link programmes in Mobile Communications in which 'anyone could form a relationship with a company, or companies, or with other universities, and bid for money'.

In addition, two government institutions, the DTI and the EPSRC, each has the status of 'related body' including representation at meetings. The DTI (or more specifically the OST within the DTI) is the funding body for the Foresight Challenge Awards, but because it had no mechanisms for financially administering the award, this responsibility was passed to the EPSRC as the relevant research council.

5.2 The Core Programme

Research for the first three-year programme of the Mobile VCE was organised around four core areas, known as the Core Programme. As described above (section 4), the four areas – networks, services, radio environment and terminals – had been established in the early discussions and were incorporated in the bid to Foresight Challenge. These areas were intended to address issues relevant to the development of third generation mobile communications, including the provision of intelligent distributed networks, the identification and support of new user services, the feasibility of reconfigurable terminals and the provision of a seamless radio environment.[38] A more detailed description of the four areas is given in the following two pages. In a bid currently (December 1999) under consideration by the EPSRC, the Mobile VCE consortium has proposed a further core programme (Core Two) intended to address issues of the convergence of mobile communications with the internet and multi-media services.

In addition to the Core Programme, the centre was devised to also be open for contract research, funded by individual companies. The VCE's first Director, Tony Warwick[39], described the distinction between the Core Programme and further contract work:

> We fund the Core research from the main subscription and therefore all Members are Participants. So the Core Programme is what binds everyone together, and it's what they get gearing for. But increasingly we are doing more research work

[38] DTI 1996b, pp 14-16.
[39] In December 1999, Dr Walter Tuttlebee was appointed Director of the Mobile VCE.

for and on behalf of a smaller number of members who commission it privately, and we don't get any government funding for this. Commonly this is companies from different parts of the industry, an operator, a manufacturer, and so on, will collaborate to get a university to do one particular study.

Core One Programme of the Mobile VCE (1997-2000)[40]

NETWORKS
Broad areas of research:

- Provision of intelligent distributed networks
- Mobility management aspects of terminals with the facility to download software
- Security
- Billing approaches that provide sufficient billing information consistent with acceptable signalling levels
- Interworking and interconnect technology
- Use of computing protocols and standards to provide open platforms for network architecture
- Convergence of wired and wireless telecommunications solutions.

Key objectives
The key objectives for the work are the derivation of system definition and advanced statements of requirements for:

Multi-media services
Multi air-interface environments
Multi-layered cell architectures
In multi-operator/service provider networks

Primary emphasis
As an aid to focusing the work and ensuring co-ordination with the other work areas, the following areas are clearly defined as being of primary emphasis:

Derivation of generic models for 3rd generation systems and beyond
Convergence between mobile communications and information services
Intelligent, reconfigurable functional architectures

RADIO ENVIRONMENT
Broad areas of research

- Convergence to achieve economic and seamless coverage across multiple environments with acceptable performance for the service scenarios. Research to include mixed mode propagation measurements in various environments and lead to new propagation models.
- EMC/Spurious Emission and how these effects can be predicted and modelled to lead to low interference probabilities consistent with acceptable cost and complexity.
- Capacity. Defining and examining measure of capacity for future systems for the various scenarios and relating this to bandwidth and infrastructure requirements. To include mix of services and take into account the three dimensional nature of the environment.

Key objectives
The key objectives for the work are the definition of radio solutions to provide:

Flexible bandwidth multi-media services
High spectrum efficiency
User-selectable quality of service
Minimum radiated power

Primary emphasis
As an aid to focusing the work and ensuring co-ordination with the other work areas, the following areas are clearly defined as being of primary emphasis:

Wideband applications – 3rd generation and beyond
Seamless transitions between indoor and outdoor environments

[40] Information from the public section of the Mobile VCE web site, last revised Feb 1999.

