# Research Interactions Between University and Industry in Computer Science in the United States and United Kingdom

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## ABSTRACT

**Title :** Research Interactions Between Universities and Industry in Computer Science in the United States and United Kingdom.

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**Summary:**

The academic discipline of computer science owes its existence to the industrial development of computer technology; the computer industry owes its existence to work undertaken by academic researchers. Close links have always existed between the two, and ideas, equipment and personnel have flowed between them.

The funding of academic research by industry, and the 'exploitation' of research results by universities, are now the subject of more interest and activity than ever before. This report examines the current state of relations between universities and industry in computer science, with particular reference to the characteristics of different kinds of formal and informal relationship, such as research sponsorship, consultancy agreements and technology licensing, and the advantages and disadvantages which each potentially offers to participants. Considerable attention is paid to the special characteristics of computer technology, computer science research and the computer industry which make certain kinds of interaction more productive and widespread than others.

Polices regarding ownership of intellectual property, the establishment of start-up companies and other controversial topics are examined. The role of personal relationships and tacit knowledge is scrutinised, as are the different roles given to formal university bodies in regulating what are essentially relationships between individuals. Where significant, differences between observed activities in the UK and US are analysed.

Primary source material is a series of 27 in depth interviews undertaken with a range of professionals working in university departments and research teams, central university offices and corporate managerial capacities in both the US and UK. These are supplemented by references to a range of research literature and by a concise account of the historical and political background to current patterns of research support.

**Thanks to** : All the interviewees, my supervisor Richard Girodano, Suzi Howe at Brown, John Leech at MIT, Henry Lowendorf at Yale, AUTM, Jeff Butler at the Business School, Simon Ritchie at BT and Andy & Mark, my long suffering proof readers. Also to ICL for sponsorship through out my degree programme.

**Special Thanks** to Chris Batty and the **Royal Academy of Engineering** who made this work possible with a bursary to meet the costs of visiting the US and by providing further support for travel within the UK. Also to the **Blau-Shane family** for hospitality above and beyond the call of duty.

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# 1. INTRODUCTION

This report is based on work undertaken between August 1994 and May 1995 to investigate the current state of research relationships between universities and industry in the field of computer science. It is a slightly revised version of a project report used to satisfy requirements for the degree of M.Eng. in Systems Integration within the computer science department of the University of Manchester.

The most important input to the report is a series of 27 in-depth interviews with those, in both the UK and US, whose work has given them extensive personal experience of a range of different forms of research interaction, particularly sponsored research, consultancy and technology transfer.[1] Participants included a diverse mix of corporate managers, prominent university researchers and departmental heads and the staff of central university offices responsible for interactions of different kinds with industry. Organisations participating included some of the best known in their fields, amongst them MIT, IBM, Cambridge University, Harvard University, Xerox and Yale University.

The diversity of the perspectives given by this material provides an insight into the way in which different parties perceive the same issues and activities. It also results in a wide-ranging survey of the different forms such relationships can take, and the ways in which different universities have dealt with the issues involved. Including in the sample two rather different countries allows an examination of similarities as well as differences between their respective approaches.

These interviews have been supplemented by a considerable number of other sources. As well as written material produced by participant organisations, changing government policy towards research funding and technology transfer in the two countries is summarised, as are historical and legal frameworks within which patterns of research interaction have developed. A wealth of research on science and technology is used to place in context and to support and develop my arguments. However, the interview findings retain their primary importance - other material is introduced to support their analysis rather than vice versa.

## 1.1 IMPORTANCE OF THE TOPIC

During the fifty year history of the digital computer, academic researchers have played key roles in the many of the most important chapters of its evolution. The first digital computers were constructed at universities, and concepts vital to the design of every modern computer - such as operating systems, time-sharing virtual memory and high level languages were originated and pioneered within universities.

There are also numerous examples of technologies which, although originated in industry, only received general recognition and maturity through their adoption by academics. RISC processors, the Unix operating system and much workstation technology fall into this category. Companies such as DEC and SUN have been founded by former university researchers.

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[1] The term *research interaction* has been used to include all forms of relationship where research and/or development is conducted on a joint basis, or where the results of research (tangible or intangible) are deliberately transferred (formally or informally) from one party to another.

Government policy, in both the UK and US, favours the deepening and formalisation of links between universities and industry in all fields of technology. In Britain, policy is directed towards 'research for wealth creation' and a fundamental restructuring of higher education is underway, with one of its objectives the increased relevance of university research to industrial needs. In the US federal funding for research is under threat and attempts are being made to divert technical expertise from military to industrial fields. Universities are being forced to seek new sources of funding in order to maintain their central research and teaching activities. At the same time companies are facing ever more fierce competition and are having to restructure themselves constantly and seek maximal value in every aspect of their operations.

Two activities on which particular emphasis been placed recently are the diffusion and licensing of technologies developed in universities to companies for commercial exploitation - a process known as technology transfer, and to the industrial funding of university research in specified areas - industrially sponsored research. Many universities have made considerable investments in the setting up of specialist offices, staffed by expert professionals, in an attempt to maximise revenues from technology licensing.

## 1.2 REPORT STRUCTURE

**Chapter 2** details the **historical and political background** to the development of computer science and technology transfer in both the US and the UK. In each case, changing patterns of funding are summarised and the recent governmental sources of research funding and technology policies examined. Both countries have recently reorganised and redirected their support for research and development, and each has deployed a number of initiatives designed to encourage research partnerships and technology transfer between public and private sectors.

**Chapter 3** examines the **range of functions** to support and encourage research interactions which different universities perform via various **central bodies**. The functions supported and their integration into different offices and university companies varies greatly in the sample of universities surveyed. These differences are summarised and overall structures in place at a number of different institutions are sketched.

**Chapter 4** looks at ongoing **research relationships**. It begins with an analysis of research and development in **corporations**, with particular reference to the function of industrial basis research and the complex nature of the relationship between research and development in the computer industry, as well as the ongoing structural changes in that industry. This provides the context for an examination of the **changing nature of research collaborations**, which are increasingly driven by companies' direct financial interests. Case studies illustrate the potential for complex, symbiotic relationships and the advantages and disadvantages of cooperative projects. **Different types of relationship** are examined in some detail, with stress on the importance of longer term informal and strategic relationships. The role of formal industrial liaison programmes is also assessed, and university policies as to preferred and accepted types of agreement and exploitation terms for research documented.

**Chapter 5** is concerned with **technology transfer, both formal and informal**. It begins in general terms with the role of technology as organisational expertise and the changing nature of companies' attitudes to technology acquisition, before looking in some detail at the different types of protection available for intellectual property and the suitability of computer technologies for formal licensing. The procedures used to evaluate and market technologies are investigated, as are particular issues involved in the exploitation of computer technology. The chapter concludes with an examination of the different kinds of **start-up companies**, both privately and university owned, which can be created to commercialise university research and of the very different climate and attitudes found between the two countries in this respect.

Chapter 6 concerns overall **conclusions**. A consideration of the limitations imposed by my methodology is followed by a restatement of the principles findings of the project. Because of the broad nature of this investigation, many important aspects of these findings require further investigation, particularly of a quantitative nature, and so some of the avenues for future research which have become apparent are outlined. The report finishes with a brief discussion of the prospects for future developments in research interaction between universities and industry in computer science.

An index of **abbreviations** (7) and a **bibliography** listing all sources referenced (8) follow in the usual manner.

**Summaries of the interviews themselves** are presented as an appendix, which is numbered separately for ease of reference. In each case the summary contains all the relevant points of substance made during the course of the interview. The interviewee themselves has been allowed to review the summary prior to its inclusion here, and a number of them took advantage of the opportunity to correct and clarify their comments. In a few cases the summaries were substantially rewritten, more details of the process used to produce the summaries is given in the discussion of Methodology below. Their format uses précis to convey items of background and information, with direct quotation favoured when opinions or experiences of particular interest are being reported. It is hoped that these summaries might be of use to others with an interest in the topic.

## 1.3 DOCUMENT CONVENTIONS

Quotations from referenced sources are presented in the usual way.

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>
> [Source, page 25]

Full citation details are presented in the bibliography.

A slightly different convention has been used to presented selected material from the interview summaries themselves.

> This indented paragraph is a section of précis of an interviewees statements, which has been approved by the interviewee themselves. ‘In quotations, this is a piece of direct speech transcribed from the interview.’
>
> > ‘Also in quotations, and indented further, this is an entire quoted paragraph transcribed from an interview. Also in quotations, and indented, this is an entire quoted paragraph transcribed from an interview.’[2]

[2] See 9.1.2.3 - Interview with Joe Bloggs of the XYZ Office of Public Statements

Wherever material is quoted from an interview summary, this is referenced via a footnote also containing the name and organisation of the interviewee to the appropriate section number of the appendix which contains the full summary of that interview. '*Occasionally, snippets of directly quoted speech are mixed with body paragraphs - these are in quotes and italic text'*

Sometimes an interviewee has quoted a third party, as in

> 'Suppliers often come to us and say "Let us sell you some equipment." We tend to look very closely at a number of different attributes...'

In these cases, double quotes have been used for all such nested quotations. Whilst this is not strictly grammatical it adds considerable clarity, and was essential for comprehensibility when e-mailing summaries to participants. Where Americans are involved, American English spellings have been used in directly quoted material and in capitalised nouns.

Finally, slightly different conventions have been used in the interview summaries themselves. For clarity all directly quoted text has been placed in italics as well as quotations.

## 1.4 METHODOLOGY

As mentioned above, the original research involved in this project took the form of a series of interviews with 27 participants, of which 5 were managers from commercial companies, 13 members of central university bodies and 9 members of computer science or related departments. Because several interviews were conducted with different members of each of the participating universities, this sample spanned 5 companies and 10 universities. The data gathering and analysis method adopted with respect to this sample was qualitative rather than quantitative throughout.

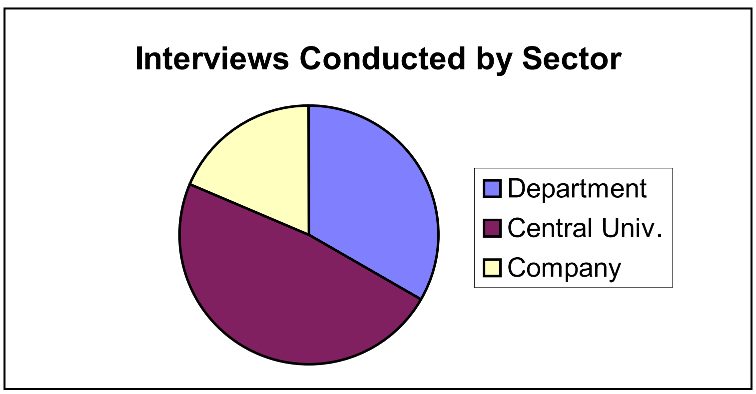


**Figure 1-1: Interviews Conducted by Sector**

Almost without exception, participants had many years experience of dealing daily with the issues raised by university/ industry interaction. My approach was therefore to allow them significant flexibility to discuss those elements of the relationship which they considered to be the most important, whilst at the same time ensuring that certain broad areas were covered so that comparisons could be made. There was no fixed set of questions or questionnaire; given the diversity of roles undertaken by the interviewees this would have imposed an unhelpful rigidity without resulting in a large enough sample to have any kind of statistical significance.

The interviews were tape recorded (with explicit permission), and in case of technical problems notes were also made. After the conclusion of the interviews, these recordings and notes were used to produce the interview summaries collected in section 9.1. All the summaries were then returned to the interviewees themselves, usually via email but sometimes physically or by fax, to allow them to examine their comments and my précis of them and to make whatever corrections and clarifications they wished. In most cases changes made were small, and involved rephrasing awkward constructions, changes of emphasis and corrections to figures. In some cases controversial statements were removed, and a few participants took the opportunity to substantially rewrite the summaries to reflect official policy. In all cases the wishes of the participants have been respected, where no response was received following an initial transmission and a subsequent reminder this lack of explicit verification is indicated at the head of the summaries themselves.

Each summary is preceded by a heading in a standard format such as:

```
Interviewee: Professor Norman Badler
Job: Director, Center for Human Modelling and Simulation
Organisation: University of Pennsylvania
Interviewer: Thomas Haigh
Date: Thursday 8th September 1994
Location: University of Pennsylvania
Revision: 1
```

Selection of interview participants was slightly ad-hoc. The American institutions studied were not an accurate cross-section of the US university system: they were all private, east coast institutions and, with the exception of MIT, members of the Ivy League. Practical considerations limited the geographical range of the sample, and these institutions were chosen because as major centres of research, many of them amongst the world's most prestigious, they had well developed and extensive arrangements for the support of research and the licensing of its results. At least two interviews were conducted within each institution, where possible including both academics and administrators.

In almost every institution surveyed, one or more of those responsible for technology transfer were participants. Either the director of the office or the officer with particular responsibility for computer technology were usually interviewed. Interviewees also included those with responsibility for industrial liaison and for corporate development. Researchers interviewed had in all cases substantial experience of industrial collaboration - most of those participating were heads of research groups, many of them heads of department, laboratory or centre.

Participating companies were major corporates, with the exception of two small companies (one controlled by and one partly owned by a university). Those interviewed in most cases had substantial overall responsibility for technology liaison with universities, and the relatively low representation of companies in the overall sample is caused by the relative difficulty involved in identifying and arranging to meet such people.

# 2. HISTORICAL AND POLITICAL BACKGROUND

An understanding of the current nature, and likely future direction, of links between universities and industry in the field of computer science can only be achieved with the benefit of a considerable amount of background information. This chapter represents an attempt to summarise much of that information for both the US and the UK.

Brief sketches of the development of the research system during the twentieth century are followed by examinations of changing policy towards and funding patterns for university research during the past two decades. Especial attention is paid to the emergence of more widespread attempts to encourage technology transfer since the mid 1970s and the various pieces of legislation and governmental programmes designed to facilitate this. Where possible this information is presented with specific reference to the development of computer science and information technology over the same period.

As well as providing sufficient background on which to build my conclusions, this chapter also provides the context needed to understand points made during my discussion of the interview findings and by participants themselves. It must be emphasised that, although efforts have been made to provide some analysis of and structure to the material in this chapter, its primary function is the support and elucidation of arguments and analysis elsewhere in the report.

## 2.1 US BACKGROUND

### 2.1.1 UNIVERSITY RESEARCH 1850 -1970

*NOTE: What follows is a very brief sketch designed to provide a minimal historical background to the remainder of the report. General information on the development of university research is condensed from [Bower], information specific to the history of computer science comes mostly from [Hartmarnis & Lin].*

Only during the latter half of the nineteenth century did American universities begin to undertake scientific and technological research on a significant scale. At this time land grant institutions were coming into existence following the Morril Act of 1862. Johns Hopkins, founded in 1876, was intended to follow the German model of advanced scientific and technical education with an integrated research component - its creation is conventionally taken as an important landmark of the American scientific institution.

During the early 20th century higher education system grew rapidly, along with the economy. Research funding increased dramatically, much of it from philanthropists - most famously Rockefeller and Carnegie. Federal government expenditure on science, although sizeable, was mostly directed towards applied work done in government organisations. Similarly, the great industrial research laboratories such as those of AT&T and General Electric were established in this period as centres of applied work which did not interact routinely with universities.

Industrial cooperation between universities and industrial organisations was first undertaken on a significant scale during the First World War. During the interwar period some universities maintained traditions of contract research and consultancy work. Despite problems caused by the Depression and the attendant falls in revenue, this period saw a consolidation of the strength of the major research universities.

During the war the role of the federal government as a contractor of research increased massively. University effort was directed towards a range of applied projects designed to assist the war effort - two of the most famous technological results being the atomic bomb and the digital computer. Following the war a continued growth in pure science was accepted as a national priority, and the necessity of Federal funding in maintaining this recognised. The **National Science Foundation**, or NSF, was established in 1950, and federal funding became the most important source of research funding. Private donations from individual foundations continued to flow, though industrial links were in general actually eroded during the period.

The **Office of Naval Research** (ONR) and **Air Force Office of Scientific Research**, also within the Defense Department, were very active in the late 1940s and early 1950s, funding such well known systems as SAGE and Whirlwind. However, their role diminished relatively as the total scale of funding increased. **NASA** made a significant contribution to the development of reliable and fault tolerant systems for the Apollo program, and the **Atomic Energy Commission** - responsible for the US atomic weapons program - was the principle source of funding for the development of supercomputers and their applications. The development of atomic weapons has always required the most advanced possible simulation techniques, and indeed ENIAC, the first digital computer, was developed for this purpose. COBOL, which was for three decades the standard language for business and commercial software development, was designed by a DOD taskforce in 1958.

A federal body with particular importance for the development of computer science was DARPA, the **Defense Advanced Projects Research Agency**. Founded in 1958 to support research in fields of military interest it was favoured by the Kennedy administration as a means of directing funds efficiently towards areas crucial to national technological progress, which in the years directly after Sputnik was viewed as being a close race with the Soviet Union. Computer research was identified as important to this end - projects were funded at universities and companies and conferences organised for the sharing of information. Together with DARPA Net, which eventually developed into the Internet, these played an important part in the development of computer science as a discipline. DARPA also funded emerging areas such as computer graphics and advanced architectures.

> DARPA has long had a reputation for supporting high-risk, high-gain research in pursuit of military applications. Its style of research support is highly proactive in that DARPA identifies areas of potential interest for military needs and orients its research support mostly toward experimental and prototype system development. Individual program managers have been highly influential, both in articulating areas of need and in stimulating the CS&E [Computer Science and Engineering] community to be interested in these areas. Thus DARPA has often played a key role in defining research agendas for the CS&E field.
>
> [Hartmanis & Lin, page 219]

The NSF only became a major supporter of explicit computer science research in the mid 1970s, prior to this the emphasis had been on funding scientific applications of computing through other disciplines. Previous impetus towards the development of computer science as a discrete field of study may thus be seen as coming primarily from deliberate and targeted military investment.

American science and engineering came to lead the world in most fields, including computing. Within the pure sciences, funding was officially channelled towards scientific excellence, without a direct concern for exploitable results - at least on the micro-level of distribution of funds between researchers and groups working within the same disciplinary field. Compared to previous European models, individual groups and laboratories generally enjoyed a greater level of autonomy to follow diverse research directions. A relatively small number of elite institutions continued to dominate research.

## 2.1.2 CHANGING PRIORITIES IN RECENT DECADES

### 2.1.2.1 The Emergence of Biotechnology as a Paradigm for Technology Transfer

The event generally recognised as catalytic in the development of a new attitude towards technologies developed by universities was the development, by Cohen and Boyer, of a gene splicing technique crucial to the manipulation and recombination of DNA. When this was published in 1973 it represented a breakthrough in basic research with profound implications for the development of molecular biology. What made it different from previous breakthroughs in pure science was the fact the Stanford university successfully patented it, and by 1976 the biotechnology industry had been born around it with the formation of Genetech Inc - founded jointly by Boyer himself and a venture capitalist. One of the other key biotechnologies, allowing the production of monoclonal antibodies, was developed in Britain in 1975 but its commercial value was not recognised and it was not patented.

During the next few years, a number of other companies were formed to exploit biotechnology, concentrating on pharmaceutical applications. Spectacular success was achieved by a few companies during the 1980s, including Genetech itself, Amgen and Biogen. New companies were founded in great numbers, as venture capitalists were eager to fund scientists founding new companies to develop promising technologies. Investment reached its peak in 1991, when a total of $3.6 billion was raised by biotech firms through public stock offerings alone.[3]

Recently, confidence of investors has diminished sharply. As these companies move the development of their drugs further through the process of development, testing and approval the costs increase sharply at every stage, but the substantial majority of the companies need further finance to meet these costs and, following high profile failures, investors are wary and available funds are not sufficient to support all the companies now active. Most of these companies have only one product, which will begin to produce revenues only at the end of seven to ten years of work, and so tend to rush through development in the hope of success - not an approach likely to produce cautious evaluation of prospects, despite the fact that only around 10% of biotech drugs entering clinical trails are eventually approved.

According to Business Week, 26th September 1994, expectation among analysts was that only around a quarter of the public companies would remain independent. Companies are seeking collaborations with larger pharmaceutical firms - in 1990 Genetech sold 60% of its stock and several other companies have followed suit. Even though many publicly traded biotech firms have disappointed stockholders, though not the venture capitalists who liquidated their stakes on flotation, they have provided a powerful model of entrepreneurial exploitation of cutting-edge technologies by small companies.

One feature of the biotechnology field which has attracted considerable interest has been an obvious blurring of the differentiation between 'basic' and 'applied' research. Because fundamental research in this area is recognised as having direct commercial relevance,

[3] Business Week, 26th September 1994

developments made in universities have been immediately patented and exploited, whilst much research carried out by biotech companies has been pursuing the same goals as that of university research teams. Industrial staff maintained close links with their academic colleagues, and scientists moved far more easily than had been traditional between commercial and academic institutions. Biotechnology, together with other pharmaceutical and medical technologies, continues to be the main focus of many university technology transfer programmes, and a question underlying much of this report is ‘To what extent is computer technology like (this general perception of) biotechnology?’

#### 2.1.2.2 University Technology Transfer - Political and Legislative Background

The conspicuous success of the Cohen-Boyer patent greatly increased awareness in universities as to the potential value of the intellectual property of their research. As is normal in the US, policy is heavily influenced by the interaction of highly organised special interest groups, and ownership of intellectual property produced by federally funded research is a valuable prize. Lobbying on behalf of university and industrial groups continues to this day.

Since 1980 and the passing of the Patent and Trademark Amendments act, usually referred to as the **Bayh-Dole Act**, ownership of rights to government funded research can be claimed by the university or non-profit research organisation which undertook the work. Previously policies had varied between agencies, but the new situation encouraged universities to protect and license their ILP. Patented inventions must be routinely disclosed to the government, and universities are expected to attempt licenses which favour manufacturing in the US. The government retains a right to use the invention for its own purposes, and vestigial ‘march-in’ rights if a patent is not being properly exploited, but essentially complete control rests with the universities themselves.

An additional motivation to universities to seek additional sources of income came with the general decline in public sector funding for non-military research during the Regan administration of the 1980s. Funding categorised under the ‘general science’ heading was static overall during the early 1980s, and showed very modest growth later in the decade. [NSF]

Because the new legislation made this more practical before, and the high profile success of biotechnology and a handful of university patents, showed the potential for huge rewards, technology licensing appeared a likely source of revenue. Many institutions set up technology licensing offices during the 1980s. The legislation aimed to ‘incentivise’ successful exploitation by allowing universities to profit from the activity - encouraging more imaginative and concerted attempts than would result from a governmental agency. Most institutions choose to pass on the incentive by providing a significant proportion of royalties to the inventor, though this is not a legal requirement. Current software licensing practices are dealt with in detail in section 5.2.

The **Small Business Innovative Research** programme (SBIR) was initiated following legislation in 1982 which forced federal agencies to direct some of their R&D budget towards small business. This was intended to encourage transfer of technology and encourage innovation in small firms - topics are announced in areas of interest to the agencies for which bids are made competitively. Technologies which have been developed far enough to form the basis of a small company are thus developed further by this route - and many of these small firms have been created by university researchers around spun-off inventions. Between 1983 and 1991 this programme awarded projects worth a total of $2.8 billion - of which more than one fifth were in computer related fields. [NSF]

One important development in industrial research arrangements came as result of the 1984 **National Cooperative Research Act** (NCRA). American anti-trust laws imposed very strict regulation on contact and collaboration between companies in market competition with each other - which prevented any kind of research collaboration even at the pre-competitive stage. NCRA allows the establishment of research consortia to spread the cost of pre-competitive research - essential in sectors such as the semiconductor and automobile industries where the research underlying future product generations is now far too expensive for individual firms to contemplate. Two of the most important consortia have been the Microelectronics & Computer Technology Corporation (MCC) and the Semiconductor Research Corporation (SRC) - the latter investing more than $125 million in US university research between 1982 and 1990. [NSF]. The leverage provided by cooperation of this kind can thus provide a significant boost to research in universities as well as in industry.

Corporate research has benefited from the tax credit which rewards '**Research and Experimentation**' (R&E) work - the exact set of incentives offered varies periodically, but throughout the 1980s expenditure overall totalled around $1.2bn per annum. [Williamson] Expenditure at this level could be characterised as implying an industrial policy, but because it was not directed, the government was absolved of the responsibility of being seen to select specific areas or companies for support.

#### 2.1.2.3 The Emergence of a Technology Policy

Under the Bush administration, policy drifted towards a more active government role in the funding of research and development of advanced technologies. The American body politic has a cultural aversion to the idea of industrial policy - and a great ideological commitment to the idea of the free market, so technology policy is a controversial area. The reality is of course that vast government subsidies, via lucrative contracts, to defence related industries played a key part in the development of the American technology base. Indeed, attempts by the government to identify technologies of central importance to national security identify as crucial the same advances in semiconductor development on which commercial success rests. As defence spending is reduced, the case for finding other means of delivering this support is strengthened.

Defence spending on R&D has been reduced substantially, from its high of $39bn in 1987 - representing 67% of all Federal funding for R&D, to $33bn. in 1993 - representing around 59% of the total. (The 'general science' category encompassed just 4% of total spending.) President Clinton is pledged to reduce this further to around 50% by 1998 - although defence cuts of any kind are alien to the newly incumbent Republican majorities. In the basic research field - a relatively small component of overall Federal R&D - defence sponsored work fell to 9% in 1994, down from 12% in 1980. Health accounted for 40% of this spending, and 'general science' (including the NSF) another 20%. 62% of this Federally funded basic research was conducted within the academic sector. [NSF]

[Kash & Rycroft] suggests that this is also an appeal of federal funding for R&D in general - it needs no political justification and leaves companies to pick and choose. It also suggests that military technology has become increasingly isolated and specialised, with much research conducted in secret - so that spin-off benefits have become less common. In several fields, probably including semiconductors, development of the most advanced technologies are driven by civilian projects, and technology transfer takes place into, rather than out of, military development. [Mowery] argues that, although the US military were once the major market for cutting edge technology, this technological divergence, coupled with the growth of civil computing and electronics applications, has radically reduced the importance of military spending to the US semiconductors and computing base since the late 1950s and early 1960s.

> 'Whether government should pick winners has never been a meaningful question. The US federal government has always engaged in 'industrial policy', by supporting sectors of the economy. The problem is that picking winners has been ad-hoc, reactive and fragmentary. Often new federal technology undertakings have been hidden behind some facade like national security.'
>
> [Kash & Rycroft, page 77]

Steps towards an overall framework for technological strategy and technology transfer came in 1988, with the **Technology Competitiveness Act**. The National Bureau of Standards was reborn as the **National Institute of Standards and Technology** (NIST), moved to the Commerce Department, and given responsibility for a number of new programmes, including the **Advanced Technology Program** (ATP). This provides federal funding for generic technologies deemed important to a wide range of products or processes - bids to undertake pre-competitive, high-risk, strategic industrial research are made by commercial firms and consortia. Proposals are screened by teams of business experts as well as for technical merit, and evidence of good business prospects for successful commercialisation is crucial. When the programme was initiated in 1990 its funding was relatively low, but following its perceived success funding was rapidly scaled up with general political support. Claimed benefits include assistance in converting from defence to civilian applications and the formation of strategic alliances as well as financial savings, expanded R&D activity and accelerated development.

In 1994 the ATP was refocused, and the bulk of its activity channelled through programmes with specific technological and business goals - each involving a number of projects. This coordination is intended to maximise the impact of the Program. Another change has been a greatly increased emphasis on the role of the ATP in spotting potential for joint ventures between businesses, universities and government departments or strategic alliances between companies. It also has a role in providing assistance to smaller companies to develop well founded business and commercialisation plans. [ATP]. Intellectual property is vested with industrial partners, rather than universities - which causes concern to universities.

Increased attention has also been focused on the transfer of technologies from national (i.e. defence related) laboratories into civilian sectors. Legislation to enable this began in the 1980s with a series of laws, the first of which was the **Stevenson-Wyldler Technology Innovation Act** of 1980. By the late 80s, a definite upturn in such activity was taking place - the number of cooperative agreements with industry entered into by the Federal labs rose from 108 in 1987 to 975 in 1991. A main thrust of the 1992 **National Technology Initiative** was the redirection of their efforts into collaboration with industry. During recent years new funds have been available to the DOD for defence wide initiatives to promote technology transfer and 'dual use' technologies. A rare growth in the atomic research budget has been in provision for technology transfer activity. [NSF]

A number of changes have been made by President Clinton. His initial policy was the concentration of research funds in six strategic, 'cross-cutting' initiatives, coordinated by the **Federal Coordinating Council for Science, Engineering and Technology** (FCCSET) amongst which was the High Performance Computing and Communications initiative detailed in the next section. Projected funding for this programme was £1.0bn in 1994, some of the other initiatives were even larger, such as the one in Biotechnology which was to be funded at $4.3bn. In August

1993 these plans were modified, with the replacement of the FCCSET with the **National Science and Technology Council** (NSTC) and the cancellations of the Biotechnology programme and merger of several others. [NSF] The NSTC has a broad mission to establish national goals in science and technology and to coordinate policy towards their achievement.

### 2.1.3 COMPUTER SCIENCE IN THE 1990S

**NB: All unattributed figures in this section come from [Hartmanis & Lin].**

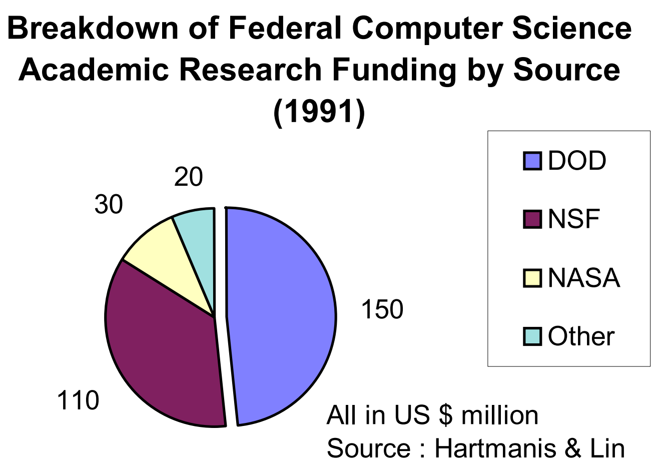


**Figure 2-1: Breakdown of US Federal Computer Science Research Funding for Universities by Agency**

Computer Science has come into its own as an academic discipline since the early 1970s. In 1977 only 954 doctoral researchers were working in the field, from a total of around 83,000 in science and engineering as a whole - representing just over 1% of the total. By 1989 they comprised 3,860 of a total of 149,000 - 242% growth against an overall increase of 80% (though at almost 2.5% Computer Science was still not amongst the largest disciplines). This rapid growth continued into the early 90s [NSF] and has been accompanied by shifts in patterns of funding.

The **National Science Foundation** has become a major source of funds. By 1992 it had become the funding source which supported the greatest number of academic researchers, and computer science was its fastest growing area of funding. Spectacular growth occurred through the late 1980s, after the consolidation of responsibility for the discipline within a single body within the NSF, the CISE Directorate in 1986. Previously funding had been channelled through a number of directorates, none of which had computing as its primary interest. In 1992 dollars, academic funding increased from a static level of roughly between $30 and $40 million for each year since 1976 to 1983 to around $110 million in 1991.

In the early 1990s the **Department of Defense** remained the largest federal source of funding for academic computer science research. Approximately one third of its overall research funding for computer research was directed towards projects conducted within universities and colleges, and in 1992 this totalled roughly $150 million. [Hartmanis & Lin, page 218]. Several distinct sources of funding existed within the DOD, the most significant of which was DARPA - now renamed ARPA. The loss of its explicitly defence related mission reflects a general attempt by the Clinton administration to redirect high technology funding and policy towards national competitiveness and away from military applications.

> In recent years, the major areas of concern to DARPA have included high performance computing, networks, software, artificial intelligence (AI), and applications of these areas. DARPA divides its overall computing program into science (including machine translation, scalable software libraries for high-performance computing, software understanding for the future), technology (including speech understanding knowledge representation, embedded microsystems), and applications (including image understanding, natural language processing, transportation planning).
>
> [Hartmanis & Lin, page 218]

Other DOD agencies have continued to fund some work in computer science, particularly the ONR and OSF which have concentrated on small scale theoretical and fundamental projects in a range of areas judged to have possible military applications in the long term.

**NASA** funded around $30 million of academic computer science research in 1991, specialising in areas such as AI, concurrency and reliability. It also remained a major consumer of applied supercomputing work. The **DOE** funded approximately $4 million of academic research in 1991, a decline of around 50% from its level in 1986. Linked as it was to the development of atomic weapons and the huge national research laboratories, this funding (and their effective subsidy for the now distinctly unhealthy American supercomputer industry) has since declined further.

Federal funding for academic computer science research may thus be seen to have increased sharply over the 1980s, with strong growth in support from both military and civil agencies. Spending on academic research was, again in 1992 dollars, about $70 million in 1976, around $100 million in 1982 and around $310 million in 1991. It is also important to remember that academia only receives a minority of overall federal research expenditure in the field - which rose from around $200 million in 1976 to almost $700 million in 1991.

The rise in the number of researchers has meant that this increase actually represented a slight drop in the available funds per researcher. However, these figures clearly demonstrate that computer science avoided the kinds of pressure which affected federal funding of research in areas with less military potential. Computer Science was the only major scientific field still showing rapid growth in the early 1990s. As a result the perceived financial advantages from industrial collaboration, technology licensing and sponsored research were less critical in this field than in many others.

A major research initiative of the early 1990s has been the **High Performance Computing and Communications** (HPCC) Program. The initiative was based on a report by the White House Office of Science and Technology Policy and involved DARPA, NASA, the DOE, the NSF and a number of other agencies. Additional spending was projected at a total of $1.9 billion over the course of five years from 1992.

The programme focused on four areas:

- High performance computing
- Advanced software technologies and algorithms
- Network technology
- Human resources and basic research (designed to enhance exploitation)

The programme was designed to address 'grand challenges' presented in various fields beyond computing itself - working towards the solution of economic and political problems as well as those in the domain of science and engineering. It is thus an important part of a general trend evidenced in both the US and the UK favouring the increasing direction of research funding towards research areas carefully targeted to further national social and industrial progress.

A trend in academic organisation which computer scientists have been increasingly participating in is the move towards interdisciplinary centres focused on a particular area of research or application which spans traditional disciplinary boundaries (see section 4.2.6). A controversial report produced by a committee of the National Research Council entitled *Computing the Future : A Broader Agenda for Computer Science and Computer Engineering* [Hartmanis & Lin] concluded that the way forward for the discipline was to broaden its agenda and to increasingly look at computing practice and to other disciplines for problems upon which to work. This would ensure the continued vitality and relevance of the field, and also have the advantage of broadening the appeal of computer science beyond its traditional funding base - important in a climate of funding shortages. Obviously the core interests of computer science must continue to be researched, but it argues that core research should be supplemented with additional work in these broader areas, and towards contributions to the solution of major social problems.

## 2.2 UK BACKGROUND

Historically, British development of scientific and technological research and the means of its funding has been very different from that of the US, reflecting fundamental differences between the university systems of the two countries and increasing divergence between their industrial bases and national incomes. This section briefly surveys the growth of public funding of research in the UK, before looking in more detail at government policy for science funding during the 1980s and a number of formal initiatives to encourage university industry research interaction and technology transfer which were initiated during that decade. Recent changes to the government science policy, including the 1993 White Paper and the ongoing Foresight exercise are summarised, as are the new goals of the science funding bodies and associated technology transfer initiatives.

### 2.2.1 THE GROWTH OF PUBLIC RESEARCH FUNDING

UK public funding of science first became significant in 1916 with the creation of the government Department of Scientific and Industrial Research. Although this body was the main source of support for science many decades, until the Second World War its role was almost exclusively in the support of applied and industrial work. In 1920 the first of the Research Councils, the Medical Research Council (MRC) was set up - distributing funds to university researchers. State funding for science gradually became more widespread. [Bower].

The Second World War was a turning point for perceptions of science, following the direct contribution made to the war effort by scientists in a number of key areas - which in Britain of course included Turing's efforts at Bletchley Park in the breaking of the Enigma code. As in the US, governmental support for science was increased massively in scope after the war, and a number of military and atomic energy research establishments were set up.

In the 1950s, government science funding came principally from the Ministry of Defence (MOD), the Research Councils and the universities themselves. No overall government policy for science or technology existed, and the proportion of total spending devoted to military and nuclear projects was greater than for most other European countries, as it has remained to this day.

An explicit science policy began to emerge during the 1960s. Harold Macmillan appointed the first Minister for Science, but the main development came with the election of Harold Wilson - one of whose best known statements was a pledge to reinvent British industry in the 'white heat of the technological revolution'. To this end a Ministry of Technology was created, a Chief Scientific Advisor appointed and a new body advisory body created. Physics and astronomy were particular growth areas, but the hoped for revolution was conspicuous by its absence. The Science and Technology Act of 1965 reorganised the Research Councils and established SRC - the Science Research Council, which later became SERC, the Science and Engineering Research Council. [Levene & Stewart].

In the 1970s it became apparent that funding could not keep pace with the increasing demands of science, because the costs of undertaking each unit of research were growing faster than inflation and the amount of research proposed also tends to increase exponentially as successful work is likely to uncover an ever growing number of new problems. The rate of increase in funding diminished, and a shift of funding away from physics and towards engineering began. [ABRC]

## 2.2.2 THE 80S - SHRINKING BUDGETS AND NEW INITIATIVES

### 2.2.2.1 Government Research Funding 1980 to 1992

Science funding was largely static or shrinking during the 1980s. According to the 1987 report by the Advisory Board for the Research Councils - *A Strategy for the Science Base*

> In contract to the cumulative real growth of the 1960s and early 1970s, the purchasing power of the Science Budget in the 1980s has, at best, been held level.

The report also suggests in 1982 spending in the Maths and Computing field totalled around 4.5% of total government research spending, compared to 3.0% for the USA. A deliberate shift towards applied fields had taken place over the preceding years - between 1975 and 1982 the real value of Physics spending had fallen 18% whilst Engineering funding had risen by about a third. [ABRC]

Significant cuts in funding during the early 1980s saw redundancies and the widespread closure of departments and relocation of staff. Since then tenure has been removed from university staff, and very large numbers of new contracts have been made on a temporary basis - many teaching and research staff are now employed on one year rolling contracts.

At this time the British higher education system included several different types of institution, principally universities and polytechnics. Polytechnics were funded at a lower level, generally had research activity only in specialised and applied areas and were very much a second choice for academically inclined students - with a greater activity in vocational degrees, professional education and part time study for mature students. Until 1988 polytechnics were under the control of local government authorities.

British governmental funding of university research was, and continues to be, provided through the so-called **'Dual Support'** system. The first channel was the **University Grants Council**, which made £622 million pounds worth of research funding available in 1986. Until that year, support was distributed according to a formula which included a major component based on the number of students within an institution - giving all universities a allocation of research funds to spend at their own discretion. During the 1970s funding from this source was allocated for periods of several years - by the 1980s contracts were made annually which made longer term planning harder.

The second channel, which in 1986 contributed £385 to university research, was the **Research Councils** - theoretically autonomous bodies funded through the Department of Education and Science. These funded specified research projects, allocated competitively across institutions. Through the 1980s the Council responsible for computer science and IT, among many other fields, was SERC. All other sources of external research funding - including industry, charity and governmental departments, totalled £253 million. In the polytechnics total research funding totalled only £100 million, with around £60 million of this coming from the government. [ABRC].

1986 saw the beginning of a move towards greater selectivity in research funding, with the amount of level of funding allocated to a university substantially determined by an evaluation of the strength of the research of each of its departments. Each triannual **Research Assessment Exercise** involved the counting of research publications produced and a judgement as to how many members of a department are of national or international excellence. This was used to grade the work of the department as a whole on a scale from 1 to 5 - to determine resource levels supplied to the university on behalf of the department this grade is multiplied by the number of 'research active' academics. As might be expected, this has resulted in a far greater concentration of research resources in institutions whose concentrations departments are predominantly of grade 4 or 5 status.

During the 1980s, OECD figures show a significant shift in overall government R&D spending viewed by socio-economic objective - defence spending rose from around 43% in 1980 to around 54% in 1987. Germany and Japan spent a much lower proportion of their total expenditure - 15% and 13% respectively, in the same category. A government report suggests that less than 20% of the research conducted by the MOD will have any relevance to civilian spin-off technologies, and so this expenditure was probably not an efficient means of stimulation of the broader high-technology base. [Webster]

By 1989/90, total government spending on science and technology R&D was £4.8 billion.

**UK Government R&D Spending by Body (1989/90)**

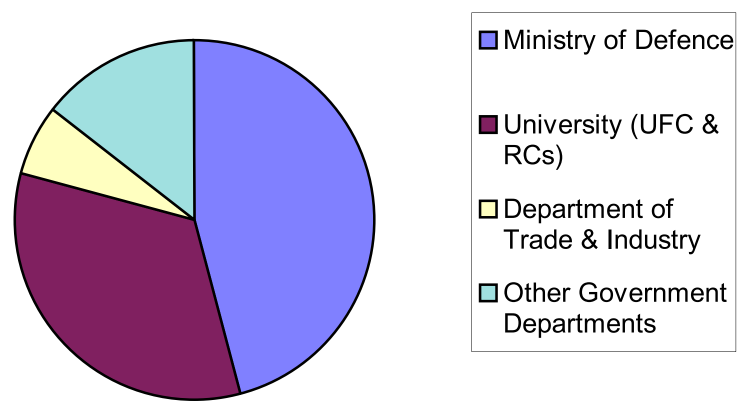


**Figure 2-2: Breakdown of UK R&D Funding by Body**

£2.2bn (46%) of that was spent by the MOD, the great majority of it outside the university system. A total of £1.6bn (33%) was channelled to universities via the UFC and the Research Councils. The remaining $1bn (21%) was spent by the civil departments of government, £310m of it by the Department of Trade and Industry (DTI). £158.7 million was spent on various technology transfer programs - of this 97% came from the civil departments. [Clement et al]

One important difference between Britain and American patterns of funding is the concentration of university research funding in two civilian agencies, both controlled firmly by the executive. This is in clear contrast with the American funding of areas, such as computer science, with military potential - where enough military expenditure is channelled through universities to make it the major source of basic research funding for the discipline. Thus whilst American computer science did very well out of the military build-up of the 1980s, Britain's continuing high level of defence spending relative to comparable nations has brought very little direct benefit to university science. Those strategic initiatives which have sustained research in the area have been of an industrially oriented nature.

#### 2.2.2.2 Industrial Cooperation and Technology Transfer

Against the background of funding from traditional sources which was increasingly unpredictable and in many areas diminishing in real terms, particularly compared to the actual cost of conducting research (which tends to rise faster than the rate of inflation) it is not surprising that the idea of supplementing their income with funding from industry came to seem attractive to many universities.

This kind of funding was also very attractive to the Conservative governments of Margaret Thatcher - for whom ideals of free markets had a powerful attraction. She felt that science should respond to the universally virtuous principles of value for money and market direction - with universities prepared to bid for contract and applied research from industry. Science and technology research was reinvented as a market, in which industry and government were viewed as customers, and researcher teams as producers or contractors.

In the applied research domain, the so called '**Rothschild principle**' of the supplier-contractor relationship in governmentally funded work, taking its name from a 1971 report, was reinforced. Customers of research were identified within each government department and given responsibility for checking on the progress, evaluation and appraisal of research - in keeping with the general philosophy of deregulation of budgeting and rigorous appraisal within Whitehall brought about by the Financial Management Initiative.

Salford University is well known as an example of an institution which significantly altered its funding base - a dramatic round of government cuts in 1981 saw its funding fall by more than 40%. It gained replacement funding from industry by a significant switch of emphasis to corporate training, consultancy and contract research and development.

The government also moved to incentivise the transfer of university technology to industry. Until 1985, a governmental body known as the **British Technology Group** - and its precursor the NRDC - was entrusted with responsibility for the evaluation and licensing of technologies produced by publicly funded research. Income generated was retained by the government - providing no direct financial incentive to universities or researchers to consider the commercial potential of their work. Although the BTG was not altogether unsuccessful in its task - with key patents for Magnetic Resonance Imaging (MRI) technology providing its most substantial revenue stream - it made a number of well publicised blunders, best know of which was decision that monoclonal antibody technology had no commercial potential. Within the computer field an earlier failure of vision was the disposal of key patents relating to virtual memory for a very small sum.

In 1985 the preferential rights given to the BTG were removed. Universities were now able to choose to retain their IPR over the results of publicly funded research. The BTG now had to offer its services in competition with other brokers, such as the US firm Research Corporation Technology - most universities set up some kind of office or subsidiary company to deal with technology licensing and exploitation but continued to use external expertise in many areas. The BTG was subsequently privatised in 1992, and has altered the focus of its operations - closing regional offices in the UK but expanding its operations internationally, now seeking to represent foreign institutions, with its own US subsidiary based in Pennsylvania, as well as to license to foreign companies. [BTG]. According to Issue 1 of Catalyst, their newsletter, the BTG returned £14.61 million in revenue to universities and other sources of inventions during 1993, with 80% of its licenses made abroad.

This transfer of IPR to universities mirrors the results of the Bayh-Dole act in the US, and is similarly regarded as a seminal event in the evolution of modern patterns of technology transfer. During the 1980s, this was complemented by a number of initiatives designed to encourage increased collaboration between universities and companies in the actual research process itself and a concentration of work in areas likely to be of strategic importance.

By far the most important initiative of the early 1980s, and one focused on IT, was the Alvey Programme. This is dealt with in some detail below because the results derived by its evaluators provide a valuable insight into many aspects of university/industry research interaction.

#### 2.2.2.3 The Alvey Programme

The Alvey Programme was a five year government IT initiative which began in 1983. Its government sponsors were the Department of Trade and Industry, SERC and the Ministry of Defence but the programme itself was administered by a Directorate manned partly by secondees from industrial and academic organisations. Industrial involvement in research was central to the project - it aimed to boost national competitiveness in IT in response to general problems and the perceived challenge of the Japanese 5th Generation project, another strategic information technology initiative begun in the early 1980s.

The Programme ran on a very large scale, with more than 300 different research and development projects undertaken. Most of these were joint projects involving both industrial and academic research teams. Strategic areas within IT were identified and efforts concentrated in these areas. One of the explicit aims of the programme was to encourage technology transfer from academia into industry to provide competitive advantage, for this reason only technological areas where Britain already had some measure of strength were included. The Programme represented a very significant proportion of overall government spending on research in the computer science field, and so helped to initiate the trend towards increased focusing of research funds. It concentrated on pre-competitive research - an underlying policy belief was that further commercialisation could and should be left to the market itself.

The official evaluation of the Programme [Guy et al], by a team from the Science Policy Research Unit (SPRU) and Manchester's PREST, concluded that direct technological goals were largely met. The aim of the Programme to address structural problems in the UK research infrastructure was also judged to have succeeded - the team found that as a result of the programme the number of researchers in key areas increased and industry was able to benefit from the forging of links with academics. The Programme sought to develop and strengthen ties within research communities, again with some success.

The practical exploitation of research did not occur to the anticipated degree. The evaluators suggest that many companies failed to integrate their research teams with production and management and the lack of capital within the industry worked against commercialisation and longer term strategy. The British IT industry over the period saw a great deal of failure, consolidation and foreign acquisition of industrial project partners which closed off many routes for exploitation. These kinds of structural problems were realistically outside the control of the Programme itself and for this reason the evaluators concluded that a pre-competitive research programme is insufficient on its own to improve national competitiveness, and suggested that initiatives in other areas by government and industry, including a corporate drive for coherent technology strategies and a greater involvement of users, should complement future projects of this kind.

Some interesting data on the research collaborations involved is presented by the evaluators. A survey showed that overall two thirds of participants felt that the overall benefits outweighed the costs (p. 140) though academics were decidedly more positive than industrial participants. Amongst the industrial teams, those from large companies were more likely to feel positively about the net gains.

> There must be suspicion that even modest increases in collaborative overheads would render the cost/benefit ration unpalatable to firms. Contemporary arrangements in the UK calling for firms to bear some of the cost of academics involved in R&D programmes deserve scrutiny in the light of this finding.
>
> [Guy et al, p. 141]

45% of the industrial teams involved and 39% of the academics felt that as a result of their participation they were able to 'enter new areas' - meaning that it was successful in encouraging activities which would not have otherwise taken place. 54% of the academic teams involved viewed the Alvey funding as a means of maintaining capabilities which would otherwise have been cut. Very revealingly:

> …when industrial teams alone are considered almost the same percentage (46%) regarded Alvey as a means of conducting research which would otherwise have been cut. This is the case even though such work was almost invariably characterised as necessary work conducted in core areas.
>
> [Guy et al, page 149]

Knowledge sharing was explicitly encouraged between participants in the Programme. As well as contact between industrial and academic partners, attempts were made to foster exchange of knowledge between different companies and institutions working on related projects and the strengthening of a broadly based IT community. Success here was mixed - only 22% of industrial and 32% of academic teams saw the Programme as an important way of forming links within their own sector. However 64% of academic and 38% of industrial teams found it was important in establishing university-industry links, and so the Programme must have played an important role in bringing together teams in companies and universities.

With respect to the transfer of expertise and technology from university to industry the results for full collaborative projects were impressive - 59% of industrial project managers found the academic contribution critical and a further 29% found it helpful. The evaluators also found that a large number of the teams went to take part in other national and international collaborative research projects such as ESPRIT II.

Some practical problems with collaborations were noted. 26% complained of lack of interest among collaborators, 43% of general collaborative overheads and 42% of the involved nature of the IPR agreement process. 56% of the academic teams reported that changes affecting collaborators had affected project progress.

The production of directly marketable products was not the main aim of most of the work carried out - the emphasis was on research rather than development and relatively few patents were granted. Only 14% of projects produced marketable products directly. Many projects were designed to improve the skills of project staff and gain familiarity with new tools and techniques. 17% of firms reported the regular use of project results or outputs by their production or business units - a figure significantly lower than expected. Again, internal corporate restructuring or change of strategy during the lifetime of the project was identified as a major factor acting against exploitation of results. The Japanese Fifth Generation project was oriented more towards skill development across design, engineering and manufacturing as well as research and therefore included a much greater emphasis on product production. These figures support the suggestions made in section 4.1.1.2 that progression from research to development is a very complex process.

All IPR from joint projects was vested with the industrial partners. This was criticised by the evaluators as causing delays and restrictions on alternative channels of exploitation without seeming to provide the desired automatic commercialisation of results by the industrial partner. This policy was

> premised on a model of pre-competitive research which anticipated an eventual split as participants ran to market with rival products. In reality this rarely occurred. Instead exploitation routes were often interdependent. In such instances effective exploitation was sometimes compromised and restrained by inappropriate IPR agreements.… exploitation itself will often be a collaborative activity. Complementarity in R&D often carries with it the implication of complementarity in exploitation.… there could be an argument for an expanded role for government in order to safeguard the original investment in R&D.