SERVICES

Broad areas of research

- Identifying specific scenarios in which 3rd generation systems are expect to be used
- Identifying specific applications that can be mapped on to mobile channels
- Changing service paradigm from network operators to service providers

Key objectives

Definition of future services
Development of service models
Derivation of new service metrics

Primary emphasis

As an aid to focusing the work and ensuring co-ordination with the other work areas, the following areas are clearly defined as being of primary emphasis:

Mobile multi-media services
Flexible, tailored, user-defined service mixes
Quality of service measurement, management and monitoring in future generations.

TERMINALS

Broad areas of research

- Feasibility of reconfigurable terminals under software control, according to user profile and location
- Signalling capacity; configuration control; use of standard toolsets with which to create modems and other system functionality according to the local air interface; network and radio environment; use of smart cards to establish subscriber identity and terminal behaviour; RF aspects, including the need for multi-code, multi-band configurable bandwidth
- General technology challenges associated with future systems. This would cover high bit rate equalisation and other multi-path countermeasures such as multi-carrier modulation; efficient power amplification; highly integrated RF and digital systems.
- Econometric aspects of terminal design, permitting use of multimedia applications in mobile scenarios

Key objectives

Supporting multiple standards
Supporting flexible services
Yielding optimum functionality/cost ratio

Primary emphasis

As an aid to focusing the work and ensuring co-ordination with the other work areas, the following areas are clearly defined as being of primary emphasis

Terminal reconfigurability
Wideband applications – 3rd generation and beyond.

5.3 The research network

One of the main stated objectives of the Mobile VCE[41] was:

> To harness the research efforts of a selected group of UK universities into a cohesive world-class virtual (ie geographically distributed) research Centre of Excellence, focused on mobile radio and personal communications technologies and applications.

One of the mechanisms for making it a cohesive centre is the distribution of research in each of the four core areas among the academic members, rather than giving different universities responsibility for discrete areas of the programme. As one of the founding academic members described the rationale:

> We wanted to make the virtual centre work as a centre. So whereas in a European project the programme organisers would agree what work packages were going to be done in what university and off you'd go and do your workpackages, in Mobile VCE we structured it so that we had projects distributed around the universities.

Each area of Core One was assigned an academic co-ordinator at one of the founding universities and involved researchers working at least three other institutions. Distribution for the Core Programme was:

- **Networks**
  Academic co-ordinator: University of Surrey
  Other members: Bradford, Bristol, Strathclyde, KCL
- **Services And Metrics**
  Academic co-ordinator: University of Bristol
  Other members: Bradford, Strathclyde, Surrey.
- **Radio Environment**
  Academic co-ordinator: University of Surrey
  Other members: Bradford, Bristol, KCL
- **Terminals**
  Academic co-ordinator: University of Bradford
  Other members: Bristol, Surrey, Edinburgh and Southampton

We anticipate that issues to do with the effectiveness of the virtual centre, including communication within the research network, will provide significant points of analysis for further work related to the iterative modelling of the VCE as an innovation network. This will include further studies of practices of communication – who communicates with whom, how often, and by what media.[42]

5.4 Intellectual Property

The Intellectual Property developed in the Mobile VCE is the property of the Company, Mobile VCE, and available to members on a non-exclusive licence, as stated in the Prospectus[43]:

> Each shareholder shall have a royalty-free non-exclusive licence to use, for any purpose, results and intellectual property generated, during the period of their sponsorship, from the core research programme. Shareholders will be able to arrange for sub-licensing to third parties with the agreement of the Centre, which will not be unreasonably withheld. This may involve royalty payments being made to the Centre.

This is not a customary arrangement for publicly funded research, and is unusual at a time when universities increasingly attempt to maximise their exploitation of intellectual property. Companies, on the other hand, are used to situations where they own research that they have funded. Ownership of IP by the Mobile VCE may thus be seen as something of a compromise between the two expectations of usual practice.