One very interesting finding was:

> The organisations which best met the aims of strengthening the UK IT R&D base were not those which succeeded at exploiting Alvey outputs in commercial settings. Organisations which performed well in terms of research tended to conduct their Alvey work in relatively autonomous research environments e.g. with projects sanctioned by R&D management rather than by higher management, and on sites separate from production units. In comparison, organisations successful at using and exploiting Alvey R&D in production settings and the market place were those which had developed tightly formulated, business-driven strategies linking their Alvey project portfolios. Organisations which had not linked their Alvey projects either together or to in-house research did not perform as well in terms of exploitation.
>
> [Guy et al, page 169]

Their data make this point very strongly. Expressed in terms of classes of project aims, research based projects worked very much more successfully when isolated from management both physically and in terms of budgetary control. In contrast product driven projects were far more successful when strategically linked to other Alvey and in-house development projects.

#### 2.2.2.4 Other Initiatives of the 1980s

There was no large scale national successor to Alvey, and the government decided not to go ahead with a planned follow-up programme which would include increased stress on exploitation of its results. A general shift in government policy led to a move away from the idea of state support for near market research, this was expressed in the 1987 White Paper *Civil Research and Development*. At the same time the DTI, responsible for industrial initiatives, began to switch its resources away from direct grants to companies and the targeting of technologies as a means of supporting innovation and towards the more general encouragement of technology transfer and collaboration. In 1984/5, 70% of its funding in this area was directed towards particular companies, by 1988/9 this had fallen to 35%, with 40% of its funding directed towards 'non-project' activities such as technology transfer, training and consultancy. [Clement et al].

Its **Joint Framework for Information Technology** (JFIT), administered with SERC, included during the early 1990s many areas of support related to computer science, including Advanced Information Technology (including Knowledge Based Systems, Software Engineering and

Human Computer Interface work), Open Systems and Manufacturing Intelligence - the application of knowledge based techniques to manufacturing industry.

The DTI's new policies included a commitment to regionally based activities, one result of which was the establishment of a number of Regional Technology Centres. These were charged to:

- Co-ordinate and encourage the flow of technology between higher education institutions and local business, particularly small and medium sized enterprises.
- Maintain databases of technology transfer opportunities
- Provide training in the introduction and management of technology
- Develop access to national information on new technology which may be of particular benefit to local industry.

[Clement et al]

An explicit exception to the general ban on support of near-market research was the **Small Firms Merit Award for Research and Technology** or SMART programme, run by the DTI. SMART was conceived as a means of overcoming some of the problems faced by innovative start up companies. They are unlikely to be able to generate revenue rapidly enough to pay for the development of new products and so require injections of finance, but have great difficulty obtaining this support from private investors - not least because overheads are disproportionate for small investments. It was inspired by the American SBIR programme, and made funds available to small firms, with fifty or fewer employees, which had been vetted to make sure that they were suitably innovative and likely to succeed from a business viewpoint. Between its launch in 1986 and 1994 a total of £66 million had been spent in support of more than 1,000 companies. Evidence also exists that firms which raised money in this way were better able to gain additional funding from venture capital sources **-** see [Moore and Garnsas]**.** A companion scheme, Support For Projects Under Research (SPUR), which was launched in 1991 provides support to medium sized companies.

The DTI's main involvement with research came through the **LINK** programme. LINK was set up in 1988, and is a framework which involves a number of programmes, each of which lasts for around five years and is run by a committee of industrial and academic members which sets priority areas for research and evaluates bids. Individual projects involve consortia including at least one industrial and at least one academic member, and support is focused on longer term and pre-competitive projects rather than development work. The government provides 50% of the total cost, with the industrial partners providing the rest. One of the broad areas in which programmes are conducted is 'electronics and communications', and a significant number of projects have involved the participation of university computer science departments. Intellectual property arrangements are negotiated between the partners. By 1993, a total of £200 million had been distributed, of which £70 million came from the Research Councils' budgets. Lead responsibility for the programme was later transferred to the Office of Science and Technology.

The CASE awards for cooperative work by postgraduate students, and the setting up of Interdisciplinary Research centres, though initiated during the 1980s, are described in the next section.

A well publicised report produced by the *Centre for the Exploitation of Science and Technology* - a body set up in 1988 and funded by government and industry - recommended that a network of **Faraday Centres** should be set up, modelled on the German Fraunhofer - a network of 46 specialised institutes with a budget of around £400m. The Fraunhofer is funded roughly equally be local government, federal government and industry, and works on contract research with industry, particularly small and medium sized companies. Most of the institutes are headed by professors, and research students spend time there working on industrial problems - one of the advantages of this approach being the enhanced movement of people and their ideas and expertise back and forward between industrial and academic sectors. Although the Fraunhofer continues to be a widely discussed model, the investment required deterred the government from implementing the proposed Faraday Centres, which were rejected in late 1992 - though the philosophy behind them is intended to inform general policy.

European science and technology objectives are set via a series of **'Framework'** programmes which establish goals and allocate funding over a four or five year period. These goals are pursued via a number of complementary programmes, many of which include an IT element - for example AIM for informatics in medicine, RACE for advanced communications technology and DELTA for the application of IT and telecommunications to education. European policy is that the results of Framework research should be available to all members of the community. Britain has been successful in attracting European funding - receiving around 20% of all European research contracts by value during the 1987-91 period according to [HMSO 93].

For collaborative IT research, the most important European programme of the mid 1980s was **ESPRIT - the European Strategic Programme for Research in IT**. ESPRIT was initiated in 1984, and was intended to be industrially led - with projects funded equally by the EC and the partners composing the project consortia. Each consortium needed to include partners from at least two different states, and it was hoped that collaborative research would avoid needless duplication and allow longer and larger projects than would otherwise be possible, and also lead to better adoption of technical standards such as OSI. ESPRIT had a high rate of participation from large firms - 47% of all contracts were awarded to firms with more than 5,000 employees.

According to [Hare, Launchian & Thompson], page 64, main benefits recognised by participants were International Collaboration (81%) and Industrial/Academic collaboration (71%), but only 26% cited a major change to their R&D direction. Major drawbacks were Overhead Costs (67%) and Bureaucracy (45%). One advantage of the scheme from the viewpoint of participants was a degree of flexibility in the definition of project areas, allowing bids in areas of particular interest to the participants. Expenditure was around 400 million ECU annually.

ESPRIT was continued with ESPRIT II and ESPRIT III. At the time of writing, bidding is underway for a further round. Far more participation by academic institutions as project partners has occurred than originally planned - they had originally been expected to take part principally as subcontractors. In 1989 an office was established with special responsibility for university-industry technology transfer. The ESPRIT model has also given rise to a number of other programmes in different technological areas. Comments from participants in this project (see 4.4.3) suggest that for many of the academic groups involved the financial motivation was far more important than any of the benefits of collaboration intended by the EU, and that considerable cynicism exists as to its overall success.

Another European programme initiated in the 1980s was **EUREKA.** Originally conceived as a response to the apparent boost given to American technological research by the SDI programme it began as a purely intergovernmental agreement in 1985, but expanded its scope considerably and by 1992 had a total value of around 8 billion ECU - similar in scale to the entire Framework programme and accounting for around 2% of total EC R&D activity. It was industrially led and dominated by large firms. Attempts were made to expand the range of contacts known to the collaborators, and proposals were circulated to encourage additional members to join the consortia which occurred in around one third of all cases according to [Peterson]. This also suggests that although EUREKA allowed small and medium sized enterprises to lead projects which would not otherwise have been possible, it paid insufficient concern to non-financial input such as guidance with IPR terms and its effectiveness was compromised by political considerations which led to poor integration of different national initiatives and of Framework basic research, and prevented it from being as focused on near-market activity as was intended.

#### 2.2.2.5 Science Parks

Large corporations are not the only kind of company which are involved in university work. Great faith has, particularly during the 1980s, been placed in the potential of small, innovative companies to generate wealth through technology exploitation. The growth of the biotechnology industry has already been mentioned, but the clusters of companies working in a variety of areas which developed around MIT and Harvard on the east coast and Stanford on the west acted as an inspiration for a number of developments designed to foster such growth areas.

A large number of science parks have been established, in both the UK and US, which seek to emulate this kind of success. By the beginning of 1990, 38 parks were operating in the UK. They aim to encourage the growth of spin-off companies from work undertaken in the university and to provide a home for research units associated with larger companies. Science parks were the most visible expression of regional policies to encourage the growth of high technology companies and effective technology transfer, reflecting a 'market-led' philosophy towards infrastructure growth.

> It has become a highly fashionable way to address a group of problems: the revitalisation of declining regional economies; the need to maximise the perceived return to the tax-paying community from universities' basic research; the nurture of small hitech businesses; and, finally, generally to foster technological innovation.
>
> [Bower, page 94]

Obviously, whilst the existence of such a park and any attached subsidy might play a part in attracting existing businesses and encouraging new ones, it cannot work miracles. If the park is associated with a well known and highly successful institution with strengths in science and engineering then it is more likely to succeed, likewise if a significant local community of innovative companies also exists then the aim of creating a 'critical mass' of high-technology industries capable of significant local economic activity is more realistic.

> These have been notoriously difficult to finance and sustain, and have in fact generated relatively few new long-term jobs. The new growth areas - the Silicon Valleys or Glens - of this world grew by a strong combination of a regionally rich concentration of innovative technological expertise and significant defence-related R&D for the state.
>
> [Webster, p. 75]

A survey published by the government suggests that science parks have enjoyed some success in meeting their objectives. In 1987 there were 412 firms located on the parks, employing 5,300 people - by 1992 this had risen to 1,188 firms employing 19,992 people - still not a very significant number on a national scale. By comparing companies located on the parks with those of a similar make-up in off-park locations they concluded that they were more likely to employ scientists and engineers, made more use of university facilities and enjoyed more rapid growth. Most of the growth was concentrated in a handful of firms - in a sample of 251 the 5 most rapidly expanding accounted for 69% of the overall growth. However, there was no evidence that the science park companies were more likely to perceive themselves as being more technologically sophisticated, they were no more likely to expand their operations from services and consultancy into product based activities and manufacturing and they were no more likely to be visited by representatives of local institutions of Higher Education. [Westhead & Storey]

### 2.2.3 RECENT DEVELOPMENTS

The initiatives and policies described above were motivated to a considerable extent by ideological considerations. The Thatcher governments had a commitment to the idea of small business as an engine of general economic development which has proved misguided, and also placed faith the emergence of a post-industrial ‘Information Economy’ based almost entirely on service industries which would replace wealth based on manufacturing. Whilst some political capital was placed in the development of IT, support for industry and technology in general was sporadic and unfocused. The government was often accused of borrowing ideas and initiatives from other countries and failing to fund them at a realistic level or of implementing without the necessary surrounding framework needed to make them successful.

The formation of a central **Office for Science and Technology** following the Conservative victory in the 1992 elections gave rise to a flurry of government activity in the field of science policy. The office was headed by a **Minister for Science** - initially William Waldergrave, holding a cabinet position as Chancellor of the Duchy of Lancaster (a post essentially without portfolio). The effective transfer of responsibility for science away from the Department of Education and Science was intended as a general signal that the government was committed to science. As discussed below, the new overall framework also sought to integrate a number of ongoing schemes and policies initiated previously. These developments parallel the moves already noted in the US towards an overall policy for technology and research - though in the UK the executive has far more ability to set and to enforce such a policy.

> **NOTE:** Since the completion of this report in June 1995, the OST has been placed under the control of the Department of Trade and Industry. The move was an unexpected part of a government reorganisation following John Major’s re-election as party leader, and has given rise to further disquiet amongst the scientific community. It seems certain to strengthen further the government’s emphasis on links between industry and research and the primary importance of wealth creation as the function of research. [The Guardian, July 21 1995]

As in the US, defence spending has fallen since the end of the cold war, but still represents the most important single category of overall government R&D. In 1991/92, total government spending on R&D was £5.3bn, of which defence counted for 44.3% - almost down to its level in the 1980. [Levene & Stewart]. Compared to the American totals, it can be seen that R&D spending on defence, whilst higher than that of most developed countries, remained lower as a proportion of overall R&D than in the US. Military R&D, funded by the MOD, is projected to fall by about a third by the end of the century. The bulk of this reduction is in development - though a 15% fall in spending over five years from 1993 is projected for the Defence Research

Agency which conducts almost all of the MOD's research. The proportion of R&D work for which tenders are invited is to increase significantly.

#### 2.2.3.1 Changes to the University System

The reappraisal of science and technology policy coincided with a major reorganisation of the university system itself. The distinction between universities and polytechnics was removed, and without exception the former polytechnics rechristened themselves as universities. The University Funding Council became HEFCE - the **Higher Education Funding Council of England.** This reorganisation meant that the same funding mechanism was now applied to all institutions - and so former polytechnics were now theoretically free to compete on equal terms with universities, whilst less successful universities would loose any advantages.

The change provided one motivation for an increasing selectivity in research funding - with the number of universities suddenly increased from 51 to 85 it was clearly no longer possible to fund each one to conduct research in a full range of fields. In 1992 the system of research funding was altered, so that universities no longer received any automatic support based on their student numbers - completing the trend away from uniform funding begun in 1986 with the first Research Assessment Exercise. The assessed quality of their departments' research became the sole basis of the calculation. The emergence of an effective 'premier league' of around a dozen elite research institutions, outside of which large scale research activity is concentrated only in departmental pockets of excellence, has been accelerated by this change.

During the early 1990s the government imposed an expansion of the number of students in higher education by making a number of alterations to the formula by which universities received funding for the tuition of students. The number of students in higher education increased from 261,900 in 1988 to 436,200 in 1993. [Economist, 24th September 1994] At this point it became apparent that the government's target of one third of all school leavers going into higher education - originally an ambition for the year 2000, had been reached early and the expansion policy was reversed. Caps on student numbers were abruptly set for each institution.

The result of this expansion was a very significant strain on university teaching resources, including faculty time - imposing further stress on staff trying to combine teaching and research duties and accentuating the emerging division between teaching and research. In addition to the sharp rise in the number of students, which occurred in well established as well as newly designated universities, the decline in teaching funding paid to the university per pupil continued - between 1980 and 1994 it dropped by around 30%. [ibid.] The rise in numbers of mature students and part time students has been disproportionately large, particularly within the former polytechnics. The government incurred widespread criticism for its lack of a coherent long term policy for the expansion of education - with the sudden shifts in policy and ad-hoc nature of funding shifts making, making longer term planning almost impossible and perhaps even undermining the kind of increasing specialisation amongst universities which the government had hoped to encourage.

For the first time, formal government assessment of **teaching standards** across the system has been introduced. During the first round of assessments, during 1994-5, categorisation was made into one of three bands and the results held only very minor direct implications for funding. However, it is widely expected that the importance of the exercise will increase substantially over coming years and a degree of selectivity comparable to that in the funding of research may emerge.

The long term result of these changes seems likely to be an increasing specialisation of universities, with the elite research institutions becoming increasingly less focused on undergraduate teaching whilst the former polytechnics look for an advantage over older universities by providing teaching more efficiently and in a more focused manner. Many established universities, including a number of the traditional civic universities, may be forced to move away from their traditional mix of teaching and research.

One university which has considerably strengthened its position in the last decade is Warwick - the most successful of the 'New Universities' founded during the 1960s and the only one to appear in most lists of prospective elite institutions. More than half their revenue is derived from business in one form or another. Many of the smaller universities from this era, with records of excellence and innovation in more specialised areas, such as Sussex and East Anglia, are eager to make sure that they maintain strong niche positions.

The most rapidly expanding of the former polytechnics has been DeMontfort University, growing from 8,000 undergraduates in 1987 to 25,000 in 1994. [The Financial Times, 9th November 1994] They have been at the forefront of move towards aggressive advertising campaigns to attract students, and have modelled their management structure on that of a corporation, with an emphasis on executive and managerial skills at the highest levels and a minimal hierarchy. Cost centres are clearly defined and coincide with academic divisions, all of which have their own targets which must be met. Efficiency is paramount, and whilst cross subsidies do occur they are transparent and must be justified.

Like many of the former polytechnics, they have always had stronger links with the local community and with local business than have most universities. At the other extreme, institutions have been experimenting with distance learning, for example Herriot-Watt's business school has grown to be the third largest in the world in terms of student numbers through its reliance on computer based teaching and communications techniques. [Financial Times, 21st April 1994]. Professional education via short courses and industrially oriented Masters qualifications has been another general growth area.

#### 2.2.3.2 Realising Out Potential - The 1993 White Paper

The most important result of the general review of science and technology policy undertaken following the appointment of a Science Minister in 1992 was the 1993 White Paper, *Realising Our Potential*.

> 'The decision for the Government, when it funds science, as it must, is to judge where to place the balance between the freedom for researchers to follow their own instincts and the guidance of large sums of public money towards achieving wider benefits, above all the generation of national prosperity and the improvement of the quality of life.'

It suggests that this can best be achieved by a concentration of funding in areas of strength in science and technology of what is claimed to have been a consistent growth in real terms of investment in the science and engineering base. Every year a **'Forward Look**' is to be published by the government, which as well as including statistics relating to current funding is to include updates to science and technology strategy.

**HEFCE** is confirmed as the major source of money for basic research. Although the size of the research component of the grant received by a university depends on an evaluation of the quality of work undertaken by each of its departments, funding is supplied as a block grant to be distributed within the university as it sees fit.

> Increasingly there will be specialisation between countries. We need the capacity to maintain flexibility and an ability to understand the achievements of research leaders elsewhere. In some areas we ourselves will lead. But the UK cannot hope to stretch its intellectual or financial resources in an attempt to support work over the entire area of every research field.
>
> [page 25]

The Research Councils are to take account of the needs of their ‘customers’ in government and industry. The potential for uptake of research results by these users is an important criterion for distributing funding, and targets have been set for the employment of senior staff within the Research Councils from industry. The Research Councils will only support basic research in areas vital to the achievements of their missions.

The **training of postgraduates**, another responsibility of the Research Councils, is also refocused - PhD students are required to begin their postgraduate work with a Masters degree and - given that most cannot expect careers within universities - an increased emphasis on the applicability of their training to industrial careers is stipulated. Similarly, concern is expressed over the high proportion of research staff on short term contracts, most of whom have no prospect of a longer term appointment. To address this better career structuring and guidance are proposed, together with a shift of funding towards Research Fellowships rather than Research Assistantships for promising young scientists and extra support for researchers between projects.

A high profile is given in the White Paper to technology transfer. This is recognised as including a general diffusion of know-how and expertise between sectors and institutions, as well as more formal ventures. The White Paper initiated an exercise known as the **Technology Foresight Programme**. This was described in [Clement et al] as

> looking to the medium to long term, selecting and supporting areas of research considered most likely to produce winning products for British industry. The programme is intended to give early notice of emerging technologies by bringing together scientists and industrialists best placed to assess the significance of technology trends and market opportunities.

The Programme began with the identification of a number of strategic sectors, each of which is receiving its own assessment. A panel collects opinions from a wide range of experts and conducts a consultation process, from which emerge documents identifying key technologies within these sectors which

- have real scientific promise,
- strong research groups are able to carry out research in, and
- companies are willing and able to exploit results relating to.

The approach thus combines the ‘science push’ of strong research capabilities and the ‘demand pull’ of industrial interest and capabilities in the evaluation of strategic areas of support.

The results of the Programme are being widely disseminated and form a key part of the government's Forward Look publications - informing judgements such as strategy with respect to international competition and the identification of gaps and imbalances within strategic areas.

#### 2.2.3.3 EPSRC, Its New Mission & Recent Initiatives

An immediate result of the change of emphasis has been the restructuring of the **Research Councils**. A reorganisation which included mergers in some areas and the establishment of new councils responsible for others saw responsibility for IT and Computer Science funding pass from the defunct Science and Engineering Council (SERC) to a new Engineering and Physical Sciences Research Council (EPSRC). The new body remains the largest of the Research Councils and has an overall budget of around £350 million. Another structural change was the appointment of a single Director General of the Research Councils within government, and the incorporation of the former Advisory Boards formerly attached to the Councils within the new Office.

A booklet produced by EPSRC to explain its mission clearly reflects the new governmental agenda. Headed *'Research and Training for Wealth Creation'*, it places particular stress on the need for partnership between industry and the 'research base' and the nurturing of interdisciplinary work.

> This, then, is the mission which the Government's Office of Science and Technology has entrusted to... EPSRC: to stimulate, facilitate and manage training, in the fields of engineering and the physical science, in such a way that industry makes the best use of the UK's research base and the research base attunes itself to the needs of UK industry.

The booklet does, however, stress the need for continued fundamental research - pointing out that wealth may result from unexpected sources and that basic research underlies more profitable undertakings. EPSRC is also responsible for the allocation between institutions of governmental support for postgraduate students and its 8,000 studentships support the vast majority of British research students in its fields.

> On the one hand, it is important that students develop the skills that industry requires, but it is equally important that they are trained to become a human resource in engineering and science that can both anticipate requirements before they arise, and blaze a trail of innovation....
>
> In the past, grants and studentships were roughly divided between purely curiosity-driven research and strategic (potentially applicable) research. Now, EPSRC apportions its resources both to projects that are directly related to industrial sectors, and to nurturing the health of disciplines in the research community. The shift is subtle, but significant.

Quite what the above means, in practical terms at least, remains to be seen. A statement signed by Richard J. Brook and attached to a '*Briefing for Industrialists*' is clearly designed to convey an impression of a more business like approach. He identifies himself as the Chief Executive of EPSRC and refers to their Corporate Plan. His list of objectives includes the following:

- The users of the research output, in industry, commerce, government, and the service sector will have a major say in establishing priorities. These users are the ultimate "customers" of the Councils, paying for research results and trained postgraduates via the taxation system. Users will be encouraged to indicate their needs in a manner which can prompt academic researchers to redirect their research talents to national goals.

- Guided by the OST Foresight exercise, and other inputs, attention will be given to the balance of the programme supported by EPSRC so that it is in tune with the developing national research strategy.

- The EPSRC programme will be judged according to the dual criteria of excellence **and** relevance. Relevance will embrace meeting the needs of specific industrial sectors, building strengths in support of generic technologies, and sustaining the health of the core research disciplines. Applicants for support will be asked the question "who will benefit from this research?".

Changes are also underway in the criteria applied to distribute research funding via HEFCE, the other main channel for government support. Most importantly, guidelines for the next Research Assessment Exercise, due to begin in 1996 although it will cover work undertaken since the last grading, specify that published academic work will no longer be the only material considered in judging the research quality and output levels of departments. Contract research for industry, applied work and patents will all now be considered on an equal basis, and it is likely that the assessment teams themselves will for the first time include industrial representatives. This exercise will also see the number of grades used increased from five to seven, further increasing selectivity of funding.

#### 2.2.3.4 Recent Technology Transfer Initiatives

Many schemes which were already in operation are now regarded as important parts of the new overall strategy for the direction and exploitation of research. These include the LINK programme run by the DTI, the SMART scheme to support innovation in smaller businesses and the **CASE - Cooperative Awards in Science and Engineering** - scheme for joint funding of PhD students. Under this scheme the student gains a slightly enhanced bursary from EPSRC, and a further £2,000 or more from the companies sponsoring them. The company makes a further contribution of at least £1,250 towards the costs of the university department, and must host the student on-site for a portion of their study - in return they gain the chance to set the student to work upon a project of interest to the company.

Another existing initiative which is favoured by the new emphasis involves the IRCs or **Interdisciplinary Research Centres**. These are hosted by one or more academic institutions and receive some funding from EPSRC, in the vicinity of £1 or £2 million each per year, over a period of around ten years - they are also expected to secure industrial support. Each is staffed by 15 to 30 core staff, plus a number of short term researchers (20 to 40) and a number of technicians, support staff and secondees from other institutions and industrial researchers. At the time of writing eight centres were fully established, including one researching Semiconductor Materials and another working with Optoelectronics. They are intended to be internationally competitive and to ensure the application and exploitation of results by industry. See section 4.2.6 for a discussion of the growing importance of interdisciplinary work in computer science.

A new governmental initiative is the ROPA scheme (**Realising Our Potential Awards**) which provide additional funding to selected researchers - an eligibility requirement is to have attracted pre-existing support from industry to a minimum value of £25,000. A **Teaching Company Scheme** provides incentives to companies to employ recent graduates on projects of strategic importance in collaboration with an academic supervisor - various government bodies act as sponsors, principally the EPSRC and the DTI. In the field of Engineering a new qualification, the **Engineering Doctorate**, is being offered by some institutions. This includes a taught component and is designed to offer skills in areas such as project management, teamwork, leadership and communications skills, financial planning and environmental impact assessment as well as a research project - which must be undertaken in collaboration with a sponsoring company.

# 3. CENTRAL UNIVERSITY FUNCTIONS AND STRUCTURES

All of the participating universities had at least one office of which the primary function was the commercialisation of inventions made by members of the university. They had all entered into sponsored research agreements with industry, and all had a ‘development’ capability which included the solicitation of gifts from industry.

There are a number of functions relating to industrial co-operation which are usually or sometimes provided by central university offices. These are summarised in Figure 3-1 over leaf. However, a range of different patterns for the distribution of functions between offices was observed.

This chapter examines how each of these broadly identified groups of functions is handled by the institutions surveyed. Not all the functions are assigned to central university bodies in all of the institutions, and in most cases more than one of the major functionality groups are assigned to a single office. Figure 3-2 shows how these functionality groups are distributed between different offices in each of the ten institutions surveyed. The exact structures employed at several institutions are then documented for both the US and UK, together with interesting aspects of structures in place at the other institutions surveyed.

The emphasis here is firmly on organisational structure rather than procedures and policies. The latter are dealt with in detail in following chapters, but this material is placed separately in order to illuminate the frameworks behind what follows and to allow clear comparisons to be made between the structures in place at the different institutions surveyed.

**1 Corporate Development**

1.1 Cultivation of relationships with highly placed alumni within corporations.
1.2 Solicitation of gifts and grants from companies and their foundations.

**2 Industrial Liaison**

2.1 Direction of industrial enquiries to appropriate research groups.
2.2 Compilation of database or listing of university research activity and expertise.
2.3 Involvement of industry via seminars and other schemes. (*)
2.4 Broadening and deepening of existing relationships into new areas. (*)

**3 Sponsored Research:**

3.1 Advice to faculty members over possible industrial research partners. (*)
3.2 Dissemination of information regarding all forms of research support available, including government funds for industrially strategic work and joint projects with industry.
3.3 Negotiation of terms (especially re. IPR and commercialisation) in research contracts.
3.4 Administration of contracts.

**4 Technology Transfer:**

4.1 Routine screening of technologies produced by university research. (*)
4.2 Disclosure of technologies resulting from government funded research (US)
4.3 Evaluation and patenting where appropriate of promising technologies.
4.4 Licensing of technologies to commercial companies.
4.5 Assistance in establishment of spin-off companies. (*)
4.6 Exploitation of technologies through university controlled companies. (*)
4.7 Administration and monitoring of licences.

**5 Consultancy Support:**

5.1 Advice and guidance to faculty regarding terms and conditions.
5.2 Monitoring of potential conflicts of interest. (*)
5.3 Administration of contracts concluded on non-private basis. (*)

**6 Other Activities Outside Scope of Report (sample)**

6.1 Executive education.
6.2 Services and use of university facilities.
6.3 Careers service, provisions for graduate placements and work experience, etc.

**Figure 3-1: A taxonomy of research oriented industrial interaction functions sometimes performed by central university bodies.**

**NB: Those items marked (*) were less frequently performed by a central body.**

| | 1: Corporate Development | 2: Industrial Liaison | 3: Industrially Sponsored Research | 4: Technology Transfer | 5: Consultancy |
|---|---|---|---|---|---|
| **MIT** | Corporate<br>Corporate Development | Relations<br>Industrial Liaison Prog. | Office of Sponsored Programs | Technology Licensing Office | Conflict of interest policy, no central regulation |
| **Thayer School of Eng (Dartmouth College)** | (Thayer Dartmouth<br>Development | School & College)<br>Offices | (Dartmouth<br>Grants and | College)<br>Contracts Office | Thayer School<br>Dvlp. Office |
| **Brown** | Development Office (not IPR clauses) | No central management. (CS dept prog.) | Office of Research Administration (coop. with --> | Brown University Research Foundation | Disclosure to Head of Dept. |
| **Harvard** | Development Office | No central facility. | Office of Sponsored Research (not IPR clauses) | Office for Trademark and Technology Licensing. | Scrutiny, COI, etc. mostly on Faculty level. |
| **Harvard Med. School** | | | Office of Transfer and Sponsored | Technology Industrially Research | <--- Advice and Guidance |
| **Pennsylvania** | Separate office. | ? | Admin separate. Most negotiation --> | Centre for Technology Transfer | ? |
| **Yale** | Development Office | (coord.)---> CS Dept Prog. | Office of Research | Cooperative (OCR) | <-- Advice & Guidance. |
| **Cambridge** | Development Offices in University & Colleges. | Industrial Liaison and Technology Transfer Office | Negotiations and IPR by <--- (Admin separate office) | <-- coordinates. University company is legal mech. | Little formal regulation or policy.<br><-- Advice |
| **Manchester** | little activity, charity grants by --> | Research<br>(Industrial Manager) | Support Unit | University Company (Vuman)<br><-- liaise | Some contracts administered by RSU. |
| **Newcastle** | little activity, charity grants by --> | Research | Services Unit | University Company (NuVentures)<br><-- liaise | <-- Advice & Guidance |

**Figure 3-2: The distribution of industrial interaction functions between central university bodies in the institutions surveyed.**

## 3.1 OVERALL STRUCTURES AT US INSTITUTIONS

Whilst the nature of the methodology employed means that most findings are based on a sample too small to permit generalisation, this study does represent a largely complete survey of structures for industrial interaction in Ivy League universities.

### 3.1.1 CASE STUDY: MIT

MIT was the participant institution with the most extensively developed industrial ties and the one most frequently mentioned as a model by those working in the field.

MIT is unusual in having a well developed Industrial Liaison Program (ILP) conducted on a central basis - the functions identified under (2) above are all the responsibility of this office. Since 1988 the ILP has been grouped with the corporate development function (1) to produce the Office of Corporate Relations. Members of the ILP pay a sizeable fee for access to its services.[4]

The Office of Sponsored Programs (OSP) had, as the name suggests, responsibility for the mechanism by which companies sponsor research. The OSP negotiated and administered research contracts, and performed the other tasks identified under (3). An Intellectual Property Officer assisted principle investigators and administrators during negotiation and provides expert interpretation. The OSP was also responsible for other externally sponsored research, such as government contracts.

The Technology Licensing Office (TLO) was responsible for the functions grouped under (4) above. Interaction between the TLO and OSP occurred to the extent that contractual obligations regarding the exploitation and ownership of results might have been established if the research was conducted under contract. Industrial knowledge and contacts were also shared between the two offices. The TLO was staffed by people with technical and business expertise, and the legal aspects of patenting were performed by external lawyers.

To give an idea of the scale on which this relatively large office operated, the TLO employed a total of 25 people, of whom ten were Technology Licensing Officers and twelve support staff. During FY '94 362 disclosures resulted in filings for 225 patents, and the issuing of 125 patents. 83 licences and 15 options were granted, and 14 companies started. Gross revenues totalled $8.7 million, of which $6.7m came from royalties and $1.7m from Patent Reimbursement. Patent costs were $4.1m.[5]

MIT did not operate university controlled companies to exploit results, and so function (4.5) was redundant. Technologies suitable for start-up companies were identified, and introductions made to investors but no financial assistance, preferential treatment or help with business plans were given to the new company and MIT would not have been involved in its management.

Consultancies were handled on a private basis, and so no contracts were administered centrally. MIT had clear and well developed conflict of interest policies and required disclosure of, for example, equity positions in firms concluding licences with MIT. Heads of department

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[4] see 9.1.6.2 - Interview with Dr John Leech of the MIT Industrial Liaison Program.

[5] see 9.1.6.1 - Interview with Alex Laats of the MIT Technology Licensing Office and [MIT].

monitored such situations, and the faculty member would not be have been able to receive research support from the company.

### 3.1.2 CASE STUDY: DARTMOUTH COLLEGE

In many ways Dartmouth represents the other end of the organisational spectrum from MIT. It was a small, liberal arts college with a very low proportion of graduate students compared to a research oriented institution such as MIT. My research focused on the Thayer School of Engineering - a financially independent and semi-autonomous body within the College.

A single office within the college was responsible for a wide spectrum of industrially oriented functions. As well as including the activities characterised as Corporate Development and Industrial Liaison (function groups 1 and 2 above), it was also active in the placement of students in companies, the establishment of consultancy arrangements for faculty members and the writing of grant proposals. Central offices within the College itself dealt with Foundation Relations and with Grants and Contracts. The Thayer School office worked closely with these.

> The Thayer School office employs three people in its development office. The director handles major gifts and oversees generally, Mark Woodward who handles foundation and corporate relations, and a third person who deals exclusively with the 'Annual Fund'. They work together very closely - 'we have the same databases, we talk, we know who's talking to whom about what, we give each other leads....' so that someone initially approached as, for example, a member of the Corporate Advisory Board might also be persuaded to contribute to the annual fund.
>
> > 'This system - which to my way of thinking is how it should work everywhere - is hardly how it works anywhere. There are a lot of corporate and foundation relations people who are not considered to be integral with the development function in the same way that [we are], there are out there a lot of miscommunication and bad communication and just bad reporting relationships among the various sectors of development functions.... Everyone is envious of me when I talk about how we do things and I don't understand why other people don't.'[6]

Consultancy was not closely supervised or monitored. Conflicts of interests with regard to start-up companies were closely scrutinised by the Grants and Contracts office which tends to the cautious. Faculty contracts specify maximum time allowed for consultancy.

This kind of integration had an obvious relationship to Dartmouth's relatively small size. However, it appears to have led to a more integrated approach to the managing of the relationships on which these all functions depend. An interesting observation is that Dartmouth appeared to be able to deal more flexibly with companies as a result - so that, for example, when a company was reluctant to make a pure donation and sought something in return, something which they stressed is becoming very common, they were able to offer corporate education or sponsored research in return. *'Pools of money'* could be tapped from technical, public relations and advertising budgets as well as private foundations which the company might have set up.[7]

The establishment and maintenance of a long term relationship, established and maintained on a personal basis, is crucial to development - just as it is to research collaboration. The integration

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[6] see 9.1.3.1 Interview with Mark Woodward of the Thayer School at Dartmouth College

[7] see 9.1.3.2 - Interview with Peter Knox of Dartmouth College Foundation and Corporate Relations

of industrial liaison with corporate development, also noted at MIT, would thus seem to have considerable advantages.

### 3.1.3 OTHER US INSTITUTIONS.

**Brown University** differed from the other institutions studied in that its technology transfer functions were handled by the Brown University Research Foundation, under contract, rather than by an actual office of the university itself. The Foundation also plays a part in the negotiation of research contracts with industry, though the Office of Research Administration is responsible for contracts in general. Sometimes they may work with the development team if a company expects some kind of IPR in return for a donation.

At **Harvard**, the Office for Trademark and Technology Licensing is responsible for technology transfer. No central industrial liaison program exists, and sponsored research administration is in general handled by the Office of Sponsored Research, although the OTTL reviews and approves IPR terms in industrial agreements and will join negotiations when requested. The Medical School has its own office, combining responsibility for both technology transfer and industrially sponsored research.[8]

> 'This office is the office of Technology Licensing AND Industry Sponsored Research. I would argue that [the cultivation of industrial research funds] is an important activity which should be handled by the licensing office because the targeting has got to be done in science and technology terms, so you're trying to match up an interesting piece of work with a company which has an interest in that field. They don't give broad brush funding anymore, so that's an essential activity - otherwise research which might be industrially funded will never see the light of day.[9]

**Yale** vests responsibility for both industrially sponsored research and technology transfer in its Office of Cooperative Research. It has responsibility for industrial liaison programmes, which are focused on a departmental basis. Conflict of Interest emphasise disclosure and monitoring by chair of department, voluntary guidelines exist of consultancy with advice and guidance available from the Office of Cooperative Research to protect their interests.

## 3.2 OVERALL STRUCTURES AT BRITISH INSTITUTIONS

The three British universities included in the study - Cambridge, Newcastle and Manchester - represent a quite limited selection. A more exhaustive survey would include some of the other leading research institutions with substantial industrial funding, such as Imperial, Warwick, Nottingham and Edinburgh, as well as representatives of the former Polytechnics - which often have a proportionally higher reliance on industrial funding to support their research.

### 3.2.1 CASE STUDY: MANCHESTER & NEWCASTLE

As can be seen from the table, organisation and policy at Manchester and Newcastle were very similar, and can be taken as representative of the situation in the larger civic universities. In both

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[8] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

[9] see 9.1.4.2 - Interview with Peter Williams of Harvard Medical School Office of Technology Licensing and Industry Sponsored Research

cases a single body, known as the Research Support/Services Unit had responsibility for all aspects of research funding. This included negotiation and administration of industrial research contracts, as well coordination of preparations for the government's Research Assessment Exercise and applications for EU funding (much of which requires industrial partnerships). Newcastle adopted this structure in 1990 and was one of the first of the large civic universities to do so, Manchester followed in 1994.

The advantage of this integrated structure is that academics seeking funding for a project can gain advice on all possible forms of funding form a single office and in a manner which is focused on the project itself. Manchester received a total of around £28 million from HEFCE in 1993/4, grants and contracts totalled a further £39 million - of which approximately £4 million came from industrial sources. The bulk of this came from a few large awards in the medical and life science area.

As in most British universities, Development was a small scale function focused on alumni rather than the solicitation of large scale donations from companies, though the office was newly formed and its activities were to be expanded. Fundraising from charities, which did form a significant source of research funding, was included in the work of the RSU.

At **Newcastle** the industrial total and proportion was similar. Another 10% (£4m) of the grants and contracts were from EU projects, with another £3m coming from the UK government departments - much of it from the DTI (Department of Trade and Industry) and so targeted towards industry through mechanisms such as the LINK programme. The RSU undertook some general promotion work for university research, produced a comprehensive directory of research and helped academics find industrial partners in other EU countries. It also had responsibility for general industrial enquiries - these are much more likely to come from small companies.

In both cases, technology transfer and licensing are undertaken in collaboration with a wholly owned university company rather than an office of the university. The companies were also involved in the negotiation of exploitation terms in sponsored research agreements. At Manchester the company was known as **Vuman** and integration was achieve by making the CEO of Vuman head of the appropriate division of the RSU. Vuman protect and license intellectual property, they also set up companies with majority university ownership to exploit it - something none of the US institutions would consider doing. A number of other subsidiary companies provided mechanisms for marketing university expertise and facilities rather than technology.

Some consultancy arrangements were processed as agreements with the university. The university does not receive revenue, and the consultant benefits from the university's liability insurance and support with negotiation.

More than forty universities have adopted the idea of a university exploitation company, which allows universities to overcome the restrictions on trading imposed by their charitable status.

### 3.2.2 CASE STUDY: CAMBRIDGE

Because of Cambridge's long history, the organisational patterns which it has evolved are rather complex and can be confusing to the outsider. Particularly distinctive is its collegiate nature, whereby considerable power and financial resources are concentrated in the colleges themselves rather than the university or its academic departments.

As its name suggests, the Industrial Liaison and Technology Transfer Office was responsible for the functions identified as falling into these categories (function groups 3 and 4 above). It was also responsible for negotiations of intellectual property terms in research support contracts, and worked closely with the offices which administered these.

A technology exploitation company, called Lynxvale, existed. It was closely tied to the Industrial Liaison and Technology Transfer Office - the director of the former was a director of the latter. Unlike many university companies, Lynxvale had no employees and existed purely as a legal and financial mechanism. Lynxvale, rather than the University, applied for patents on Research Councils funded work and concluded licences for technology and software with other companies. The Office was also involved in assistance to start-up companies, in which Lynxvale held stakes.

The Industrial Liaison aspect of the Office's function included dealing with speculative enquiries from companies - quite common in Cambridge due to its excellent research reputation and the number of small high technology companies in the area.

Formal regulation of consultancy and other faculty activities was minimal, provided that responsibilities to the university, department and college are being met. Cambridge did not claim rights to inventions made by an member of staff unless they were directly supported by external funds - a policy shared by only a very small number of other British institutions.

# 4. RESEARCH RELATIONSHIPS

## 4.1 INDUSTRIAL RESEARCH

A corporate cost centre which funds research in a university is likely to be doing so because the results of the research are in some way valuable to it. Note that 'the results of the research' need not mean simply the analytical findings, papers and intellectual property which ensue, but may include many other things which occur as a result of the research or collaborative process itself taking place.

However, the decision to support work in a university is also a decision not to conduct the same work on a solely in-house basis by a corporate research team. In order to understand why a company might wish to support a piece of university research it is therefore first necessary to have an appreciation of the reasons why companies undertake research in the first place, and of the extent to which the same benefits may be accrued by supporting an external team.

### 4.1.1 WHY DO COMPANIES CONDUCT RESEARCH?

A distinction is conventionally drawn between basic research, applied research and development work. Basic research is held to be work undertaken without a specific non-scientific goal in mind, simply to expand the limits of human knowledge. Applied research is research towards a particular goal, and development work is the application of techniques resulting from research to produce a product which can be manufactured and sold commercially.

Basic research is often understood as the preserve of the university, and to involve such 'pure' disciplines as physics and astronomy. Applied research is undertaken in corporate labs and in university departments such as engineering and computer science. Development work is not traditionally undertaken by universities, but is the exclusive preserve of industry.

Of the three, development is the only activity which can usually lead directly to revenues for the company, though sometimes research might produce patents which can be licensed or used to create a monopoly. According to the classical, linear, model of the process the function of research within a company is to create new inventions and techniques which can then be fed 'down the pipeline' to development teams, turned into products and sold to produce revenue. In many modern markets, especially IT related fields, the continual introduction of new technologies and the improvement of processes is necessary simply to retain a marketable set of products. A high level of development activity is therefore required simply to remain viable.

#### 4.1.1.1 Basic Research in Corporations

Corporations do sometimes conduct basic research, and indeed IBM and AT&T have been well known for their scientific research capabilities and the contributions they have made to the world of science. A Bell Labs team won the Nobel prize for their discovery of cosmic background radiation, confirming the big bang, whilst an IBM group made the initial discovery which lead to a flurry of developments in higher temperature superconductors in the 1980s. Multinational petrochemical and pharmaceutical corporations maintain sizeable labs.

Such central facilities, conducting strategic and general research, complement more applied and development oriented work conducted in business divisions. Not only do they involve a very substantial financial investment, meaning that only large and profitable firms can afford to maintain them, but it is also the case that only a company with operations spanning a wide range of technological fields is likely to be in a position to make use of a significant proportion of the results of more general research. Companies like IBM and AT&T once enjoyed such dominance within their industries that they could be confident that they would be in a position to benefit from any new technologies with potential to expand their markets. They would also be better placed to exploit the advantage of being the first to introduce a new type of product. It was not necessary that they should be the only company to benefit from research in order for it to be worthwhile for them to undertake it. The further removed a piece of research is from known applications, the greater the inherent risk and the less likely the direct result of the work is to be patentable.

As suggested earlier, (2.1.2.3) the US government also had a part to play in the expansion of research and development activity among American firms.

> The rise of corporate R&D in the US had two sources, Partly it was the result of major increases in private corporate R&D funding, based on optimistic beliefs in the profitability of such investments which, by and large, turned out to be well founded. Partly it was due to massive DOD, and later NASA, investment in new systems. In the mid-60s, private funds accounted for about half of corporate R&D, government funding the other half.
>
> [Nelson]

In a paper entitled *Why do firms do basic research (with their own money),* Nathan Rosenberg suggests that the returns for the company are more likely to be in access to the expertise of the researchers than the direct outputs of their research itself. Further more

> Historically, some of the most fundamental scientific breakthroughs have come from people like Carnot, Pasteur and Jansky, who <u>thought</u> that they were doing applied research.
>
> [Rosenberg a]

Furthermore, scientific research itself is not necessarily free to access. Ostensibly, research findings which are published in a journal can be used by any one - which might suggest that the knowledge produced is now public property. In fact, the information has only been released to a relatively small scientific community, who are not only likely to be the only people to read it but may well also be the only people equipped to understand the results and their importance. A major part of every scientist's job is to keep pace with developments in their specialised field, hence the central importance of journals and conferences to scientific life. The potential importance of new discoveries is therefore only apparent to those sharing what has been called the same paradigmatic background.

By employing a scientist working in a particular area, a company thus gains access not only to his findings but to the findings and insights produced by the whole of his or her particular scientific community. Only with the benefits of such expertise can companies hope to make use the findings of research performed elsewhere. Statistical conformation of this is provided by [Gambardella] with respect to the US pharmaceutical industry, showing that the existence of in-house scientific researchers raised the ability of the firms to take advantage of 'public' science.

> Although knowledge is a public good it cannot be absorbed costlessly. Instead, depending on the type of knowledge and the characteristics of the firm, a certain level of internal R&D has to be conducted in order to create an absorptive capacity.
>
> [OST & PREST]

As well as this specialised professional expertise which is shared by colleagues working in the same field still more specialised expertise and capabilities, often known as ‘tacit knowledge’, develop as a result of carrying out research. This tacit knowledge will not be available simply from reading a short account of an experiment or procedure in a journal. If we take scientific knowledge as involving the ability to do something, it may be that important aspects of this knowledge cannot easily be formulated and passed on to others through formal mechanisms.

A well known demonstration of this is the study of the diffusion of the TEA Laser presented in [Collins]. An exciting new type of laser was produced by a Canadian laboratory, and announced to the world in 1970. With the right skills, it took no more than a few weeks and a few thousands of pounds to produce one, and so a number of British labs attempted to build their own. Despite the existence of several publications relating to the laser, successful attempts to reproduce it resulted only from direct contact with those who had been successful - via visits, telephone calls or exchange of personnel. The crucial importance of certain elements of the design became apparent only in retrospect when experience had been gained, and only those who had themselves practised the skills involved could pass them on the information in a usable form. Some labs adopted a subtle technique of not passing on important information which was not specifically requested. Many of the successful contacts were based on previous personal relationships.

> The benefits of basic research tend to be localised because they involve the transfer of tacit knowledge. That transfer process is best achieved through people working together, the implication of which is that there needs to be mobility between institutions and sectors.
>
> [HMSO 1994]

When a company allows the results of its research to be published, it does not follow that they see themselves as placing the benefits from that research in the public domain. Some inventions can be protected by patents, and what is published may only be a part of the original research.

> ‘Look at publication as a management tool... you need external validation, and all research organisations need that, to make sure that the work which is going on is world class. The fact of publication is a good way assessing your credibility, also it’s a good way of “moving the barrier”, and as a manager you can insist on certain kinds of publication.... It’s also important motivationally that the people feel that they are in a community, and that community is of course providing feedback and the flow of information and knowledge in is often much greater than the flow of information out.’[10]

Bob Anderson, Director of Rank Xerox’s Cambridge lab, provided an insight into the other functions which a lab conducting research into techniques involved in ‘next generation but two’ technologies fulfils for its parent organisation.

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[10] see 9.2.5.1 - Interview with Bob Anderson - Director, Rank Xerox Research Centre

> 'Envisionments, prototype technologies, design specifications and intelligence. What corporate research does for Xerox is to manage risk, it reduces uncertainty. All these things are outputs by which we reduce uncertainty for Xerox.... We do lots of other things for Xerox that it doesn't really often recognise it gets - we give it high visibility, we penetrate communities... we provide a certain credibility for some of its longer term envisionments and provide a "feel good factor"....'

These less obvious contributions can be very important. For example, to retain and motivate able and ambitious staff it is essential for a corporation to present a credible future strategy for continued growth and the potential for "exciting" careers. 'Corporate research provides a part of that internal credibility, and I think that's something which is often forgotten.' Equally important is the appeal to customers of knowing that their investment in the relationship is protected by corporate commitment to technological improvement.[11]

#### 4.1.1.2 The Complex Relationship Between Research and Development

> 'Until recently most academics had the concept that you watered the tree of basic research with dollars and the fruits of that tree would be inventions, and in much the same way that an apple falls from a tree, an invention would sort of fall (somehow), in rich fallow ground (somewhere) and spring forth into a new product'.[12]

We have seen that the main advantage gained by companies from conducting research (as opposed to development) is probably the development of expertise and access to externally produced knowledge rather than the generation of results of direct and proprietary commercial significance. We have also seen that in many areas of both science and technology 'tacit' knowledge, embedded in people and their skills, is essential to the use of new techniques and to the production of new products.

The idea of a linear flow, whereby an orderly and methodical progression turns the results of basic research conducted in an undirected manner into applied research, which then identifies applications which are developed into prototypes, and eventually products, is no longer generally accepted as a model for the innovative process.

> 'We used to talk about pipelines... we don't talk about pipelines anymore, transactions are one thing that we think about - the ways in which we are exchanging between groups.... It's no longer viewed in this linear way where we "see what's coming down the line" or try to "speed up the flow"'.[13]

The evaluators of the Alvey Programme identified three factors which cause a non-linear progress from research to project (and therefore make very problematic the attempt to measure exploitation resulting from a research programme.)

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[11] see 9.2.5.1 - Interview with Bob Anderson - Director, Rank Xerox Research Centre

[12] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

[13] see 9.2.5.1 - Interview with Bob Anderson - Director, Rank Xerox Research Centre

- individual end-products often owe much to a multiplicity of R&D inputs other than the discrete input being evaluated;
- discrete R&D inputs can often influence the evolution of a multiplicity of outputs, some quite directly, but many others much more indirectly and subtly;
- the flows of information, influence and impact from input to eventual output are rarely unidirectional, with many feedback steps involved in a complex, non-linear process.

[Guy et al, page 158]

The discussion of their findings in section 2.2.2.3 above, suggests that often research collaborations were regarded as valuable by both participants even though they did not lead directly to patents or products.

> 'If nothing I did in the lab ever ended up in the marketplace then people would start to ask questions, but if 90% of what I do never ended up in the market place that wouldn't necessarily be a disaster - as long as it was clear that we made the decisions and what the basis of those decisions was.'[14]

It has been suggested that research and development patterns can be categorised into 'offensive' and 'defensive' approaches [Webster]. A defensive strategy involves marginal improvements to products and the incorporation of innovative technology only where necessary to maintain competitiveness, an offensive strategy implies a commitment to the research in novel areas in search of radical new innovations.

However, the fact that a company has chosen to allow its researchers to undertake work in a particular area does not imply that it is necessarily interested in transforming whatever prototype is developed into a commercial system. The production of a prototype usually costs only a fraction of the amount needed to bring a product to a manufacturable and economically competitive state, and considerable further investment is required to market, distribute and support a new product. The company will have its own strategic direction, which will usually be driven by their desire to achieve a particular position in the market place by meeting the needs of a particular class of customer. The deployment of innovative technology is a means to meet those needs, rather than an end in itself, and the company must remember that its customers have their own investment in its previous technologies to balance against possible advantages of a new technology. As an organisation a corporation will also have made considerable investment in existing technologies.