The Mobile VCE has developed mechanisms to encourage researchers to submit patents, including an inventor's fee. It has also instituted a system where researchers regularly

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[41] DTI, 1996b, p20.
[42] Several interviewees have commented on the failure to use video conferencing, which is now familiar in some industrial environments. The range of comments includes both regret and relief at the absence of video conferencing.
[43] DTI, 1996b, p 12

submit work before publication, so that it can be checked to see whether it contains any patentable ideas.[44]

5.5 Management and accountability

The administration of the Mobile VCE by a company and its management by an executive committee have implications for both institutionalised and informal practices of accountability in the VCE. In particular, it is significant that the researchers report horizontally to consortium management, rather than vertically to outside funding bodies or companies. The research programme as a whole is run by the Executive Committee, made up of representatives of the industrial and academic members and the Director. In addition each of the four core research areas is answerable to a steering committee chaired by an industrial member. These four steering committees are responsible for overseeing IP (as described in the previous section), enforcing deadlines and monitoring progress.[45] The main board is responsible for the programme as a whole, and has drawn up a bid to the EPSRC for Core Two, the follow-on programme, which is due to begin early in 2000. Core Two has been agreed by the consortium and is planned to continue under the current agreement.

These mechanisms of accountability provide the context for much of the communication that takes place between industrial members and academic researchers. In particular, the steering committee meetings for each of the four Core Programme areas are the occasion for researchers to present ongoing results, and for industrial and academic members together to revue progress and agree any changes needed in the direction of research. In addition, however, research is also presented at technical meetings open to all the membership, and as the research programme has begun to product results, these are

[44] In the words of one researcher: 'The VCE has a very straightforward policy that when a piece of work is presented they make a decision immediately whether there is any relevant IPR in it. If there is it gets patented and then the academics are free to publish it. If they decide that they don't want to patent it or its not suitable to patent it, then the academics are free to publish it.'

[45] One academic commented: 'The Mobile VCE feels much more like working on a company contract. Company contracts are tightly managed, they have deadlines that you have to meet, working night-times and week-ends.'

available to members on a CD ROM disk. The relationship between industry and academic researchers is therefore one of client/contractor, unlike many other collaborative research programmes with public funding. This may raise issues of how effective technology transfer is within the consortium, insofar as policy texts frequently claim that this is best done where industrial and academic researchers are working together within a research project. However, this argument would need to be balanced against the claim that the Mobile VCE research programme was more long term than companies would themselves have engaged in.

6. The industrial take-up

At the time of the setting up of the Mobile VCE, the mobile communications market was just beginning to take off, thanks partly to the success of the GSM standard for second-generation digital mobile phones. At the same time, work was underway to institute the next (third generation) standard, and this provided a broad context for the research programme of the Mobile VCE. In this section, I discuss how the industrial context may have contributed to the success of the Mobile VCE in recruiting and maintaining a sufficiently large industrial membership to support its research programme.

6.1 A brief history of standards[46]

The first generation of mobile telephones was analogue, which confined its use to voice communications. In addition, a variety of incompatible cellular systems in different parts of the world meant that users could not 'roam' from one country to another – a particular problem within the European Community attempting to open up trade links. The development of GSM, as a European standard for digital cellular systems, began in 1982 in a study group called Group Spécial Mobile[47] set up by the Conference of European Posts and Telegraphs (CEPT). The responsibility for developing GSM was taken over by

[46] Sources for this section include Scourias, 1997; UMTS Forum web pages; Mike Pratt's web pages; the *GSM World* web pages; and a special telecoms feature in *The Economist*, 9 October, 1999. Web page addresses are given at the end of the References.

the European Telecommunications Standards Institute (ETSI) in 1989, first phase recommendations were published in 1990, and commercial operation of GSM networks began in Europe in 1991. In the UK, Vodafone launched a GSM network in 1991, One2One in 1993, Orange in April 1994 and BT/Cellnet in July 1994. The GSM standard, however, was adopted beyond Europe. By the beginning of 1995, GSM networks were operational or planned in 60 countries in Europe, the Middle East, the Far East, Australia, Africa and South America.[48] By the late 1990s GSM was 'the standard of choice' in 118 countries and 40% of the world's users.[49] In the US, where the development of second generation standards involved a more laissez-faire attitude, four different standards were implemented, each backed by powerful industrial lobbies; and Japan had its own second generation standard, PDC (Personal Digital Cellular).