> 'If any organisation tells you that they've got a smooth flow from research into development then they're lying to you. It's a political process... it's about negotiation, it's about getting win-win situations, making investments.... Taking a technology, no matter how revolutionary it is, and getting a development group that's made a amount huge investment in personnel and skill to accept it, if that technology actually undermines what they've invested in, is extremely difficult.... '[15]

In the computer industry, most activity seems to be defensive. This is interesting, because there is no other industry (except perhaps for fashion) in which constant change and development of products is so universal. Customers and suppliers both expect the computer power available for a

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[14] see 9.2.5.1 - Interview with Bob Anderson - Director, Rank Xerox Research Centre

[15] see 9.2.5.1 - Interview with Bob Anderson - Director, Rank Xerox Research Centre

fixed price to double in less than two years, and outside the most specialised of markets no particular version of a product has a life of more than a few years, whilst software must constantly be updated to support new operating systems, customer demands and integration with other systems. Despite this constant change, it is rare for a system offered by one manufacturer to offer capabilities which differ radically from those offered by other vendors, and rarer still for such features to remain unique. Especially in commodity markets, such as the PC industry, technologies (hardware and software) only become established if supported by most of the major players. In many fields industrial consortia, and sometimes international standards groups, play a key part in defining progress.

Computer products are therefore the embodiment of a complex web of different technologies. Whilst constant improvement to designs is required to maintain the performance and power improvements expected, there is much less scope to introduce new kinds of product if these might be incompatible with existing systems. The industry has its own momentum, and seems increasingly to evolve technologies incrementally - modern PC architecture is a hugely clumsy result of a decade of gradual change. Carrying out basic research and constructing prototypes involving new technologies may give a major computer company competencies in new areas, allowing the development of products involving new technologies when the time is right, but even the largest companies can no longer control the market sufficiently to pursue an independent technological strategy. The products into which new technologies will be incorporated are hard to predict, except to some extent for discreet devices like memory and processor chips or mass storage devices where future demand for increased power, decreased size and so on can confidently be predicted. As Alex Laats at MIT commented, a company is unlikely to be seeking research collaboration to '*establish the standard for high speed computing in the year 2000 or 2005 - they're working on next year's chip*'.[16]

This impression is supported by analysis presented in [Kash & Rycroft]. They argue that shifts in the importance of different types of technology, as evidenced in the breakdown of world trade figures, shows a clear shift from simple products and processes towards complex products and processes. In 1970 simple products and processes, of the kind which can be most easily patented and licensed and the development of which may be adequately described by the linear model, accounted for 58% of world trade by value, but by 1990 this had diminished to just 12%.

The balance has shifted decisively to technologies involving the production of complex products by complex processes. Whilst these technologies often exhibit continuous innovation, changes are usually incremental and involve gradual improvements to existing products. The direct input of science, as opposed to engineering, is minimal and little university research is directly commercialised.

> For complex technologies, however, base understanding often plays little or no role in commercial success. Even when it is linked to product or process innovations, its impact may be difficult to separate from a pattern of cumulative tacit learning and the utilisation of technology provided by other sectors.
>
> [Kash & Rycroft, page 80]

[16] see 9.1.6.1 - Interview with Alex Laats of the MIT Technology Licensing Office.

### 4.1.2 THE CHANGING NATURE OF THE COMPUTER INDUSTRY

It is not just universities which have changed their attitudes and modes of operation over the last fifteen years. Many industrial organisations have undergone still more profound changes and reorganisation during the period, particularly in the IT field.

Despite the huge technological advances made over the last fifteen years, and the massive increases in unit sales, once dominant firms such as IBM and DEC have lost their stranglehold on the market. The rise of the microcomputer has seen hardware become an inexpensive commodity with very low profit margins - only now Intel commands the kind of profit margins enjoyed by IBM in its prime. In the 1970s the corporate computing market supported a relatively stable industry, improvements were steady but incremental, proprietary systems were almost universal and single-vendor sites the norm - giving rise to a stable customer base with long term commitments.

In the 1990s this has been replaced by fierce competition in every market sector, a convergence on open systems and standards and the widespread usage of heterogeneous systems involving the integration of commodity products from a range of suppliers. At the same time, software companies such as Microsoft release new versions of their products continually and vendors of applications, utilities and tools need to keep pace - with the result that the replacement rate of software, and of hardware capable of running it, have gone up as unit costs have gone down. The main areas of growth and profitability within the IT sector have been in consultancy and service provision.

Corporations have reacted to increased global competition by seeking greater efficiency, encouraged by the free market ethos promoted by governments in both the US and UK during the 1980s. Most large companies have substantially reduced their workforce over the last decade, and many have sought efficiency through the breaking apart of monolithic management structures to create smaller units better able to respond to customer demands. Often this takes the form of a internal marketplace, with different ‘businesses’ serving different customer groups (vertical integration by market) and contracting with each other to provide corporate services. ICL, the British based computing group, has moved so far in this direction as to close down its corporate headquarters all together. IBM, after recording some of the worst losses in financial history in the early 1990s, has moved in the same direction - and at the time of writing is now healthily profitable, having adapted to the loss of its former hegemony.

Because a principle goal of this kind of reorganisation is the elimination of central corporate expenditure which is not directly required to service customer needs, it is not surprising that it has mediated against the continued existence of large, central research organisations undertaking work not directly related to core products. Research funding, whether of an in-house group or an externally sponsored academic team, is now scrutinised far more closely than before. At Xerox, restructuring of relationships has

> ‘forced a closer alignment... in both dimensions. Researchers have become more concerned with knowing how business is going, but the business themselves now realise that they are dependent on research, and since they are paying for it... they ask questions like “How can I make sure that the investments I am making are the right investments for me to make.”[17]

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[17] see 9.2.5.1 - Interview with Bob Anderson - Director, Rank Xerox Research Centre

Of course, this theoretically also opens potential opportunities to universities if they are able to show that a contract with them represents better value for money than the employment of an internal team to conduct a particular piece of research.

> 'In places like Digital and IBM there are two conflicting forces at work - one is a very strong pressure to contain costs in the short term, the other is the sincere realisation of top management that the only hope of these large companies of surviving is to discover these high-overhead applications and to be in that market before everyone else is. On the one hand research is expensive and hard to evaluate - but if you don't do research then basically you're going to end-up building washing machines. The profit margins on building PCs are so razor thin that you can't support a company of the size of Digital or IBM. Research is at least touted as being the best way to do this - whether it is or not is somewhat mysterious.'[18]

This is part of a more general trend towards the 'outsourcing' of as much peripheral activity as possible, motivated by the idea that a company will function most efficiently when it is able to concentrate on those aspects of its business in which it has the most unique expertise and is thus best able to 'add value'. Tasks such as building maintenance, administration and support of computer systems and component production can therefore be transferred to contractors and suppliers of one kind or another, leaving the core organisation smaller and more adaptable. If misapplied this process has potential to weaken a company's ability to conduct long term research. A similar move to a 'profit centre' organisation occurred within the chemical industry during the 1960s and 1970s:

> More than ten years were needed for the most vigorous companies to realise that profit centres were destroying one of the strengths of the chemical company as an institution of technological change - namely its multiproduct character which allowed for the cross fertilisation of technologies and the diversion of some cash flow from prosperous to problematic and emergent sectors... Another common corporate policy was to seek growth and diversification by acquisition of small companies... that policy proved largely unsuccessful as the smaller parties could not impose their technological goals on the established and still thriving corporate technological traditions of the parents.
>
> [Achillandies et al, page 30]

Against this background of globalisation and widespread discussion of the 'virtual corporation', much attention has been focused on the places within such a network where 'added value' is produced. On a national level, is the most benefit derived from housing a corporation with most of its manufacturing overseas, or from hosting the manufacturing capabilities of a foreign owned company? If a company places research centres overseas in order to benefit from local expertise, are they benefiting unfairly from local investment in scientific infrastructure, or are they strengthening and broadening local activities? [Sparrow] [Granstand, Håkanson & Sojölander]. Some have suggested that multinational corporations are becoming 'stateless', capable of shifting their headquarters and research facilities in order to benefit from changing conditions with as little hesitation as they already relocate their factories.[19]

Although the answers to such questions lie well outside the scope of this report, these questions have played an important part in discussions of national science and technology policy and have a direct bearing on technology transfer. It may be that in the future national expertise continues

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[18] see 9.1.1.2 - Interview with Maurice Herlihy of Brown University Computer Science Department

[19] Robert Reich, a Harvard economist and US Labour Secretary, is a leading exponent of the idea that nationality of ownership of multinationals has become unimportant.

to become more focused on particular activities and technologies - following the pattern seen in the UK over recent years.

## 4.2 COOPERATIVE RESEARCH

Industrial support for research is, across the US university system as a whole, a significant but secondary source of funding. In the US 56% of all academic R&D was funded by federal sources in 1993, down from 68% in 1980. 20% came from the institutions' own funds, and 7.3% was funded by industry - almost twice the 3.9% total reported in 1980. [NSF]

In the UK, those universities with the largest and most successful research programmes have in general been amongst the most successful in gaining industrial funding, at least in absolute terms. In some cases a rather higher proportion of research funding at universities with less activity overall comes from industrial sources. In the list below, Nottingham is notable as an institution which has improved its research standing, and industrial funding, in recent years.

Greatest Recipients of Industrial Research Funding, 1993

| | | |
|---|---|---|
| 1st | Nottingham University | £6.3 million |
| 2nd | Imperial College, London | £6.2 million |
| 3rd | Cambridge | £5.9 million |
| 4th | Oxford | £4.8 million |

Source: University Statistical Bulletin. Quoted in [The Times, 13th December 1994].

**Figure 4-1: Greatest UK Recipients of Research Funding**

### 4.2.1 THE DECLINE OF PHILANTHROPIC RESEARCH SUPPORT

Those participating in this study were unanimous in the opinion that, outside of certain specialised areas, 'pure' philanthropy on the part of corporations is no longer a significant source of research support. As Peter Knox of Dartmouth College Development Office made clear:

> 'It's really been a major shift over the last ten years or so. Whereas previously they would give unrestricted funds to colleges and universities in this country, because they just looked at education as a good thing and it was very wide open, now we find it's really a quid pro quo situation - they want some kind of payback and in most cases a direct payback, whether it's in the form of recruiting, or sponsored research as you just mentioned, or advertising - whatever they can get out of it. It makes it more difficult from a fundraising standpoint, but at the same time even at a small college like Dartmouth there is so much going on here that we are usually able to find some kind of match.'

Has the move from traditional philanthropy towards an increasing targeting of corporate funding of universities and research come about as a change of strategy within particular branches of the company, or has the change resulted from one budget being slashed and another entirely separate function expanding?

> 'It's really a mixture of both I'd say.... Many companies, as you know, have their own private foundations set up, their own private by-laws and board of trustees, set up for the express reason of giving away philanthropic dollars. But then within the corporate structure itself there's often pockets of money that we can go towards, whether it comes out of an advertising or public relations budget, or out of a technical marketing budget, or from a technical area - that's where you get more involved in technical arrangements as opposed to the straight philanthropy. We're always looking for any pool of money, wherever we can get it, but the competition for those dollars is really fierce.'

> Given the mass layoffs and harsh economic conditions, being seen as major donors might even damage companies from a PR viewpoint. Money has been directed towards local communities, 'and we've seen a switch away from Higher Education and towards some of the more basic things like the social services - and it's a tough argument to make that Higher Education is more important than these starving people'.[20]

Speaking of the work of the Development Office, Henry Lowendorf of Yale's Office of Cooperative Research said

> 'more and more people in that office will go to industry and say "we would like money for certain kinds of research", so in the past it used to be more gifts, but now it's aimed at something that companies will benefit from.'[21]

One of the main remaining areas of corporate support for higher education is the granting of scholarships for under-represented groups. Even when philanthropic funds are available for universities, their targets might not fit with the universities' own perceptions of important areas. Mark Woodward, of Dartmouth's Thayer School, gave an idea of what other kinds of priority foundations might have:

> I was at a conference six months ago at which a number of corporate foundation people gave talks.... it was amusing because each of them had their own priorities.... They all said "Our priorities are much more specific than they used to be" and they listed some. One of them - a large, well known food processing company - from the examples given seemed to limit its philanthropy almost entirely to named public spaces and facilities that had absolutely no use to the university at all except as a gathering place for students. Maybe it means something to the company to have its name on courtyards and student lounges and gazebos and fountains, but I can't imagine what.... Many of us there laughed afterwards, because we thought "How does that help us at all?". It was an example of a corporate priority that had no match to an institutional priority what so ever.'[22]

He suggested that future success in obtaining such funds would involve carefully targeting a fairly small number of philanthropic bodies and building close, long term relationships with them across a range of activities.

IBM confirmed that their philanthropy was now directed towards primary education, this being perceived as a national priority. '*Companies just don't have the money*' to give away large, open ended sums any more.[23]

Of course, as Bob Anderson of Xerox reminds us:

> Even a philanthropist does things for a reason.[24]

Companies have realised that investment of their philanthropic funds in the local community, and in areas perceived as public priorities, will bring them greater returns in terms of good will

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[20] see 9.1.3.2 - Interview with Peter Knox of Dartmouth College Foundation and Corporate Relations

[21] see 9.1.8.2 - Interview with Henry Lowendorf of Yale Office of Cooperative Research

[22] See 9.1.3.1 - Interview with Mark Woodward of the Thayer School Development Office at Dartmouth

[23] see 9.1.5 - Inteview with Hoecker & Greis of IBM US Higher Education Business

[24] see 9.2.5.1 - Interview with Bob Anderson - Director, Rank Xerox Research Centre

and public relations. Although corporate philanthropy was traditionally considerably more widespread in the US than in the UK, these comments were echoed by the British universities.

> Currently an appeal to raise £250 million is underway by the development office. However, big companies are now less likely to make large donations with no strings attached - for example whilst a company might once have established a chair in perpetuity they might now fund it for a fixed period and in a more highly specified field. In the current business environment 'just giving money away isn't always favoured, people may not like showing it on their accounts'; most donations come from trusts and from private individuals.[25]

### 4.2.2 EMPHASIS ON DIRECT RETURNS

In keeping with the shift in attitudes to philanthropy documented above, funding for sponsored research has become far more focused, and appears to be increasingly concentrated in areas where companies anticipate a direct and fairly short term payback on their investment.

Legally, gifts are distinctly separate from sponsored research. Under British law, for example, nothing can legally be asked in return for a gift, and the university is able to recover tax from a corporate donation in a way they cannot from a research contract. A similar situation exists in the US, and Garry desGroseilliers of Daimler Benz gave a specific example of how this had affected MIT's industrial liaison programme:

> 'A lot of the memberships of programs like this one at MIT were goodwill gestures on the part of the corporations. In many cases the payment came from the philanthropic side of the company. Around 1980 there was a legal ruling in the states.... that a company's philanthropic organisation could not make a donation to a university and receive a donation in return. This was considered a violation of the gift tax laws... All the memberships in this industrial liaison programme had to be converted from gifts to actual research co-operations paid for out of the research budgets of the companies.'[26]

Thus there has for some time been a necessary legal distinction between research supported by a philanthropic grant, and sponsored research undertaken with a contract. However, the latter may previously have had some philanthropic or public relations motivation, or been seen as a speculative long term investment.

For researchers in a major corporation, support of a research group in a university may once have been viewed as a peripheral and inexpensive activity. This was particularly true in equipment manufacturers, who were able to donate equipment from their own company. Maurice Herlihy, formerly a member of a Digital research group, made this clear

> At Digital, support for academic research was primarily through grants of equipment - to support a research team in a university his organisation 'needed to come up with 5% of the book value' of the equipment. The remainder was made up by a central subsidy - though as actual costs are secret the extent of the subsidy was unknown to the group, and tax-write-offs are based on the book-value. 'By and large this wasn't considered very expensive' - though it has now been cut severely. Groups supported in this way would be carrying out research relevant to that being carried out by his own group....

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[25] see 9.2.1.1 - Interview with Richard Jennings - Cambridge Industrial Liaison and Technology Transfer

[26] see 9.1.2.1 - Interview with Gary DesGroseilliers of DaimlerBenz Research and Technology, North America

> ‘If you really think it's of strategic importance then you don't give a handful of workstations to an academic somewhere with high hopes. In some senses we felt we had our hands full doing internal technology transfer. The support for academic research was viewed as a long-shot that you don't put much money into, but it was somewhere where a little bit of money could have a big pay-off.’ [27]

The general move in the computer industry towards devolution of budgetary control and responsibility to individual business groups, combined with the greatly increased financial pressure on companies such as Digital and IBM, has eroded this kind of support. IBM in the US no longer subsidised this kind of support with central funds - ‘*the people who pay for it should be the ones who get the benefit*’.[28] A similar policy applied at ICL, Britain’s most important computer company.[29]

The American academic participants were in agreement that industrial support was now far more difficult to obtain than five years previously for open-ended research without an apparent direct relation with the immediate commercial needs of the company. Steve Reiss, well known for his work on programming environments and the designer of a system licensed by Digital, complained that funding problems meant he now had one graduate student working with him rather than five.

> Computing companies have had to cut back on their research budgets - 'probably even more than the Government has - I used to have funding from IBM, Digital, Sun - now I have funding from none of the above.... There are two ways of getting industrial funds - one is to promise to do something, the other is to get them interested enough to fund basically whatever you feel like doing...’ [30]

The freedom to follow his own research agenda is what attracted him to a university career in the first place, and in his view an attempt to target the interests of companies is mitigated against by the fact that the very nature of research it is impossible to agree to build something with particular characteristics. His experience suggests that it is no longer easy to gain industrial funding simply by doing completely independent research in an area of direct interest to industry - rather something specific must be offered to the sponsor in return for their investment. The nature of these returns is something which will be examined closely in the remainder of this chapter, and in the chapter on technology transfer which follows.

### 4.2.3 THE IMPORTANCE OF GOAL ALIGNMENT

Evidence from some of the academic participants suggested that, in some fields of computer science at least, the goals of both the sponsor and the research group can be achieved without prejudice to either. It is important to remember that a research project has more than one kind of output, and so can satisfy more than one requirement. It is thus not necessary for the goals of the two parties to be identical for them to be complementary. The process of goal alignment takes place in many different dimensions, reflecting the complex concerns involved, but might be

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[27] see 9.1.1.2 - Interview with Maurice Herlihy of Brown University Computer Science Department

[28] see 9.1.5 - Inteview with Hoecker & Greis of IBM US Higher Education Business

[29] See 9.2.2 - Interview with Peter Wharton - Chief Engineer of International Computers Limited.

[30] see 9.1.1.4 - Interview with Steve Reiss of Brown Univesity Computer Science Department

visualised in two dimensions as the maximisation of overlap between a pair of partially discreet circles.

> 'What you get... is a role in how the research goes - you're helping to direct it and you're going to be the first to see the result'. This produces an environment where researchers are happy 'doing what they want to do, but with interlock between what they do and what we need'.[31]

> ‘The reality is that you do two things, you seek to latch into the things that they are seeking - you select among and align yourself with what they see as the objectives of buying external research... they’ve usually got a fairly clear idea... the alignment may not be perfect but by and large you’ve got to talk to them and thereby maximise the alignment that already exists in terms of the research that you can undertake.’[32]

Nick Carriero, a member of the team at Yale researching parallel systems, commented that *‘everyone seems to have brought into the “let’s get a little more practical” side of funding’*. Their experience was of a shift in the nature of industrial support. A decade ago, support for research in parallelism was motivated by the needs of the national laboratories for very high performance and very expensive machines. The group worked with basic research teams from these laboratories and from similarly massive corporate research centres such as Bell Labs. Industrial funding then was for general, exploratory research.

By 1994, the focus of parallelism research in general had shifted towards improvement in cost/performance ratios, to broaden the base of economically viable applications of high performance systems. Yale’s own contribution had been the exploitation of parallelism implicit in the networks of high performance workstations owned by most major research centres. The vast majority of processing time on such networks is wasted - if this can be exploited then the result is a parallel machine for the price of a piece of software. They had also moved towards projects which dealt more directly with specific styles of applications and the needs of particular kinds of user - ‘packaging’ capabilities so that they can be used easily and transparently for practical tasks.

This new direction resulted in new kinds of funding relationship. IBM became a major sponsor, and the group’s research moved much closer to product oriented work. However, this did not represent an abandonment of academic virtue.

> 'The focus has shifted dramatically from exploratory research to practical development, which from IBM's point of view allows them to say "Oh, you want to speed up your application? Well, let's try to work with Yale and we can talk with them...", and there's a much tighter relationship with business activities than we would have had with Bell Labs in the past.'

This development of example case studies allows a 'portfolio of technology demonstrations' and data to be built up for IBM's use. This relationship is symbiotic, as Yale welcome the provision of equipment and real situations for their work.

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[31] see 9.1.5 - Inteview with Hoecker & Greis of IBM US Higher Education Business

[32] see 9.2.4.1 - Interview with Tom Anderson of Newcastle’s Centre for Software Reliability

> 'We don't just want to build parallel systems and let them sit and say "Well, we've done it so let's more on to something else". We want to use them, make sure they work, achieve a certain level of efficiency, understand where the weakness are and improve them - and in the course of doing that work we will naturally develop the kinds of case studies that IBM are interested in.'

> This willingness to be involved with real 'industrial codes' is a great strength of the group in its relations with industry. Yale provides 'reasonable access' to IBM, its sales people and its potential customers - most demonstrations are internal within IBM. IBM's contribution is a 'loan of equipment' valued at over $1 million - machines, switches and resources to support them. As far as he knew, no cash was involved. IBM gets the results of the group's efforts for a substantially lower price than it would cost to duplicate them internally, and the group are doing ‘work that they wanted to do’ anyway. An agreement which provided resources for work which was not of direct interest to the group would be counter-productive.[33]

This demonstrates that opportunities exist for companies to gain a direct financial return from their participation in research, without forcing academics to do development work which is contrary to their own interests. To some extent one of the main rewards for IBM - software which provides a set of demonstration of the capabilities of its systems - is a secondary output for the university researchers themselves, who produced it in order to learn the more general principles involved but whose work would inevitably involved producing an experimental implementation on some platform.

The reason the arrangement was attractive to IBM lies in the cost advantage they achieved over carrying out an in-house development programme. Had the university team not been interested in such work, and IBM therefore been required to pay the full cost on a contract basis, it seems unlikely that this would have been the case. We thus see here a major strength of university research as its ability to leverage funding from industrial sponsors with money from other companies and from government. Furthermore it is clear that the researchers themselves felt that the quality and usefulness of their work benefited from the contact with industrial requirements.

This was also apparent at the University of Pennsylvania’s Center for Human Modelling and Simulation. The centre received funding from a large number of different sponsors, most of them governmental. Because funding in the US comes from a potentially broad and diverse spread of agencies and departments, it is possible to gain considerable leverage from each of their dozen major sponsors. Their most important system was ‘Jack’, a simulated human. Any improvements made to the system, and paid for by one of the sponsors, were available to all its users. Because of cuts in funding from many areas of government, this also had the advantage that the delays and unexpected cancellations of funding which had become common did not cause catastrophic disruption to their research. Because of the practical nature of their work, much of their military funding was coming from development and training budgets, and so could survive a major cutback in military research funding.[34] Andreis van Dam, from his viewpoint as head of a large research team agreed that a broad portfolio of sponsors was essential, because both government and industry were in the process of reducing their support for research.[35]

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[33] see 9.1.8.1 - Interview with Nick Carriero of Yale University Computer Science Department

[34] see 9.1.7.1 - Interview with Norman Badler of Pennsylvania’s Center for Human Modelling and Simulation

[35] see 9.1.1.5 - Interview with Andreis van Dam of Brown University Computer Science Department

Requirements as to the outputs of the research are not the exclusive domain of corporate funding - all research funding bodies have their own agendas. Perhaps the relative diversity of US funding patterns, as opposed to the dual support system of the UK, has given research groups more experience of dealing with different expectations. Even the NSF attaches funding to particular projects, and other agencies are becoming more strict in their specification of deliverables.

> 'It used to be that government agencies wanted to know how many Ph.D.s you produced, how many publications, how fat is the final report that you submitted, and "Oh yes, is there any software that we might be able to try". Increasingly it's turned the other way around - most of our sponsors, not all, expect that they will be able to use, literally use, the software which we produce as part of a research project. It's not so important to some of them whether we generate Ph.D.s or write papers - though if we do they like the attribution..... We have found that these are good drivers.... to codify our ideas and research in a way we might not have done previously.'[36]

### 4.2.4 ADVANTAGES AND DISADVANTAGES OF INDUSTRIAL SUPPORT

The consensus from the university side was that the different regime imposed by industrial sponsors possessed both advantages and disadvantages. The quotation from Nicholas Carriero above alluded to the potential of the relationship as a two way flow of ideas. Researchers investigating areas such as computer architecture, communications and graphics are very likely to be motivated by the demands of real world problems and to welcome input from industrial partners.

> 'active collaborations where we work with people on joint problems, and they may put in a minor amount of time and we put in a major amount of time, but it's still a two-way stream - I thank that's the best, it's even better than research sponsorship because that way you really learn from the other party.'[37]

Roger Needham, head of Cambridge's Computer Laboratory, agreed that the industrial perspective was invaluable.

> 'I think this is all good.... If there wasn't an industry concerned with making and using computers the subject wouldn't exist. It's not like physics - physics was made by God, but computer science was made by man. It's there because the industry's there.'[38]

Whilst recognising the usefulness of industrial contributions to research, Eugene Charniak, head of Brown's Department of Computer Science, suggested that another incentive was even more important.

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[36] see 9.1.7.1 - Interview with Norman Badler of Pennsylvania's Center for Human Modelling and Simulation

[37] see 9.1.1.5 - Interview with Andreis van Dam of Brown University Computer Science Department

[38] see 9.2.1.2 - Interview with Roger Needham of the University of Cambridge Computer Laboratory.

> 'One of the key reasons, from my vantage point, for encouraging industrial relations is that it means to the government that you're not some ivory tower intellectuals. That's probably the core benefit that a university gets out of industrial funding - it helps them to look legitimate. I would say that the second most important thing is that it helps them to be legitimate - and we actually do get some feel for what's worrying people in the "real world". Even if you choose not to work on those, I think you should at least be aware of what you're choosing not to work on. The last and least important benefit is the money.'[39]

Industrial money may also be more flexible, according to Charniak, because whilst a sponsor will specify the project on which funding must be used, they may actually give more freedom than would governmental sources over the way in which it is spent. Another advantage, cited by Steve Reiss, is that an industrial grant proposal might consist of one page rather than twenty or thirty for a federal proposal, and the process of making a decision and supplying resources can often take much less time than the year or more seen from federal agencies.[40]

Mark Woodward of Dartmouth's Thayer School made clear that preferences vary between faculty members. Attitudes were changing, but slowly - '*like pushing a glacier*'. Younger faculty were likely to be more open to industrial input.

> 'What we find here in this small school is that because our faculty are eminent at what they do they prefer to rely quite heavily on government funding, and because they are eminent, although the competition is fiercer for government funding they haven't seen much of a drop-off in it yet, so they haven't become convinced that they need to deal with industry more than they have done. The fact is that it's easier to get a couple of hundred thousand dollars from the government with a vague idea of where you're going with it and be set loose to follow your own agenda then it is to have a very specific contract with a company which has to be renewed every year, with time lines and checkpoints and the necessity of moving forward to a goal which that company wants over a specific period of time..... There are faculty members who enjoy that kind of challenge - that's what engineers do - but it's easy to be spoiled and over the year's we've been spoiled.' [41]

Tom Anderson, head of the Centre for Software Reliability within the Computer Science department at Newcastle University, gave an insight into the way in which corporate expectations of management practices might accompany their support for a project. Like so much else, this would appear to involve a learning exercise for participants on both sides.

> 'They impose demands that follow patterns that they insist on us working to; so they require project plans, time-scales, deadlines - very fixed deliverables, on schedule. They would criticise if these were not adhered to.'
>
> 'I think this is an aspect of what you do see from industry - that's the way industry operates in its own field and they are reluctant to accept that real research, which is what we're genuinely supposed to be doing for them, does not fit that model. What they may do is to say "Yes, we fully accept that it doesn't fit that model" and then ask you to follow the model anyway, because they have nothing else to operate with...'

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[39] see 9.1.1.1 - Interview with Eugine Charniak of Brown University Computer Science Department

[40] see 9.1.1.4 - Interview with Steve Reiss of Brown Univesity Computer Science Department

[41] see 9.1.3.1 - Interview with Mark Woodward of the Thayer School Development Office at Dartmouth

Adherence to this pattern is 'a little bit artificial for us... but it's easier to adhere to it because they don't pester us, they let us get on with the work. They don't give us as much feedback as we'd like...'. In order to gain feedback from the engineers of one sponsoring company it was necessary to build into the contract additional money to be returned to pay them to take part - although this arrangement initially struck the academics as odd, 'when you think about it, it makes sense... looked at from their perspective.' This kind of cost accounting is an example of the kind of cultural differences which exist between the two sides.

Problems had previously existed in the relationship with one sponsor due to differing expectations of what constitute appropriate management structures.

> 'You can fall into the trap of over specifying, over-stipulating, over-egging the pudding with things that are beneficial. Separate activities, ideas and ways of working when treated on an individual basis can be hard to criticise, but that does not mean that the [totality] of those things, is a good thing - indeed it can be enormously detrimental... Early on we fell into the trap of trying to do too many good things and over-managing the process... We realised that this was the case and now have a much better mechanism in place. Now when good ideas come along for us to do we say "That's a really good idea, which of the last set of good ideas are we going to drop?"... put too much management overhead in and you won't have any research..'[42]

A disadvantage of the new funding climate, in which awards of all kinds are likely to be more focused and harder to obtain, was the amount of time which must be spent by senior academics securing funding for their group's work.

> 'I have had to work enormously hard to build up my base of industrial sponsors and keep that portfolio constantly changing as old sponsors drop-out in the process of cost-cutting, and must be replaced by new sponsors. It has been enormously disruptive of my time, and I think trying to make ends meet for a reasonably sized group today is almost a full time job for whoever takes on that responsibility. I think it's a way of surviving and it's something you've got to do - you've got to have a broad portfolio, you can't rely on either government or industry because they're both downsizing and you've got to change who your industrial partners are.... It's constantly looking for opportunities - to support a group with a research lab in it you really have to be very entrepreneurial. And all that time spent being an academic entrepreneur does interfere with research, publishing and other professional obligations. Senior faculty have trouble doing justice to all that they are responsible for, including working with their students. It is not a job for those who want a calm, "scholarly" life as the layman frequently pictures it.'[43]

### 4.2.5 THE PARTICULAR NATURE OF COMPUTER SCIENCE RESEARCH

Computer science is in some senses a hybrid between science and engineering. Like biotechnology, it is a field in which the frontiers between 'basic' and 'applied' research can be very fuzzy.

Whilst there are undoubtedly some theoretical areas of computing which are not directly oriented to industrial needs, even researchers in areas such as algorithmics and complexity may produce new techniques with direct commercial applicability. Much work in the formal specification of computer systems is motivated by software engineering concerns, and many key areas, such as

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[42] see 9.2.4.1 - Interview with Tom Anderson of Newcastle's Centre for Software Reliability

[43] see 9.1.1.5 - Interview with Andreis van Dam of Brown University Computer Science Department

networking, architecture and graphics, the impetus for research is likely to come directly from practical problems. To quote Roger Needham again:

> 'Our research is pretty well goal directed - but the goals are set by us. In a lot of computing there is no such thing as basic research, excepting some theoretical areas of the subject. We do a lot in networks and communications and so forth - I would assert that there isn't any basic research in networks and communications... the statement "They discovered an important truth about packet switched networks and it's no use for anything" is just inconsistent - it wouldn't be an important truth unless it was useful for something....'

It is incorrect to assume that research which is selected by academics and pursued without the direct involvement of industry is necessarily 'basic'. In the strict sense, of being conducted without a particular goal, very little computer science research is basic though such work may often be reasonably described as 'fundamental'. This can clearly be seen in the work of the researchers described above. The teams profiled, at both Pennsylvania and Yale, were clearly performing novel and important research, they had their own goals but as a direct result of pursuing them technologies of direct practical applicability could be produced.

> 'It's very fuzzy here - because I think that very few of the students working on Ph.D.s believe that they're doing applied research - they all expect, and I believe for the most part that it's true, that each one of them is doing basic research in the sense that we don't know how to solve these problems. It just so happens that, as a by-product, when they do solve them frequently there is an application or code which actually works.'[44]

At the same time, compared to workers in most engineering subjects, a computer science researcher is probably less likely to discover something which in itself has spectacular and realisable commercial value. This is because computer systems are usually a complex product of a large number of different techniques and technologies, each of which is probably playing only a small part. (See the discussion in section 4.1.1.2). The commercial significance of the whole is far more likely to be a result of market positioning against customer needs than of a single outstanding piece of novel technology. No radical, new and patentable technique produced as a result of computer science research is likely to have a significant commercial impact in the same way that a new chemical process or material might.

Computer software can be particularly hard to categorise. Software is routinely produced by researchers, as a part of fundamental research. Unlike a traditional invention, the reproduction and manufacturing of a piece of software is trivial - if software is saleable then it can easily be physically reproduced. However, the kinds of software produced by an academic in the course of their employment are likely to be little more than crude proofs of principle - scale models of the kinds of program which might form part of a saleable system. To commercialise this requires the same kind of product oriented development, in the form of debugging, porting, interface design, integration into a larger system and enhancement as is required to go from a prototype to a commercialised product; but the point at which a program crosses the line from applied research to finished product is very hard to define. If a crude differentiation between science and technology is expected, then the status of an algorithm is problematic indeed. (Arrangements for the commercialisation of software are examined in section 5.2.4.1)

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[44] see 9.1.7.1 - Interview with Norman Badler of Pennsylvania's Center for Human Modelling and Simulation

### 4.2.6 THE IMPORTANCE OF INTERDISCIPLINARY AND APPLICATION ORIENTED RESEARCH

There is a sense in which computer science, perhaps because it is still a young discipline, is inherently interdisciplinary. Computer science research often involves the development and application of concepts developed in a range of other subjects - mathematics, engineering, linguistics, psychology and even biology. The results of computer science research often have important implications for a wide range of academic disciplines, with computer modelling, analysis and simulation techniques increasingly central to many areas of research, as well as to a very large number of different industrial activities.

Because computer science research can, as discussed above, be in some senses both fundamental and applied at the same time, much research is devoted towards particular goals. Whilst these goals may be expressed in broad and general terms, and research will usually not work to directly produce commercial products, research remains 'goal oriented' - and as we also saw above researchers in many cases find useful the stimulation of real world problems.

The general trend, from both government and industry, towards funding which is more tightly focused and motivated by a concern to address specific problems works strongly to favour the adoption of such goals. I observed in those most successful in obtaining funding a willingness to distinguish between what might be termed strategic and tactical objective. For example, for the Center For Human Modelling and Simulation strategic goals were very broad: '*to do the best job that we can do in understanding humans and simulating them by computer.'*[45] Several subgoals had been identified, each of which involved interdisciplinary work and encompassed a range of potential fields of application.

These strategic goals provide an overall framework into which individual projects can be placed. Because they are so broadly defined, tactical directions chosen can be determined by the particular fields of investigation for which sponsorship and funding are available without compromising the Center's overall mission.

> 'It never hurts to say to them "These are our overall goals, and you can help us move toward them and along the way we will provide back to you the fruits of the labour and your investment.'

The centre is fortunate in that its work has many applications, and to repay sponsors and satisfy their own 'engineering' instincts they are happy to *'turn these things into useful tools and deliver software to sponsors'*. Furthermore, within the overall strategic framework of the centre even work which is viewed by the sponsor as applied can be generalised to provide valuable findings.

> 'Applied research has a slightly different flavour... we do see this from corporates - they outline a problem to us, "Can you help us solve that problem?" and usually the problem is fairly specific and instead of saying "Yes, I'll solve your problem" my preference is to say "I'd like you to fund us to help solve a slightly more general problem of which we hope some of that you really need to solve will be a special case".... I believe that strategy (though it might just be the area that we are working in) has paid off.... We've got a lot of interesting specific problems from sponsors but have built general solutions'.

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[45] see 9.1.7.1 - Interview with Norman Badler of Pennsylvania's Center for Human Modelling and Simulation

Official status as a Center (or indeed Centre) has direct advantages, in terms of facilitating interdisciplinary or focused work and providing a high visibility to potential sponsors. According to Tom Anderson of Newcastle's Centre for Software Reliability it provides a

> 'label to hang things on... at that time it consisted of a secretary and a telephone - rather more support than the standard university infrastructure gives an ordinary member of a department.' Increased independence as a centre allows the raising of additional resources - 'secretarial support and then research staff and projects and other activities get attached to your organisation, and before you know it you have something much more substantive.'[46]

Industrial research itself has always tended more towards the interdisciplinary than has academic research, and so if universities are to attract increased funding from industry then they may need to work more flexibly in this respect.

However, powerful factors in traditional academic organisation and culture mitigate against interdisciplinary research. Promotion within a particular academic community may require a concentration of work in theoretical areas deemed to be of central importance to the discipline. Projects which span disciplinary boundaries can also be very hard to attract funding for.

> 'An example, a lot of lip service is paid these days out of Washington to so called "interdisciplinary research". It's a total fabrication. Interdisciplinary research does not exist, it is not funded from federal sources. Why? If, for instance, you were a chemist interested in exploring the behaviour of peptide mimics, and you want to explore various clever chemical things like computer aided synthesis... and you wanted to collaborate with your medical school friends just to see how useful this stuff is in an interactive way, where would you send that proposal? If you sent it to the NSF, to which you had sent all your previous chemistry proposals, the National Science Foundation would come back and say "Gee, this looks like a medically related proposal. Dear Researcher, you should send this to the National Institute of Health." You send it to the NIH, they say, "There's an awful lot of chemistry involved here, we think you should send it to the NSF because they handle chemistry." Because the reviewers at the principal basic research funding agencies are all pigeonholed in disciplines, there is no formal mechanism to evaluate an interdisciplinary research proposal.'[47]

Despite this, change is gaining momentum and a number of those interviewed felt that major readjustments in attitudes to interdisciplinary work was underway.

> 'The traditional departments which make up universities, the Department of Physics, the Department of Chemistry, these things are starting to break down anyway - and what you're replacing it with is just a big soup of people.... You work in one subject and you end up contributing to another subject - and all the time, when dealing with people in the university doing mechanical engineering and genetics and geology, all the projects that people are getting involved with are all interdisciplinary, multi-disciplinary.... I think that because computers and computer software are so esoteric they tend to permeate almost everything, so that to an extent people in the area of computer software tend to be leading this cultural change.... replacing the conventional barriers within universities with a heterogeneous series of barriers, all of which are project based.'[48]

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[46] see 9.2.4.1 - Interview with Tom Anderson of Newcastle's Centre for Software Reliability

[47] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

[48] see 9.2.6 - Interview with Peter Moforth of the Turing Institute

## 4.3 DIFFERENT FORMS OF RELATIONSHIPS AND SUPPORT

### 4.3.1 THE IMPORTANCE OF PERSONAL AND INFORMAL RELATIONSHIPS

A research relationship between a university and a company is most likely to exist primarily between a group of researchers within that company and a specific research team within the university. In the substantial majority of cases, the contact on which this relationship is founded will have occurred as a result of professional contact between researchers in the two groups, rather than as a result of an initiative concluded at a higher level.

To quote Henry Lowendorf of Yale's Office of Cooperative Research,

> An agreement is "sold" by a researcher and her work. A company comes to Yale not because of a general interest in research (although we do get that) but because there is someone at Yale doing research that is of interest to the company. The company may not be doing specifically that research at the moment, but wants a window on what happens to that research, or a company may have its own research projects going on but wants to keep close tabs on that particular investigator's work.[49]

Richard Jennings, Director of the Industrial Liaison and Technology Transfer Office, agreed.

> '[T]hey're similar people, they read the same journals, they go to the same conferences, they go to the same seminars - therefore they'll meet each other. As a result I feel that the academics themselves are very much at the leading edge of the marketing activity.'[50]

Similar statements were made by all those participants engaged in central support of sponsored research, and by the corporate representatives included in the interviewing process. This would appear to be universally agreed upon.

> 'I have found that some academics are much better than others at [sponsored research], and you learn which ones will be able to serve you the best, and those are the ones which you build a relationship with.'[51]

Sponsored research agreements are thus developed from informal and long term professional contacts between researchers. Roger Needham, head of Cambridge's Computer Laboratory, stressed this particularly.

> Informal relationships are very important, many of which involve no contractual element whatsoever. Companies have provided equipment donations 'because they thought it would be a good thing and they enjoy talking to us.' The best example of this is Olivetti - the head of Olivetti research is a member of faculty, and resources have been supplied to the Lab over a long period, most of them on an informal basis. Such donations bypass the central University mechanisms, which are based around contracts, and so do not appear on official statistics. Many faculty members have good relations with, and sometimes receive support from, various companies.

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[49] see 9.1.8.2 - Interview with Henry Lowendorf of Yale Office of Cooperative Research

[50] see 9.2.1.1 - Interview with Richard Jennings - Cambridge Industrial Liaison and Technology Transfer

[51] see 9.2.5.1 - Interview with Bob Anderson - Director, Rank Xerox Research Centre

> An Interdisciplinary Research Centre is currently being set up to research communications systems - a total of £100,000 has been raised from companies and trusts to employ a senior person to oversee its establishment. Pledges were raised on the strength of long term relationships, rather than particular contracts.....
>
> > 'If you look at formal relations, they underplay the reality. If you insist on formal relations to make the statistics look good then you're not doing anybody a kindness; and the best things are corporate friendships, where you may formally collaborate from time to time, but probably not all the time. When a collaboration is obvious then it happens.'[52]

The establishment of such contacts is inevitably a long term process. The organisation of events such as that mentioned by Tom Anderson of Newcastle's Centre for Software Reliability has the potential to be an important means of strengthening such links. Members of their 'Community Clubs', most of which were industrial, received a newsletter and attended one day events roughly monthly. Their annual three day symposium attracted around 200 delegates.[53] It seems likely that the focused, and industrially applicable, nature of the centre's work makes industrial interest in such contact considerably easier to sustain.

#### 4.3.1.1 How Important is Geographic Location?

As discussed previously with relation to science parks in section 2.2.2.5, and mentioned several times during the discussion in this chapter, contact with a local base of innovative, high technology companies is often perceived as important to the development of a supportive environment for research collaboration and exploitation.

It is clear that geographical location is much more likely to be an important factor in some kinds of relationship, and for kinds of company, than for others. Large scale sponsored research agreements are most likely to exist with larger companies, and as discussed previously to result from professional contacts between researchers. Because academic communities are international in nature, opportunities exist to forge such links regardless of geographical location, and many large companies do adopt a global view when considering the spread of their research funding.[54] Peter Williams suggested that research in Britain need not therefore be unduly handicapped by the relative weakness of British industry in many sectors.

> 'To the extent to which research in Britain continues to be four or five star rated, I think that the infrastructure argument is of secondary importance because it is a world market, and people in tech transfer offices in the UK are going to be speaking to as many American, German and Japanese companies as they are UK companies. Overseas companies are willing to invest.... if the science is good then the UK can sell it.'

As we have seen, companies are increasingly focusing their research funding on projects which are seen as providing direct benefits. Whilst this does indeed suggest that centres of excellence may gain funding from farther afield as companies look to work with the best teams available, it also suggests an increased emphasis on the company's ability to absorb and gain unique advantage from the results of the research being funded. As discussed elsewhere, in fields such as computer science effective technology transfer often requires close contact and is often reliant

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[52] see 9.2.1.2 - Interview with Roger Needham of Cambridge's Computer Laboratory

[53] see 9.2.4.1 - Interview with Tom Anderson of Newcastle's Centre for Software Reliability

[54] see 9.2.3.2 - Interview with Mike Taylor of Manchester University Research Support Unit

on the diffusion of tacit knowledge and expertise and so active collaborations will often be essential for both parties to benefit fully from their relationship. Although improved communications technology may function to make collaboration between teams composed of physically remote members more feasible, there seems little doubt that a company will, other factors being largely neutral, find it very much more convenient to collaborate with a group located within a hundred miles travel than with one on another continent. The shorter the duration of the collaboration and the more directly oriented to the transfer of expertise, the more important location becomes.

However, in some ways geographical remoteness may even serve to increase the perceived value of contact, by making an institution seem more exotic and prestigious. This is likely to be most important for institutions such as Cambridge, Harvard and MIT which are known of around the world. Even the Cambridge Lab, a major research centre in computer science and part of the country's most respected university, felt disadvantaged

> 'At the MIT Media Lab, at lot of companies - including many British companies - subscribe to fund their research without controlling what it is. You can whistle for money from the same companies if you are British, and the companies will spend money at MIT when they won't spend it here, even if they got the same thing for it. It's for the same reason that grocers sell imported delicacies - you tend to think that the thing from overseas is better.'[55]

Smaller companies are more likely to seek short term returns, and are more likely to license technology than the fund research. Technology based small companies may also employ academics as consultants, and will find local expertise more convenient and easier to locate. Small companies are, as discussed in the next section, more likely to rely on university programmes and offices in locating contacts within universities. For all these reasons, geographical location is far more likely to be a crucial factor in dealings with smaller companies. Roger Needham of the Cambridge Computer Laboratory, located amid Britain's best known concentration of innovative small companies, outlined the way in which the needs of these companies are addressed.

> 'A 'supporters club' is run for companies, many but by no means all of which are local. In return for an annual contribution, which varies according to size and wealth, members receive invitations to seminars, copies of technical reports and easy access to faculty. A mutual benefit is the opportunity given to companies to recruit students from the department - smaller companies do not have the resources to participate in the Milkround and so value the annual event where they make presentations to the students. A dinner afterwards allows the companies to form links and to do business with each other - and some formal collaborations have emerged from these relationships.'[56]

Philanthropic funds are also, as discussed in 4.2.1, being targeted far more specifically towards major social problems and to improvements in corporations' own local communities. This can work to the disadvantage of universities whose location is remote from centres of corporate activity. Peter Knox, of Dartmouth College's Development Office, made this clear while talking of the need to raise funds for a programme which gives school teachers computing and Internet skills.

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[55] see 9.2.1.2 - Interview with Roger Needham of Cambridge's Computer Laboratory

[56] see 9.2.1.2 - Interview with Roger Needham of Cambridge's Computer Laboratory

> 'It's probably going to be a very tough sell, frankly. Because we don't have a corporate base here... Ameritech would probably be more inclined to give their philanthropic dollars to organisations in Chicago as opposed to hand it over to Hampshire where they don't have a presence and don't need one.'[57]

### 4.3.2 THE DEVELOPMENT OF STRATEGIC RELATIONSHIPS

We have seen that research relationships are essentially based on personal contact between researchers in different organisations. At the same time, aspects of the relationship are handled a higher level between the two institutions. Any formal contract for research support will exist at this level, and will need to be approved by a specialist office within the university. Both sides thus face the difficult task of promoting and managing on a strategic basis what are essentially a set of personal relationships. The organisational patterns adopted by universities are documented in section 4.3.2 and their official provisions for industrial liaison in section 4.3.3.

Computer equipment manufacturers are increasingly likely to target institutions on a strategic basis, and this section illustrates some of the ways in which computer companies may seek to develop their relationships with those universities and departments perceived as being of strategic importance.

IBM North America had gone a long way in integrating its relationships with universities. Following a profound, corporation wide restructuring into a vertical integration by market structure, Higher Education was recognised as a separate industry with its own business division to deliver marketing, consultancy and support services in an integrated manner. This structure, based round marketing and relationships, provided a single clear point of contact between the two organisations.

Sixty six institutions recognised as ‘premier’ had been allocated their own designated campus executives. These were often senior people - MIT received regular visits from the Senior Vice President of Technology and Research (overall head of research) and MIT’s President was a member of the IBM board. Elite institutions were also potentially eligible for special support, such as the Shared University Research (SUR) programme which distributed IBM equipment. These formal initiatives complemented the support agreements reached directly between IBM and university research groups. Managing the overall relationship in this way also allowed coordination between sales activity and research support.[58]

ICL, Europe’s major computing firm[59], had not gone so far in the integration of their relationship with universities, but a high level group including technical and sales people met on a quarterly basis to consider overall strategy. All internal research was conducted within ICL’s business divisions, which curtailed support for academic research spanning division boundaries - in recognition of this mechanisms to pool the costs between interested divisions were being put in place. Research collaboration with universities centred on a handful of universities with particularly relevant research strengths. No formal ‘most favoured buyer’ status existed for

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[57] see 9.1.3.2 - Interview with Peter Knox of Dartmouth College Foundation and Corporate Relations

[58] see 9.1.5 - Inteview with Hoecker & Greis of IBM US Higher Education Business

[59] ICL is in fact largely owned by Fujitsu, but retains its European culture and management and remains a separate business.

universities, and until recently the supply of equipment to universities had not been a priority - though this was largely because the requirements of universities had diverged from the areas in which ICL were competitive.[60]

As discussed in section 4.2.2, reorganisations of this kind often also have the result that research groups within large corporations wishing to contribute to the support of external research groups were required to meet the full cost of the research. Because many companies are seeking to integrate their internal research operations more closely with their business divisions, the resulting narrowing of focus is still greater.

For manufacturers of computer equipment, such as IBM, Apple and Sun, grants of equipment remained perhaps the most important kind of support given to universities. However an important change of attitudes had taken place in universities, according to IBM -

> ‘A lot of universities have discovered [that when] they get a lot of free equipment from people, they end up with this huge mess that costs them more to maintain than they would have paid for it.... Because you get something for free, it doesn't mean it doesn't cost anything.’[61]

At Brown, Eugene Charniak considered this the most important form of direct support received by the department. However, the department has become far more discerning. Like any large site, a computer department can only effectively support, maintain and administer their computing resources if the profusion of incompatible systems is kept to a minimum.

> ‘[A]t one time we were really looking to build up our equipment, so we would take pretty much anything that anyone would give us. This turned out to be a bad idea because it meant that we were operating on five or six different operating systems and the maintenance people were just going nuts.... We then went to the other extreme which is basically saying that “There’s only one platform that we will allow in this department” - we obviously couldn’t expect any one vendor to give us enough machines for the entire department but we could and did try to organise a sort of competition among the vendors so that we would get the best possible deal... and that tended to work very well.’[62]

One of the attractions to the company is that students will become used to their equipment, and that when they move into industry they will therefore wish to continue using it - so developing a future skill and customer base for their systems.

> 'The general feeling... is that by providing outright gifts or steep academic discounts one establishes one's hardware product in an environment where people who are going to be future users and buyers of your equipment are going to be exposed to it, and will be predisposed to want to import it to their companies. We trade on that... I don't know if we're being disingenuous by so doing because the environment being what it is and workstations being outmoded every three to five years anyway, and the major players changing as people with new ideas come in, it's hard to know if five years down the line the people you're accepting equipment from will even be in business...'[63]

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[60] See 9.2.2 - Interview with Peter Wharton - Chief Engineer of International Computers Limited.