The success of GSM is often credited with creating a global market for mobile phones. As one interviewee put it:

> The thing that's made [the market] huge has been the adoption of a common standard across Europe and across much of the world, GSM. That's given the economies of scale that were necessary to get prices down and to give good return on the investment of companies who make the product. Before that we had a fragmented market, different systems in different countries, and it never really took off strongly.

European companies in particular were benefiting from the market, which meant that they had cash to invest in longer-term research, when invited to join the Mobile VCE. In addition, because the UMTS standard process took longer than originally expected, work at the Mobile VCE helped inform the development of 3rd generation standards. The VCE's Director, Tony Warwick, remarked:

> When we embarked on the programme we expected that all the standards for the next generation would be complete during the course of the research work. It

[47] Scourias (1997) cites this name as the origin of the acronym GSM; *The Economist* (9 Oct 1999) suggests that it stands for Global System for Mobile Communication.
[48] Scourias, 1997
[49] *Economist***,** 9 October 1999, p 14

> turns out that for various reason that was delayed, and this research had more immediate impact in informing those decisions than we could have predicted.

GSM networks have the capability to transmit data other than speech but in practice are still mainly used for voice communication. Third generation systems will offer increased capacity and much higher data transfer rates and are expected eventually to extend the range of services available over the mobile phone network to include multimedia, internet access. As *GSM World*, web magazine of the GSM Association puts it:

> Video on demand, high speed multimedia and mobile Internet access are just a few of the possibilities for users in the future

UMTS (Universal Mobile Telecommunications System) is a third generation standard, building on GSM, and part of the IMT-2000 third generation family of standards being developed by the ITU (International Telecommunications Union). The other enabling development for the third generation is the licensing of increased bandwidths, needed to support multi-media services, by the various national agencies. Finland awarded the first 3G licences in March 1999, and Germany, Britain, Austria and the Netherlands all preparing to award licences. UMTS services are expected to be available from 2002.[50] Issues related to the convergence of mobile telephony, the internet and multi-media services provide the context for Mobile VCE's Core Two programme, planned to start in spring 2000.

6.2 The industrial network

That the Mobile VCE was successful in enrolling and retaining industrial members was significant for its continued existence. Not only did it enrol a sufficient number of members to fund its projected programme but it also included most of the major companies in the mobile communications field.[51] However, it failed to attract any SMEs as Associate Members. In this section I explore some of the reasons given by industrial

[50] This date is given by the UMTS Forum. *The Economist* (9 October 1999) suggests that Japan will be the first, to launch 3rd generation services in 2001.

[51] This judgement is generally agreed by interview participants. As of late 1999, the major non-member (cited by several interviewees) is the Germany company Siemens.

members for joining the Mobile VCE and, more generally, consider reasons for the consortium's success in recruiting companies. I also draw some comparisons with the case of the Digital VCE, which was set up at about the same time with a similar structure (though without Foresight Challenge funding) in the field of multi-media and digital signal processing, but which failed to attract the same numbers of industrial members.

Several of those interviewed mentioned previous experience of collaboration as an important precedent for the Mobile VCE. The Radio Frequency Engineers training project was cited as bringing together the three original universities and some of the companies[52] involved in drawing up the bid for the Mobile VCE; among other things, familiarity with the work of the universities was said to give companies confidence in the potential of their research. As discussed in the previous section, the industrial members of the Mobile VCE also had experience collaborating in the discussions leading to the development of the European second generation standard, GSM. This is sometimes cited by members of the Mobile VCE as one reason for the willingness of members of the mobile communications industry to work together. However, GSM was under development for nearly ten years, and those involved would not necessarily repeat the experience. One industrial representative commented:

> Many organisations in Europe, with hindsight, look back on the American policy and say they did us a favour [...] but GSM did take an enormously long time to specify, much longer than it should have done. While GSM was an enormous success, there are no plans to repeat that process, because it did take too long. Every single bit of it was thrashed out in committees.