[61] see 9.1.5 - Inteview with Hoecker & Greis of IBM US Higher Education Business

[62] see 9.1.1.1 - Interview with Eugine Charniak of Brown University Computer Science Department

[63] see 9.1.3.1 - Interview with Mark Woodward of the Thayer School Development Office at Dartmouth

The supply of equipment to such a site thereby becomes a crucial part of the development of a strategic relationship such as that sought by IBM. In this event, the contract went to Sun. As IBM commented:

> '[T]hey made themselves such a visible target that they got all the companies involved, including IBM to offer this incredible good deal.... You won, you got the rights to basically give your stuff, but it would be all over computer science at Brown.'[64]

In general, universities were being required to provide more of the cost of equipment than they had once been. However, with the falling price of hardware, longer term considerations were becoming more important on both sides and, in keeping with the IT industry as a whole, the focus was also moving towards support and services. For IBM, the provision of a person to work with a group might be the most expensive part of a support agreement, and additional sale of consultancy and services a major area of potential profit.

### 4.3.3 INDUSTRIAL LIAISON PROGRAMMES

In section 3, a number of 'Industrial Liaison' functions were identified, including the redirection of speculative enquiries from companies towards appropriate research groups, the compilation of directories or databases of university expertise and research activity, the organisation of seminars and other activities on behalf of industrial participants and the overall management, broadening and deepening of existing relationships.

As the overall summary of different patterns of central organisation presented there showed, the provision of such activities was one area where considerable variance was observed in the sample. At many institutions, central activity was limited to the general fielding of speculative enquiries, with the central listing of research expertise becoming a priority for the British institutions. Brown and Yale both had relationship-building industrial liaison programmes specific to their computer departments, the latter being managed by a member of the central Cooperative Research Office. MIT stood out in having a major industrial liaison programme which demanded a substantial fee from the industrial participants.

#### 4.3.3.1 Case Study - MIT Industrial Liaison Program

The Industrial Liaison Program at MIT, which with Corporate Development comprises the Office of Corporate Relations, was founded in 1948. It remains the best known programme of its kind, and is manned by a number of Industrial Liaison Officers, each one of which is responsible for a focused portfolio of companies and has responsibility for staying in touch with relevant advances on campus.

Companies pay a fee which varies according to their size, but is far from nominal.[65] Around two hundred companies are currently members. The programme produces an internal surplus, some revenue is returned to MITs general revenues rather than being earmarked for particular industrially linked projects. Some 10% of gross income is returned to faculty members on a pro-rata basis in return for their participation in activities such as company visits.

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[64] see 9.1.5 - Inteview with Hoecker & Greis of IBM US Higher Education Business

[65] MIT are reluctant to reveal exact amounts, my impression is of several tens of thousands of dollars.

The fee entitles the company to use of the ILP's facilities without further charge. These include specialised information services, such as a seminar series which is free of charge to member companies - in 1994 topics included *'Designing the 21st Century Organisation*' and '*Global Communications Networks: Corporate Visions*'. A monthly newsletter is distributed which includes details of ongoing research at MIT and outlines findings and new inventions, helping to promote opportunities for research sponsorship. The ILP also produces the directory of MIT research activity, which is now organised by area of expertise to make it easier to track down faculty with particular interest, and has a role in organising faculty visits to companies and setting up meetings between interested companies and faculty members with relevent expertise - such meetings often result in consultancy or research sponsorship.[66]

IBM felt that their membership was valuable, although as a large company it used the ILP more to support relationships then to provide entirely new opportunities.

> For a company like IBM it is useful to provide another way of maintaining relationships, but 'it can be very beneficial for smaller companies that don't necessarily have the resources or the relationships, because these folks at the ILP can really help a company negotiate the MIT maze and find out where things are of interest.'

Daimler-Benz suggested that the main benefit gained from their membership of the ILP was convenience,

> 'MIT is the only university where we have a formal, established, contractual relationship.... The main reason that we have not entered into that kind of a relationship with other universities is that there are very few other universities which have the breadth and scope and importance of research that MIT has.'

> Because their office is located in Massachusetts, they can maintain a higher level of contact and have regular meetings with MIT faculty, making the agreement good value.

> 'Another reason that we do not pay other universities for this kind of access is that it's not always necessary - most universities are relatively open places, and we can call a faculty member at any university in the US, and if they are working on a project that is of interest to Daimler-Benz, and if we have people who are working on that same subject then it is very easy to schedule a meeting and to have discussions with anyone at any university in the US....'

> Even at MIT faculty members would usually be willing to talk to a representative of any major company. 'The access that we gain through the ILP is really quite general - what we get is an hour or two of a person's time to discuss to discuss a general interest in a topic.'[67]

Other participants sometimes mentioned MIT as a special case, and felt doubtful that other institutions could hope to derive the same levels of commitment from companies.

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[66] see 9.1.6.2 - Interview with Dr John Leech of the MIT Industrial Liaison Program. Also 'MIT Office of Corporate Relations Industrial Liaison Program, Executive Summary for Faculty and Research Staff'.

[67] see 9.1.2.1 - Interview with Gary DesGroseilliers of DaimlerBenz Research and Technology, North America

> 'MIT in my view is unique in all the world... even Stanford doesn't hold a candle to MIT's leading position in many developing technologies. People are willing to join their industrial liaison programme at a considerable price... and many, many, many companies are members of that affiliate programme, and they get nothing other than some glossy newsletters and the right to sit for a little time with faculty members when they come to campus and invitations to seminars which are put on specially for them, but there's no technology transfer other than discussions.'[68]

IBM considered it possible that a similar scheme might be successful elsewhere.

> Would the approach work for anywhere apart from MIT? 'If you identify a very motivated, bright group of people to do it then I think other universities could do it, but I think the less visible and the less known they are the more they have to get out there, and they might need to be more flexible about what they ask from the companies.' The best approach might be to identify corporations, work with them for a year on a trial basis and then ask them to help support the costs involved. 'Good seminars' are invaluable, to 'show companies what they're getting'.

#### 4.3.3.2 Other Industrial Liaison Activities

Although MIT's was the only fee-paying, university wide scheme in operation at the universities surveyed, both Brown and Yale had relationship oriented programmes in operation at the departmental level for computer science.

Brown's scheme is known as the 'Industrial Partners Program', and stresses opportunities for collaboration with staff and students. This offers a package of activities to the company, including a series of special seminars on specific topics involving speakers from industry - the most recent having been on the theme of '*Ubiquitous Computing*'. Other benefits include invitations to departmental seminars and colloquia, copies of technical reports and research papers, access to faculty, use of university and departmental facilities, the chance to recruit students and a subscription to the department's newsletter. Their material,[69] documented six member companies, and a basic fee of $35,000 but since my visit they have reduced the fee, finding computer companies very conscious of their expenditure. The programme at Yale had a similar form.

As mentioned previously, Cambridge's Computer Laboratory ran a 'supporter's club', and Newcastle's Centre for Software Reliability operated a 'club' for companies interested in the centre's work.

> [Relationships with firms] are strengthened through the approximately monthly events organised by the centre. These are based round 'community clubs', most of the members of which come from industry. These are mostly one day affairs, though some are longer and a three day symposium on safety systems with around 200 delegates is held annually. Club members which contribute a small 'participation fee' receive a newsletter and a discount on the cost of participating in the events - income from which is the other source of funding for the clubs. At present the clubs' income does not cover costs, in the longer term it will have to do so.[70]

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[68] see 9.1.1.3 - Interview with Bill Jackson of Brown University Research Foundation.

[69] A booklet entitled 'Industrial Partners Program'.

[70] see 9.2.4.1 - Interview with Tom Anderson of Newcastle's Centre for Software Reliability

Cambridge was the only one of the British institutions to have a separate office responsible for Industrial Liaison - both Newcastle and Manchester had integrated responsibility for the compilation of a research directory and response to industrial enquiries into their main Research Support/Services Units. The Office of Industrial Liaison and Technology Transfer does not operate a membership based scheme, and is very much smaller than MIT's operation.

General agreement existed that general enquiries regarding work underway at the university or expertise available was more likely to come from smaller companies, which do not have the same range of professional contacts available through their own researchers as do larger companies.

> 'Always, the perennial difficult question is - how do universities link with small companies? My answer to that question is rather facile, and is "With great difficulty". There isn't at first sight a natural basis for collaboration, because the small companies don't have the resources, they don't do research - they are product and market oriented and the timescales on which they act are in general very much shorter and more immediate than those on which most university research activity occurs. Having said that, it's the exceptions that prove the rule and there are increasingly high-tech companies which are more research focused and the start-ups do increasingly undertake research activities with the University.'
>
> 'In general the links are to do with specific problem solving, in many cases consultancy type activity on a single person basis. Participation in more applied student projects and things of that nature can be very effective... you can get a bright undergraduate to work on a project for a month, and somebody good... can make a very valuable contribution to a company provided the management issues are addressed. Sources of material, exchange of materials, use of equipment, use of libraries - transfer of knowledge in a very broad sense is clearly a very real thing.'[71]

### 4.3.4 CONSULTANCY AGREEMENTS

Under a consultancy agreement, an academic contracts to supply consulting services to a firm. Consultancy agreements are usually private arrangements made directly between the academic and the company involved, with the formal involvement of the university confined to possible vetting of controversial agreements and the provision of advice and guidance to safeguard the academic's interests.

Terms vary substantially between agreements. A typical agreement would run for one to three years, and involves the provision of a specified number of days consultancy, usually ten to twenty five. Some consultancy agreements may be exclusive with regard to particular scientific areas. [Harvard].

Andreis van Dam outlined the advantages of consultancy for both sides.

> 'I think it's very important and I've done it all my professional life. I started consulting when I was still a graduate student and I found it a very, very useful way of keeping anchored in reality - a source of problems and also a way of learning what the really important issues are. Plus there are a number of very smart people who you come into contact with through consulting who you wouldn't otherwise meet, it keeps you from getting in-bred.... It's also a way in which academics can afford to teach....'

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[71] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

> 'I think typically companies are looking to bring in a heavy-hitter from outside who has expertise in a particular area that they don't have in-house, or they use it to check the expertise that is in-house, but it's a way for them to get somebody on a temporary basis that they otherwise would have to hire and pay a lot of money to - temporary employment basically.'[72]

Valuable as it is, consultancy represents a considerable additional workload for already busy academics. As van Dam made clear, to discharge all his responsibilities demands a routine seven day week.

> 'If you want weekends to yourself you don't have time to consult and still be a contributing academic - you're allowed a day a week for consulting but if you took it on a regular basis, it would destroy your research and publishing productivity... if you're going to do consultancy then basically it has to come out of your spare time'

As well as providing academics with valuable exposure to industrial concerns and financial support, consultancy also plays an important part in the development and maintenance of other links, both formal and informal, with companies. A particular form of consultancy involves membership of a company's 'scientific advisory board'. Such boards are a particularly important feature of smaller, high-technology companies in fields such as computing and biotechnology.

Consultancy agreements routinely accompany technology licensing agreements (see 4.4.2). Although revenues from licenses themselves are usually shared between the inventor, the university as a whole and perhaps the inventor's department, accompanying consultancy agreements are private and income goes directly to the individual concerned.

Consultancy can also be the beginning of formal contact between an academic and a company which later results in other collaborations between them. Whilst the direct contact is between a particular individual and the company involved, their opinion of the work of the academic's department as a whole will be substantially determined by their impression of the quality of consultancy given. Good work may result in the hiring of graduate students by the company, in future research support agreements or in grants of equipment.

> 'I consult for Digital in a purely private capacity, but it's because I consult that so many of our students are taken on as summer interns in their research lab, and it's because Digital know me so well that they're lending us some equipment to use in a research project, but none of this is written down.'[73]

Whilst consultancy is clearly distinct from large scale collaborative work and strategic research, it is not always clearly possible to distinguish it from applied, contract research. At Manchester, some consultancies were processed as contracts with the university.

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[72] see 9.1.1.5 - Interview with Andreis van Dam of Brown University Computer Science Department

[73] see 9.2.1.2 - Interview with Roger Needham of Cambridge's Computer Laboratory

> Even centrally processed consultancy agreements do not generate direct revenue for the university. They are permitted and encouraged because they motivate academics and stimulate more general relationships with companies. Whilst it is not practical to centrally support very small pieces of work, some 'fairly significant' projects are undertaken on a consultative basis. Consultancy agreements can also be made directly between the individual and the company - these cannot include significant use of university time or resources. Private arrangements are carried out at the individual's own risk and do not benefit from the university's liability insurance.[74]

Even when consultancy work is very much oriented towards small scale contract development, the stimulation provided by contact with a new environment and a new set of problems may help to stimulate new ideas and lead to insights which can be fed back into an academic's work, which must remain their priority.

> 'It would be bad it we were diverted by the need to get money in this way from doing what we are good at and what we are for. It's good if you pick up good ideas from talking about industrially relevant projects, and it happens sometimes. We did some consulting the other year to do with burglar alarms which gave us some very interesting ideas and we got several papers out of it.'[75]

The expertise and knowledge for which an academic is hired have also tended to become more specific, and more related to their own current research. Consultancy has therefore come to overlap more with specific technology transfer, as opposed to general expertise transfer.

> 'It used to be that someone in chemistry would be hired as a consultant because he knew something about catalytic chemistry, and not specifically to consult on his own research. That's changed - more and more consultancy requires faculty to talk about, and give advice about and respond to questions about research very close to, or even in, the investigator's own area of specific research.'[76]

This shift produces increased scope for conflict of interest problems and ownership disputes. For example: if an invention results from this discussion, based on the faculty member's ideas, who owns it? This underlines the need to ensure that terms in sponsorship agreements do not conflict with general policies regarding the ownership of university research.

[74] see 9.2.3.2 - Interview with Mike Taylor of Manchester University Research Support Unit

[75] see 9.2.1.2 - Interview with Roger Needham of the University of Cambridge Computer Laboratory.

[76] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

## 4.4 PROVISIONS OF SPONSORED RESEARCH AGREEMENTS

As we have seen, the impetus for research collaboration will almost always come from the researchers themselves. However, the final sponsored research agreement exists between the company and the university rather than with the researchers themselves. Whilst the particular arrangements varied from university to university, all the participant institutions had a designated office with responsibility for participating in negotiations and concluding agreements.

The university offices with specific responsibility for sponsored research agreements are likely become involved some time after exploratory negotiations have begun. As Richard Tomlin, Head of Research Services at Newcastle University made clear, some academics deal with these negotiations much better than others.

> 'There's almost a triage in these things - there are those academics who know how to do it, because they've done it before. They do it well and basically they come across to us with three quarters formed projects and deals, which are essentially fine. At the other end of the spectrum there are people who turn up with something so comprehensively awful and done at the last minute that there's not really anything we can do with it... and then there's the group in the middle... of people who come fairly early on in the conception of a relationship with a company and come to talk about customer pricing and what kind of an agreement would the university look for....'[77]

The Intellectual Property Guide of Harvard Medical School contains a concise summary of the negotiating process. They emphasis that it is essential to clearly identify at the exploratory stage exactly what the goals of both parties are, what the innovative ideas of the scientists are and what they can bring to the company.

Before these shared objectives can be extended to an agreement in principle, it is essential that representatives on both sides with the power to make commitments are involved. Detailed negotiations can then take place as to the exact terms, with the whole process usually taking six to twelve months. It suggests that the following issues must be addressed for all kind of agreement, including consulting and technology licensing as well as sponsored research:

- Term of the agreement
- Exclusivity of the agreement
- Definition of the scientific or technological field covered by the agreement
- Compensation
- Publication rights
- Confidentiality of information
- Rights to, and compensation for, intellectual property
- Rights to terminate

[Harvard, page 9]

These concerns were shared by the other institutions surveyed. The three most controversial are the ownership of intellectual property, the right to publish and the need for confidentiality of information.

[77] see 9.2.4.3 - Interview with Richard Tomlin of Newcastle University Research Services Unit

### 4.4.1 ACCEPTABLE KINDS OF AGREEMENT

None of the American institutions participating in the survey were willing to conduct research which could not be published, and whilst policies were less absolute in Britain, none of the participant universities had undertaken any such research in the computer science field. Incentives for faculty to conduct such research were, in any event, limited, because academics career progression is to a large extent determined by the quality and frequency of their publications - though the British government is currently attempting to alter this by giving equal weighting to confidential research in its research assessments.

The general opinion was also that companies would have no desire to see important, proprietary research done by university teams. Some of the research groups themselves saw the potential for flexibility if the terms were right, but felt it unlikely that companies would be willing to pay enough to justify this. As Eugene Charniak of Brown remarked,

> ‘if someone waved a very large cheque in front of me I might reconsider. In my experience, though, companies don’t wave cheques that large anyway - so it’s probably not a situation that’s ever actually going to occur.’ [78]

Neither did universities feel able to carry out this kind of work.

> ‘Many companies have scaled down their in-house R&D, and that’s a bit of a worry because I don’t really want the university to be doing research which is of such central commercial importance to a company that if it goes wrong or it gets leaked at a critical moment then some major calamity is going to befall the company. Companies need to think carefully about why they are commissioning research within a university.’[79]

IBM were in agreement with this.

> 'Most companies don't go to universities and say "I want you to produce this confidential piece of work that only I will ever see" because that's just not practical.' However university may be given confidential corporate information to work with - which is itself problematic. 'The last thing I want is having some guy who spends all his time surfing the Internet having my information with no restrictions on it'.[80]

In terms of formal policy, at least, there was a distinct difference in attitudes between the American and British institutions. Harvard had perhaps the strictest policy, allowing agreements which gave the sponsor rights to see results before publication, but not before submission.

> ‘Many companies, in their proposals for industrial research, will require the researcher to submit the paper to the sponsor before they submit it for publication. That, of course, is not acceptable - not in my cases.’[81]

MIT were prepared to allow the sponsor the right to a short delay before publication, but not to allow any kind of veto on publication of the research itself. In the US, university charters sometimes forbid research which is too applied, and restrictions imposed by their legal status

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[78] see 9.1.1.1 - Interview with Eugine Charniak of Brown University Computer Science Department

[79] see 9.2.4.3 - Interview with Richard Tomlin of Newcastle University’s Research Services Unit

[80] see 9.1.5 - Inteview with Hoecker & Greis of IBM US Higher Education Business

[81] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

prohibits 'work for hire'. However, definitions of 'applied' are in practice quite flexible - usually any work for which a graduate student could be awarded a thesis on the basis of will be acceptable.

> 'It depends who is doing the defining, usually - and I know this may sound a little cynical - if a professor is employed by a company to do some research, he is apt to find that research basic or useful, and not apt to find it applied in that definition.'[82]

In Britain, attitudes were less absolute. As discussed previously, the government is keen to encourage universities to become suppliers of all kinds of research to industry. However, in the small sample of institutions and researcher surveyed, no confidential research was taking place in the computer field. The kinds of research which academics find worthwhile, and which universities are well positioned to undertake, are unlikely to be so commercially sensitive that they cannot be published.

A clear distinction was draw here between the research findings themselves and confidential information supplied by the sponsor. General agreement was observed on the part of the universities that restrictions on publishing the central theoretical results and findings of a researcher's work were unacceptable; however if the particular problem on which the research was based had been supplied by a sponsor, and so contained detailed and commercially sensitive information, then it was acceptable for the company to insist that the details of its activity should not be revealed. Providing both sides interpret this reasonably, and that the company is able make a quick decision on the release of its information[83] and does not employ bureaucratic procedures which leave researchers waiting for months or to seek excessive control over findings, then these arrangements are unlikely to prove too problematic in practice.

It is very important for there to be clear agreement over exactly what research is covered by the agreement, as well as what the exact nature of rights over that research are. Many of the institutions reported companies drafting terms so as to gain rights over research which they were not actually paying for.

> 'The key thing in all these contracts is that you define the results by what you deliver in the report to the company. That's where we have to be careful that we don't deliver results that haven't been genuinely funded by the company, because that becomes the basis for any exclusive licensing or ownership by the company.'[84]

Companies must also understand that, although a contract is being signed, the university is not actually agreeing to produce anything of use. If the utility and exact nature of the results were already known then there would be little point in carrying it out. Hence the contract can only document the area to be investigated, time and effort to be spent, procedures used and status of the results. Even the exact format which the results will take cannot be assured, and it may not be possible to give a timescale on which they will become known.[85]

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[82] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

[83] see 9.2.4.1 - Interview with Tom Anderson of Newcastle's Centre for Software Reliability

[84] see 9.2.4.2 - Interview with Nick Cook of Newcastle University Computer Science Department

[85] see 9.1.1.5 - Interview with Andreis van Dam of Brown University Computer Science Department

### 4.4.2 EXPLOITATION TERMS

Although it is not the only benefit which companies gain from sponsoring research, they are in most cases concerned to gain rights to exploit any of the results of research which have commercial value to them. These rights can take a number of different forms, and much negotiation takes place on a case by case basis, however in general the experience of UK institutions was that companies were more likely to demand ownership of research results and less likely to accept licensing of exploitation rights as a separate process. As documented in section 3, in most cases the office or company responsible for technology licensing plays a part in drafting and negotiating terms relating to ownership and exploitation in sponsored research agreements.

> 'Sponsored research has a real sharp point to it, and what I mean by that is that a company will come in, speak to a particular professor - because that professor has particular expertise in an area of interest - and enter into discussions with the professor to undertake certain set of experiments or body of work, they'll pay for that and if any inventions come from that they'll want rights.'[86]

At MIT, most agreements allow research sponsors a six month period from the identification of a patentable technology produced during the research to elect to license it, and an expression of interest on the part of the sponsoring company will often be the most important part of the decision to patent the invention. The sponsor must negotiate licensing terms in the same manner as any other company, though if they decline the chance to license and the technology is eventually licensed by a another company they receive 25% of royalties from such agreements.

Harvard took a firm stance: whilst it was acceptable to offer companies rights to see a researcher's work, there could be no guarantee than the sponsorship of research would automatically make them licensees of results. It was not acceptable for a company to

> 'establish licensing terms as conditions which are buried in the grant document; [Harvard] won't participate in that... it is inappropriate to lock in and make captive the research activity of a university laboratory. The faculty could then become indentured researchers for the companies supplying the money... the influence can become quite pervasive.'[87]

The right to be the first to negotiate is subtly different from the right of first refusal. Policies differ - Pennsylvania were reluctant to grant a right of first refusal,[88] whereas Brown and Yale appeared happy to offer the right of first refusal of a licence (in Brown's case exclusive). None of the American institutions were willing to assign ownership of the rights to the results of sponsored research to the sponsoring companies.

> 'What one has to be very careful about in that process is not ever to feel that the granting of a research contract to an investigator is a suitable substitute to payment for the intellectual property rights granted. That's why we like to keep them as separate agreements and negotiate them separately, otherwise you under collect.'[89]

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[86] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

[87] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

[88] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

[89] see 9.1.1.3 - Interview with Bill Jackson of Brown University Research Foundation.

> Whilst gratitude is expressed for sponsored research support, results of the research are 'discreet bits of technology' and the company must pay the market rate for them - 'they'll try to connect it, when you get into licensing negotiation, but it fails'.[90]

American institutions, at least those in the elite group surveyed here, seemed reluctant to give up ownership of IPR over research to sponsors under any circumstances. Some of them were actively involved in the political process to ensure that their rights to all Federally funded research, granted under the Bayh-Dole act, were not eroded.

> 'In recent years the creation of a new 'Advanced Technology Program' by federal agencies effectively counter key provisions of the [Bayh-Dole Act]. There is also another 'Technology Reinvestment Program' which, while not precluding university ownership of intellectual property, nonetheless places control of the research in the hands of the for-profit partner, and places the university in a disadvantageous negotiating position. And, there is draft legislation being considered by the US congress that would create a government-operated corporation to centralise and control all federally-related technology transfer-including, perhaps, university inventions.'[91]

In Britain, by contrast, universities seemed in general prepared to compromise on virtually any aspect of ownership providing compensation was sufficient to make the agreement appear attractive when taken as a whole.

> 'It's a cultural thing too - different countries are happy with different arrangements. In America companies in general are quite comfortable for the university to retain ownership, comfortable to have an option to license. British companies traditionally go for assignment and ownership.'[92]

Although companies can sometimes be satisfied with a right to negotiate and an assurance of 'fair and reasonable' terms, in other cases it is necessary to assign ownership or agree to a cap on royalties. The two specific things which Newcastle University were unwilling to consider compromise on were the rights to publish and the right to use results as the basis of future work -

> 'providing we can arrive at that we are happy to enter into almost any arrangement that makes both parties feel comfortable.'[93]
>
> '[IPR ownership and fees payable] are obviously linked - if the university retains ownership of all the intellectual property then one would expect the amount of funding to vary because they are not buying the results - they're buying the right to exploit the results rather than the actual ownership.'[94]

This was mirrored in the attitudes expressed at Manchester, where it was also made clear that moves toward a more definite policy were afoot. One problem, alluded to earlier, is that by the time the specialists in a university's central administration become involved, preliminary negotiations will often have taken place during which academics will have taken positions

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[90] see 9.1.8.2 - Interview with Henry Lowendorf of Yale Office of Cooperative Research

[91] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

[92] see 9.2.1.1 - Interview with Richard Jennings - Cambridge Industrial Liaison and Technology Transfer

[93] see 9.2.4.3 - Interview with Richard Tomlin of Newcastle University's Research Services Unit

[94] see 9.2.4.2 - Interview with Nick Cook of Newcastle University Computer Science Department

incompatible with university policy. Policies must therefore not just be formulated, but disseminated widely throughout the university.