On this view, the major lesson was the need to avoid the protracted defence of individual corporate interests. An academic member also remarked:

> There probably will never be a repetition [of the collaboration to build a GSM standard], because what is happening now is that we are looking to have an environment in which different standards can co-exist, interact and share infrastructure. The technology is advancing to the point where that is feasible; it wasn't when GSM was conceived.

[52] According to the Prospectus (DTI 1996b, p 10) eight companies were involved in the RFE programme.

In addition to the experience of collaboration, standards may also be important in the mobile communications industry in a way that is not usual in other industries. One interviewee remarked on the contrast between mobile communications and the requirements of broadcasting transmissions relevant to the work of the Digital VCE:

> In broadcast transmissions there are technical differences between the way in which satellite and terrestrial and cable will handle the detailed coding because they are addressing different problems; but they do not interact.

The requirements of interactive communication are even more important in mobile telephony than in computing systems, and may be a reason for the perceived need to agree standards rather than allow a de facto standard to emerge (as happened for example in personal computers with Microsoft DOS and then Windows).

In discussing reasons for joining the Mobile VCE, many industrial members pointed to its cost-effectiveness as a means of gaining access to advanced research. [add Groves quote] Although they usually only participate actively in one area at most, all industrial members have access to the research results of all four Core Programme areas, and the right to license products of all four areas. The cost effectiveness is itself partly a result of the numbers involved in the project – as was discovered by members of the Digital VCE, fewer members means a smaller research programme. The achievement of critical mass was important not only in respect to value for money, but also implied a need to join for companies who saw that their competitors were all members and so they 'could not afford not to join'. Some interviewees, in citing cost-effectiveness, also pointed out that market growth meant there was no problem in paying the subscription. However, one representative of a large multi-national also pointed out that he was required to justify membership on a yearly basis:

> It's to be compared with all the other opportunities for what we call 'externalisation investment' globally.

The same speaker, asked to speculate on what might make his company leave the Mobile VCE, summed up most of the reasons given by companies for membership:

If that came about, it would be obviously in terms of value for money, if the fees are forced to increase significantly, perhaps through lack of membership; the chosen subject areas for future direction; and the efficiency with which it is operated - should it lose the support of some key players then that would also influence the situation.

To summarise, suggested reasons for the success of the Mobile VCE in establishing an industrial consortium include:

- Experience of collaboration – RF Engineers Education Initiative
  – GSM standard discussions
- Importance of standards
- Growing markets in mobile communications
  – cash available for research
  – vision of future
- Cost-effectiveness/critical mass
  – return on investment
  – matching competitors

Digital VCE, by comparison, was attempting to create a collaboration in an industry that not only had no previous experience of collaboration, but didn't necessarily identify other potential members as being in the same industry, either as competitors or as having complementary research interests

7. Evaluation: criteria and practices

In the previous section, I explored a variety of reasons that might be given for the success of the Mobile VCE in attracting and maintaining its industrial membership. This achievement also provides a measure of success in the evaluation of the VCE itself. However, there are many other questions to be raised about the effectiveness and the ultimate value of the VCE as a collaborative funding mechanism, as a mechanism for supporting excellence in research, and as a contribution towards promoting progress and growth, both from a national and a European perspective. This section provides a brief

survey of some of the different criteria available for evaluating the VCE, considered first in the context of different institutionalised practices of evaluation, and secondly in relation to what I earlier called the policy discourse (section 3).

In section 5.4 I referred to the horizontal reporting system practised within the Mobile VCE; this involves the deployment of criteria such as research progress and the timely delivery of reports. In addition, industrial members are accountable to their own companies for their continued membership of the Mobile VCE, which they again assess in terms such as research quality and exploitable IP; in this context, cost-effectiveness of membership of the VCE (cf section 6.2) is a significant criterion of evaluation. Academic members are also accountable to their own institutions and while the winning of research money itself acts as an important justification of their membership of the VCE, they also may need to show that it is useful in terms of research quality, and as a source of journal papers and other indicators recognised in academic assessment (and in particular in the Research Assessment Exercise). Other institutionalised practices of evaluation that may be relevant include those that may be carried out by the DTI/OST and the EPSRC, both of which bodies customarily carry out formal evaluations as well as producing institutionalised terms of accountability for their own employees. The DTI/OST has as yet no specific plans for formally evaluating the VCE mechanism or the Foresight Challenge Award, but many of the projects funded by the Award are still ongoing. The EPSRC has a formalised system both of assessing bids and evaluating funded projects which relies on peer assessment; the assessment process is under way for the Mobile VCE's second research programme (Core Two). The following table is intended to provide an indication of the way in which different criteria of success may be deployed in different institutional contexts. It is not intended to be an exhaustive list, but merely to illustrate how different groups do not necessarily share common terms of judgement. Common values, such as 'research excellence', may be implicit for most groups, but are adduced in different ways for different communities.

Institutional context	*Terms of accountability*
Academic Institution	Contributes research funds Generates journal papers (RAE value)
Company	Cost-effective Ultimate market relevance
Research Council	Satisfies peer review (Deliverables to timetable)[53]
DTI	Industrial involvement Academic/industrial links
Mobile VCE	Patentability Deliverables to timetable

The above terms of evaluation relate to formal or semi-formal practices of accountability which are self-evidently associated with different institutional or organisational contexts. However, although they are relatively stable, they are contestable in the sense that they are likely to change over time, and are informed by the policy discourse. The policy discourse also opens up a broader set of terms of evaluation which are open to dispute and debate. In this context, evaluation of the VCE involves questioning not only how well it works in its own terms (that is, attracting industrial membership, producing world-class research), but also how it contributes to broader political aims of generating social and economic benefit. In section 3, I suggested that policy discourse in general tends to accept that the encouragement of technological innovation within a context of richer links between industrial, academic and other interests, is the most effective way to promote social progress and economic growth. However, within this consensus, there is a variety of views in relation both to interpreting the underlying structures and assessing the best policy mechanisms. On the one hand the Mobile VCE may seem to justify itself

[53] This criterion has not been applicable in the case of the Mobile VCE, because the EPSRC had only a financial management role; it has however organised peer review of the VCE's bid for Core Two.

through its success in enrolling members and continuing through to a second research programme, but on the other hand its role within broader policy may still be an issue.

The case study format lends itself to exploring the first sort of question – how the VCE acts both as a research network and an industrial consortium, for example – but also makes it possible to raise questions of generalisability which relate to the broader effectiveness of the mechanism. The latter sort of question may be approached, for example, through comparing it with other sorts of industrial-academic research consortia. In addition, the place of the VCE within the UK policy environment may be compared to its possible role in other contexts, particularly European technology policy. These are among the questions which will be explored further in the continuation of this case study.

8 Conclusions and future work

In this case study I have described the history of the Mobile VCE from its origins in a recommendation of the Foresight Communications Panel. As a deliberately designed collaborative funding mechanism, the principle questions are whether it is effective and whether it is generalisable. I have suggested that the Mobile VCE must be judged successful at least insofar as it managed first to enrol and maintain a significant industrial membership and secondly to produce the conditions for its own continuation in further three-year funding. That is to say, it has successfully survived, which is a minimum requirement on an effective collaboration. At the same time, however, it may be argued that it has been effective in a more substantial sense in that the encouragement of industrial/academic collaboration is itself a policy aim, because such collaborations are perceived as a way of promoting progress and growth (cf section 3). This achievement does not, however, settle broader questions about the value and generalisability of the VCE as a policy mechanism (cf section 7), which are among the questions to be addressed in the continuation of the case study.

The present paper represents a preliminary case study, and part of its aim has been to identify questions that need to be addressed in the remaining phase of the SEIN project. These will include further study of communication within the Mobile VCE (both among researchers, and between researchers and industrial representatives); questions of comparability with other collaborative institutions (virtual and/or bricks-and-mortar); questions related to the broader policy context including issues specific to the European Community; and questions raised by comparing the case of the Mobile VCE with the other case studies in the SEIN project. It is intended to continue developing the case study in an iterative dialogue with the development of a simulation model of innovation networks.

REFERENCES

ACARD, 1986. *Exploitable Areas of Science.* London, HMSO.

ACOST, 1988. *Optoelectronics: Building on our investment*. London, HMSO.

ACOST, 1994. *Technology Foresight. The identification and promotion of emerging and generic technologies.* London, HMSO.

Bush, Vannevar, 1946. *Endless Horizons*. Washington DC, Public Affairs Press.

DTI, 1994. *Competitiveness, Helping Business to Win*. London, HMSO.

DTI, 1995. *Competitiveness, Forging ahead*. London, HMSO.

DTI, 1996a. *Competitiveness, Creating the Enterprise Centre*. London, HMSO.

DTI, 1996b. *Virtual Centre of Excellence in Mobile and Personal Communications*. London, DTI.

Economist, 1999. Survey on Telecommunications. London, *The Economist*, 19 October 1999.

European Commission, 1995. *Green Paper on Innovation.* (COM (95) 688) Brussels, EC.

European Commission, 1996. *Action Plan for Innovation in Europe*. Brussels, EC.

Faulkner, Wendy and Jacqueline Senker, 1995. *Knowledge Frontiers.* Oxford, Clarendon Press.

Gibbons, Michael, Camille Limoges, Helga Nowotny, Simon Schwartsman, Peter Scott and Martin Trow, 1994. *The New Production of Knowledge*. London, Sage.

Henkel, Mary, Stephen Hanney, Maurice Kogan, Janet Vaux and Dagmar von Walden Laing, 1999. *Academic Responses to the UK Foresight Programme.* Unpublished Report for the Nuffield Foundation. Uxbridge, CEPPP, Brunel University.

Latour, Bruno, 1987. *Science in Action*. Cambridge, Mass, Harvard UP.

Leydesdorff, Loet and Henry Etkowitz, 1996. "The Future Location of Research: A Triple Helix of University-Industry-Government Relations II" (Theme paper for a conference in New York City, January 1998), *EASST Review*, Vol 15.4, Dec 1996, pp20-25.

Martin, Ben R and John Irvine, 1989. *Research Foresight: Priority Setting in Science*. London and New York, Pinter Publishers.

OST, 1993a. *Realising our Potential – A strategy for Science, Engineering and Technology*. Cmd 2250. London, HMSO.

OST, 1993b. *Research Foresight and the Exploitation of the Science Base*. London, HMSO.

OST, 1995a. *Report of the Steering Group of the Technology Foresight Programme*. London, DTI.

OST, 1995b *Report of the Steering Group of the Technology Foresight Programme. Number 6, Communications*. London, DTI.

POST, 1997. *Science Shaping the Future? – Technology Foresight and its Impacts*. . London, POST.

Rosenberg, Nathan, 1994. *Exploring the Black Box. Technology, Economics and History*. Cambridge, Cambridge UP

Scourias, John, 1997. "Overview of the GSM Cellular System. Extended Abstract". Web publication: jscouria@www.shoshin.uwaterloo.ca

Woolgar, Steve, 1991. "Configuring the user: the case of the usability trials" in John Law (ed) *A Sociology of Monsters. Essays on Power, Technology and Domination.* London and New York, Routledge.

WEB ADDRESSES

Mobile VCE
http://www.mobilvce.co.uk/

Digital VCE
http://www.digital-vce.com

Hairy Dog Guide to Mobile Phones
http://home.clara.net/hairydog/cell1.html

GSM World (GSM Association)
http://www.gsmworld.com/index.html

Mike Pratt's GSM and UTMS news
http://www.prattfamily.demon.co.uk/mikep/gsmnet.html

UMTS Forum
http://www.umts-forum.org