> 'There's a complete spectrum here - from the sponsor claiming rights to not just what comes out of the research but everything the investigators find in the next fifty years to no rights being conceded to the sponsor. We are trying to put some policy in place - there is quite a long education job there because often the researcher has more or less agreed all the terms before he comes into the Research Support Unit... the researcher can't commit the University, but in practice the University is seen in a bad light if after something has been purportedly agreed by a researcher somebody in the centre says "No, you can't do that." We want to get all of that clear, the fact is that we are keen to see intellectual property exploited, but we are not keen to see the University exploited by industry. We want fair reward for the inventive efforts of out staff.'[95]

It is, of course, possible to set up a strong framework for future licensing terms within a sponsored research agreement, establishing principles for due-diligence and so on, but to leave discussions as to the exact rates of royalties and terms of the agreement until the results of the research become known. Because these depend crucially on the exact nature of the inventions, plans of the company and state of the market, as discussed in section 5.2.2, it is unlikely that arrangements made entirely in advance will be fair to either party.

There would appear to be a potential transfer of risk here. As the discussion in section 5.2 makes clear, most research produces no inventions worth patenting, of those which are patented most are not licensed, and of those which are licensed, most do not recover costs. These universities which have earned very large sums from technology licensing have done it from a handful (usually a single) patent which has been spectacularly successful, and in many cases is not even a product of exceptional scientific research. By allowing ownership to rest with the sponsor, agreeing caps on royalties or allowing terms to be agreed in advance, the university is selling its lottery ticket to the sponsor, rather than keeping it for itself. In most cases the rights will be worthless, and so the university will benefit from whatever negotiating advantage was gained in return, but the occasional spectacular success from which millions of pounds might result will be sacrificed.

### 4.4.3 EXPERIENCES OF GOVERNMENT FUNDED SCHEMES

As discussed previously, a variety of initiatives have been established by governments in both the US and UK to encourage technology transfer and cooperative research. Obviously a full scale evaluation of these programmes is not within the scope of this report, but many participants did mention their own experiences of these programmes and so some of these are summarised below. In general experiences seemed somewhat negative.

Although ESPRIT (see 2.2.2.4) was a major source of funding for many British participants,, and was supporting work which would not otherwise have happened, its modes of operation were not regarded as helpful.

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[95] see 9.2.3.1- Interview with Peter Schaefer of Vuman (University of Manchester)

> 'I regard it as a total a waste of time. We were in there right at the start, and we've been involved in a dozen different ESPRIT projects in one way or another, and I can't think of a single useful bit of technology we generated, or a case where we did something that led to any kind of genuine commercial business or a technology produced as an ESPRIT result actually went out and was commercially successful for Europe. The only beneficiaries I have actually witnessed are the international airlines and the hotels. I'm extremely cynical....'

The projects involved work with organisations of all kinds, including large and small companies and universities. 'I suppose we have made some interesting links, but I honestly there's any business has come from them.' However, a further ESPRIT proposal is currently under preparation. Preferred projects are those 'in the corners' of a diagram which are not reliant on the inputs of other groups.

> 'It really has to be a piece of code that you've already written, or failing that - which would be annoying - something that you had to do anyway.... You've also got to make sure that there's a member in Greece or Portugal to hold your summer management meetings and someone near Grenoble for your winter meetings - quality of life. Given the amount of money that's gone into ESPRIT it would have been far better used if people had made these projects much smaller, with a much much lower bureaucratic overhead.'[96]

Roger Needham suggested that Cambridge's experience of ESPRIT had been similar.

The Lab has also been involved as minor participants in a number of the large scale ESPRIT projects with international industrial partners. 'My observation, which I hope is untypical, but I fear isn't, is that if you're going to waste that much money there must be easier ways.' Companies often try to base projects on work which they have already undertaken, are subcontracting or planned to do anyway, whilst often most of the work in a project comes primarily from one of the partners. However, some projects have achieved 'respectable' results, and of course, the process does encourage greater contact between European companies - 'but it's hard to think that you couldn't achieve this amount of conversation slightly more cheaply.'

Their experience of collaboration with other academic institutions, via '*Basic Research Actions*' has been

> 'entirely favourable, we are involved in a number of them and I am sure that this has increased greatly our contact with Continental European universities. It's an interesting observation that people of my generation tend to look west for collaboration, because when we were young there wasn't much going on in Europe to collaborate with, whereas my colleagues twenty years younger tend to look to Europe.'[97]

This was echoed by Tom Anderson at Newcastle, who also felt that basic research collaborations worked far more smoothly than those with industrial partners.

> 'in collaborations with industry the partners often have very different drivers which can lead to different directions with the collaborative project.'[98]

Several participants had also been involved with schemes such as the DTI LINK programme to encourage collaborative research. Whilst welcome in principle, these schemes were also agreed

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[96] see 9.2.6 - Interview with Peter Moforth of the Turing Institute

[97] see 9.2.1.2 - Roger Needham of the University of Cambridge Computer Laboratory.

[98] see 9.2.4.1 - Interview with Tom Anderson of Newcastle's Centre for Software Reliability

to have practical problems. (See section 2.2.2.4 and 2.2.3.4 for details of the schemes). CASE awards were mentioned as successful and inexpensive examples of beneficial collaboration, whilst Richard Tomlin[99] of Newcastle suggested that, despite their relatively low value, the new ROPA (additional grants only available to teams with existing industrial sponsorship) might successfully act as a catalyst in encouraging industrial funding. According to Richard Jennings of Cambridge, the attractiveness of the schemes to the smaller companies at which they are aimed is limited by the bureaucracy involved - the LINK scheme, for example, does not even have a sample agreement to act as a guide to negotiations (unlike the much criticised ESPRIT).

> ‘These sponsored awards are very helpful in principle, the problem with all of them is that small companies see them as bureaucratic and difficult and see an enormous opportunity cost associated with them.... LINK is a very good programme in principle but it’s a bureaucratic nightmare - everybody’s been saying that from the very beginning but there’s no will by the DTI or anyone to sort it out - the people involved are just saying “Oh you sort it out, we’re government, we don’t get involved in that sort of thing” and that’s not helpful.’[100]

Participants in the US placed less emphasis on the role of specific government programmes in encouraging collaborative research, though it must not be forgotten that much corporate research and development work is made possible through tax credits, and that companies can receive substantial tax advantages from gifts to universities. These incentives are much more general and programmes such as LINK or even ESPRIT.

What specific programmes do exist in the US, such as SBIR (the model for SMART) and the ATP (see section 2.1.2.3) are oriented towards the support of small innovative companies as a means of encouraging exploitation of universities research. These are discussed further in section 5.3.3.

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[99] see 9.2.4.3 - Interview with Richard Tomlin of Newcastle University’s Research Services Unit

[100] see 9.2.1.1 - Interview with Richard Jennings - Cambridge Industrial Liaison and Technology Transfer

# 5. TECHNOLOGY TRANSFER

## 5.1 WHAT IS TECHNOLOGY TRANSFER?

Technology Transfer is a phrase much used when discussing research. In its broadest sense it can be used to describe and movement of a technology or technique from one context to another, and indeed it is often used when discussing the movement of technologies from developed countries to the third world. However, its use in relation with scientific research is usually to denote the movement of technologies developed in research laboratories into the market place, and hence to describe the process whereby technology is commercially exploited. The particular flow of technologies which we are most concerned with here is from universities to companies, but it must be remembered that for many companies the most important transfers of technology will be internal and that the transition from corporate lab to corporate product is a more important one.

American Universities, in official policy at least, tend to view technology transfer as a matter of providing benefit to the public. MIT's policy and procedures document on Technology begins its discussion of commercial development as follows

> It has long been acknowledged that the primary functions of a university are education, research and public service. It is in the context of public service that MIT supports efforts directed towards bringing the fruits of MIT research to public use and benefit.
>
> In many cases, mere publication of research results will be sufficient to transfer MIT research to the public. In other case, it is necessary to encourage industry, by the granting of license rights, to invest its resources to develop products and processes for use by the public.
>
> [MIT, page 13]

There is a very real sense in which all the mechanisms of research oriented interaction discussed previously, including sponsored research agreements and consultancy agreements, are motivated primarily by the transfer of technology. The assimilation of a new technology is likely to involve much more than the simple movement of an artefact from one party to another, and although the licensing of a piece of clearly defined or tangible intellectual property often plays an important part in such transfers its importance is easy to overstate. This chapter thus focuses on technology transfer in its broadest sense, including an examination of the different moments of technology which might be transferred and the importance of different formal and informal mechanisms for doing so.

### 5.1.1 TECHNOLOGY AS ORGANISATIONAL EXPERTISE

> 'Technology licensing is a good thing, and I think it needs to be considered, but I don't think it's the primary mechanism of technology transfer. I think the primary mechanism for technology transfer is direct contact between researchers in similar fields where they exchange information and know-how.... It's normally exchanged freely on the basis that it's of benefit to both parties. It doesn't cost anyone anything.... it's an informant network.'[101]

[Rosenberg b] investigates industrial innovation in detail, and comes to conclusions regarding technology within companies which amplify the importance of 'tacit' knowledge and the

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[101] see 9.1.2.1 - Interview with Gary DesGroseilliers of DaimlerBenz Research and Technology, North America

development of organisational capabilities through accumulation of scientific expertise which were noted in section 4.1.1.2. It suggests that the reason that inventions are primarily made in companies rather than universities is that the technologies and needs of industries are not known within universities - such inventions come from the interaction of market needs with research expertise and so companies develop what are essentially their own specific technologies.

Such technologies are specific because, in many industries, patentability is not a key consideration and expertise is crucial. The results of his questionnaires reveal that patents are most important in industries where chemical composition is important, such as the chemical, pharmaceutical and materials industries. Patents are also important where products are devices which can be easily copied.

However, in other fields the importance of patentability is negligible. He suggests that for products such as missiles and aircraft it is likely to cost an imitator around 75% of the original development cost to successfully copy a design. This is because learning details of the technology is crucial to the duplication of its functionality, so almost the same expertise is required to understand and copy the design of the product as to produce it in the first place. This very specific expertise is what makes the technology proprietary.

It follows that the transfusion of such technology is a product of the spread of expertise, rather than a matter of licensing a patent or reading an article in a journal. Informal networks of information exchange and personnel movement are far more important, and the main role of patents may be to guard against potential infringement suits from others.

> I suspect that patent licensing... is basically the tip of the iceberg of technology trading and sharing, most of which does not involve explicit licensing.
>
> [Rosenberg b]

It seems likely that the IT industry represents another field where the role of patents is firmly secondary to that of expertise.

Rosenberg's research also investigates the perceived importance of research, and university research, in different disciplines across a wide selection of different industries. His findings show that computer science research is viewed as crucial to a large number of industries. Fields such as chemistry and, especially, physics, displayed a high perceived importance but a obtained low marks for the relevance of university research, whilst academic computer science research scored just as highly as the field in general.

Some quantitative data on the importance of formal technology transfer as a motivation for research collaboration is provided by [Cokar], which is based on an examination of 35 university collaborations in one company. Of these collaborations, 49% were intended to involve transfer of both technology and knowledge, 34% to transfer knowledge alone and 17% to transfer technology alone. In 43% of collaborations the professor involved was known to the corporate collaborator before the project, and in a further 31% of cases they knew of them by reputation. 57% of projects were judged to have successfully transferred information, 31% to have transferred materials, devices and software and just 3% (i.e. 1 so this is probably not a very reliable figure) to have transferred 'technology' (presumably patentable). In as much as these results may be generalised, they suggest that formal technology transfer is an uncommon result and is very rarely the only planned outcome of a collaboration.

A more substantive evaluation comes from a survey by the US General Accounting Office quoted in [Feller]. 168 firms were asked their motivations for taking part in the NSF Research Centers scheme. Of a total of 15 suggested motivations, the production of patentable products came last. Selected results are shown below:

| **Motivation:** | **% of sample citing** |
|---|---|
| 'Match between research interests' | 89% |
| 'Interest in "state of the art" research. | 88% |
| 'Leverage of research funding' | 48% |
| /\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/\/ | /\/\/\// |
| 'The production of patentable products' | 8% |

Figure 5-1: Selected Results from US GAO Survey of Participants in NSF Centers scheme

### 5.1.2 FROM R&D TO TECHNOLOGY ACQUISITION

Today, attention is focused on 'innovation' rather than invention. Innovation is a continual process, involving feedback, and is considered in a business context, involving the successful deployment of products and processes as well as their development. Successful innovation involves the use of new technology, which may have been developed in-house or acquired from elsewhere. Jeff Solash suggested that there are factors in corporate culture which have mitigated against technology transfer.

> If a company are offered a piece of technology, they will often send it through internal channels to an expert in R&D, together with a vague covering memo asking him to evaluate it. The natural reaction this causes is often one of suspicion and resentment, worry for his own job security and an instinctive rejection of the technology - 'Why don't you increase my funding instead?'. A switch is required away from thinking in terms of a 'Research and Development' department to a 'Technology Acquisition' department - 'the president of Technology Acquisition should be in the business of acquiring technology whether it comes from internal or external sources'. This department also needs to be better integrated with sales and marketing efforts.[102]

A company may acquire new technologies in a number of ways. One traditional way has been the use of suppliers and contractors - the producers of automobiles or aeroplanes often gain the benefit of new technologies via their adoption by the manufacturers of components. Another traditional way has been to develop it within the company. A smaller company which has developed a novel technology may be acquired or brought into an alliance, or a group of companies may come together in a consortium to pool the costs of research.

One thing which companies seek to do is to involve the risks inherent in product development. Like all projects, there is a risk that a development programme designed to lead in time to a new product may fail - at early stages this may be due to technical problems, other companies may establish themselves in a stronger position with equivalent or better technology, the market may

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[102] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

alter or management conflicts may prevent the successful conclusion of the project. A corporation therefore wishes to hold a broad 'portfolio' of projects in different stages of development, to introduce new products as rapidly as possible and to have as much flexibility as possible. Many of these considerations lead naturally to a consideration of joint research and development ventures and to the licensing of technology. [Bower].

The shift from technology development to technology acquisition has undoubtedly been accelerated by the restructuring of major corporations, which as discussed previously has in general caused closer integration between research and development activity and business divisions, and by the huge complexity and expense of new products in many industries.

> 'companies no longer think .... if they don't develop it internally then it's bad. Companies are recognising that with everything from legal work to menial work to R&D that they can piggy-back off R&D that is being funded by the government or they can cheaply, by funding MIT research, take advantage of all the MIT overhead and equipment and experience to take a technology and move it forwards.... companies will start to recognise that it's the same thing, by giving up a little bit of a big pie you have more than if you try to keep all of a small pie. That's the way to make money. Industry is looking to be flexible in its R&D and to capitalise on opportunities to collaborate, not only with universities but with other companies.'
>
> 'More than anything else, whether you really believe in it or whether you're cynical about it - it's more popular, it's the buzz. Licensing out is acceptable, it doesn't mean that you're weak - it means that you're nimble and competitive.... It's seen now as smart business. '[103]
>
> 'People looking very much at what their core business is, considering whether to spend money internally or outsource, ultimately this must benefit the universities. The good news is that it's reached the top of the industrial agenda - when I started in this office seven years ago, one felt that, both in companies and universities, industrial liaison officers were somewhat marginal. Now, both are much more a part of the core business, and the quality and the exchange has increased dramatically, as has the support in both sectors.'[104]

Small firms are unlikely to be able to take part in longer term research projects. As discussed previously, they are less likely to have either the resources or the long term focus needed to invest in such schemes, which from the point of view of the company involved in highly speculative. Other mechanisms of technology transfer are therefore more important for such companies. These include the kind of informal links discussed in 4.3.14.3.1. The employment of graduate students can be an important mechanism for such companies.

> 'Small local technology companies are increasingly employing graduates, and that's a very real, and in some ways the most important, source of technology transfer: the movement of intelligent people.'[105]

### 5.1.3 BRIDGING THE DEVELOPMENT GAP

Although, as discussed in 4.1.1.2, the progression from basic research to product is often far from linear, by the time that a piece of technology has been assessed as being of likely commercial value, and is under consideration for patenting, at least one commercial application

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[103] see 9.1.6.1 - Interview with Alex Laats of the MIT Technology Licensing Office

[104] see 9.2.1.1 - Interview with Richard Jennings - Cambridge Industrial Liaison and Technology Transfer

[105] see 9.2.1.1 - Interview with Richard Jennings - Cambridge Industrial Liaison and Technology Transfer

must have been observed for it. Unfortunately for technology transfer offices, the state in which a university research programme is likely to have left the embryonic technology is not usually sufficiently advanced for a company to be able to easily adopt it and turn it into a viable product with a minimum of effort or risk. Alex Laats at MIT stressed the centrality of these problems to technology transfer.

> 'The real difficulty in terms of taking technologies and getting them from an embryonic stage to a product stage, and then from a product stage through a scale up to a large market is funding along each step of the process. Whether it be an industrial sponsor or the US government that is funding research here at MIT, MIT is not in the business of delivering products - its role tends to be more open-ended - taking the technology to a very embryonic stage'.

> The first stage is research - 'MIT all the way', followed by development - generally also funded by the sponsor and carried out at MIT. However, the government rarely goes beyond these to the next stage - 'the creation of prototypes on a bench in the lab'. Still more rarely will it fund trial manufacturing of a product. Industry by contrast, is usually much more interested in an idea if it can be presented in the form of a manufacturable prototype which they can then investigate the scaling up and marketing of. 'The problem is in the gap between R&D and the things that industry is interested in capitalising on'.[106]

Most technology transfer initiatives, such as the US Advanced Technology Program (see 2.1.2.3) are designed to help overcome this, by supporting the development of technologies until they reach a more commercially viable stage.

One of the attractions of an ongoing active research collaboration is that technology will often be transferred to the company as it is developed (at least in the informal sense - they may have to license IPR separately) and so transfer will be from an internal research group to an internal, product oriented product development group. Even in this case, however, the biggest hurdle which the project has to jump is not from university to industry but from research teams (university and industry) to product development teams. As Alvey Programme showed, even when research collaboration has been highly successful and ownership is clear, its commercialisation is far from automatic (see 2.2.2.3).

[106] see 9.1.6.1 - Interview with Alex Laats of the MIT Technology Licensing Office

## 5.2 TECHNOLOGY LICENSING

> ‘Everyone says that technology transfer is truly wonderful, but everybody also says that universities ought to “exploit” the technology which they have generated for money, as effectively as they possibly can. These two things are actually slightly opposed to each other.’[107]

There are undoubtedly some situations in which formal licensing works well and is necessary. As implied previously, these often occur in fields where a clearly defined process or product has a direct and clear commercial value and can be patented, or where a piece of software can be licensed under patent. Often the exclusivity which can be gained by a formal license is necessary to make product development worthwhile for a company.

Although, at least in the US, university policy may stress the importance of technology transfer as a service to society and a means of making good the public’s investment in research, there can be little doubt that a considerable part of the motivation towards the widespread establishment of technology transfer offices has come from the spectacular revenues derived by a few patents. Even at Harvard, the most conservative of the institutions surveyed, some financial motivation was admitted.

> ‘Although nobody [in the university's central administration] looks at our small group with a totally ‘green eyeshade’ viewpoint, they have been known to ask us to project what our royalty revenues will be next year....’[108]

As Alex Laats emphasised, many patents only realise their full value after some time when products finally reach the marketplace. Similarly, an equity stake in a start-up company may only be realised several years later when, and if, the company becomes public.

> 'I have a business plan on my desk for a technology where I'm seeking a 5% royalty, and the business plan calls for revenues $26 million in a couple of years. I'm making $1.3 million, and that's if the company doesn't take off. That's a lot of money - it's not Michael Gates of Microsoft, but 5% of sales for any good company could be huge. It [technology licensing at MIT] has only been around in its current form since 1984 or so, a lot of the pay-offs are in the future'.[109]

A small number of well known patents have generated very large sums. These include the Cohen-Boyer patent mentioned in section 2.1.2.1, also a patent for a successful breed of strawberry, the patent for fluoride in toothpaste and a patent for the soft drink ‘Gatorade’. These patents are each worth tens of millions of dollars annually, and in many cases are responsible for the vast bulk of revenues generated by the offices concerned.

Figures from the University of Wisconsin, which was one of the first institutions to actively pursue patents, show from the 2,426 disclosures made between 1925 and 1985, 448 patents resulted, of which only 203 have ever been licensed. Whilst 100 of these resulted in income greater than licensing expenses, over the entire period just 10 patents were responsible for 90% of the overall revenue. [Feller] concludes from these figures that the establishment of a

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[107] see 9.2.1.2 - Roger Needham of the University of Cambridge Computer Laboratory.

[108] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

[109] see 9.1.6.1 - Interview with Alex Laats of the MIT Technology Licensing Office

technology licensing office is like buying a lottery ticket and that for most institutions costs will probably never be recovered.

> There is little reason to expect, based on past performance, that any sizeable reallocation of faculty efforts towards commercially oriented R&D will generate appreciable new net revenues for other than a select handful of universities.... Profitable or not, these ventures serve to shift academic researchers from the social roles in which they are most efficient - as suppliers of a collective good - scientific knowledge.
>
> [Feller, page 334]

Feller's suggestion of scientific knowledge as a collective good is, as argued previously, rather naive - at least in technological fields - but it seems likely that, whilst a university which produces a number of valuable inventions might be able to profit by their exploitation, that a reorganisation of research motivated by the hope of increasing licensing revenues, something which UK government policy might encourage, would be profoundly misguided. The most valuable patents are not necessarily those which emerge from the most important research (as the case of Gatorade shows), and in many cases the patentable invention is an unexpected result, or even a by-product, of the researcher's work. Richard Jennings at Cambridge commented, '*I feel very strongly that what we deal with is often a by-product*'.

> 'Despite the role of this office I think that it's crucial that we don't eat our future seedcorn - there is some extraordinary naiveté around in government, it suits current party dogma. That's what I find so distressing - they are intelligent people, they know the situation and yet they pretend that it's different from what everybody tells them it is.'[110]

In 1991 a total of 1,324 patents were awarded to universities in the US, compared to 437 in 1981. During this period the proportion awarded to the top 100 research institutions rose (to 85%), though the proportion to the top 10 institutions fell significantly - representing a substantial increase in activity amongst the mid-tier research institutions. 197 exclusive licenses generated $29.3 million, primarily in medically related areas, whilst 339 non-exclusive licenses were worth a total of $52.7 million.[NSF]

## 5.2.1 INTELLECTUAL PROPERTY

In both the US and UK, universities usually hold the rights to intellectual property resulting from research undertaken with government funds, and of course to any work paid for with their own income. As discussed in section 4.4.2, they will usually retain ownership to industrially sponsored research - the most important exception to this amongst the participants in this research being Cambridge's policy that the rights of internally funded research may be vested with the researcher themselves. These legal rights take several distinct forms. Intellectual property is owned by its originator but can in general be brought and sold in same way as other kinds of property. It may pass by contract of transfer (sale or licensing) or contract of employment to another owner.

### 5.2.1.1 Patenting

The best known form of protection available for an idea is its **patenting**. Once an invention has been patented all rights to its use are held by the inventor for a specified period. Only something which can be characterised as an invention can be patented - American law allows for the

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[110] see 9.2.1.1 - Interview with Richard Jennings - Cambridge Industrial Liaison and Technology Transfer

patenting of a quite wide range of inventions: as well as machines, processes and articles of manufacture protection can be extended to ‘compositions of matter’, asexually reproduced plants and - famously - a genetically engineered mouse. Improvements to existing inventions can also be patented.

British law differs somewhat here, and the Patents Act 1977 specifically excludes a number of categories - including varieties of plants and animals and computer programs.

For a patent to be granted, the invention must fulfil three, rather subjective, criteria. It must be:

- Novel - clearly distinct from previous inventions disclosed to any member of the public,
- Non-obvious - to someone knowledgeable in the field, and
- Useful - in some way of greater utility than existing methods.

> The patents system exists to encourage innovation. At its heart is a bargain between the Government and an inventor whereby the inventor is rewarded for revealing full details of the invention by the grant of a patent which provides an absolute monopoly in the invention for 20 years.[111] The country also benefits by gaining full knowledge of the innovation.
>
> [Irish - page 109]

This explains the strict requirements for novelty. Any publication or disclosure, anywhere in the world, is sufficient to destroy the patentability of an invention - this includes, of course, the normal kinds of academic communication via conferences, papers and electronic systems. Once an invention has been disclosed before a patent application has been filed it cannot then be patented by anyone.[112]

Before a patent is issued, checks are carried out by patent examiners to ensure that it does indeed appear to be novel. In some fields, especially computer software, a very high proportion of patents applied for and issued fail to meet this criteria but are not detected due to lack of expert knowledge and resources on the part of the examiners. Although software is not, in itself, patentable it is in general possible to protect systems of which software forms a key part. In the US a number of important cases have involved the patenting of algorithms, which is increasingly widespread within the computer industry.

Patenting is an expensive process, involving legal fees for the preparation of the application and the payment of a fee to the patent office itself. In the US, these fees total around $4,000 - $8,000 per application. [Harvard]. However, there is no such thing as a ‘world patent’. Essentially, a separate application has to be made for every country for which protection is sought - although the EU has moved towards a single patent system and the Patent Cooperation Treaty provides a simplifying mechanism for initial claims. The costs of obtaining international protection are thus much greater, and in practice only states in North America, Australia and parts of the Far East are worth seeking protection in for most inventions. Details of patent law vary between countries, though harmonisation is taking place as a result of the GATT agreement.

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[111] This reflects the situation in Britain. In the US, protection is usually for 17 years. Harmonisation is underway as a result of GATT provisions.

[112] US law allows patenting within one year of disclosure - however rights will still have been lost for most other countries wherever the disclosure is made.

The other expense associated with patents is in their defence. A patent grants its holder a legal monopoly - but if the holder wishes to maintain this monopoly they must be willing to take legal action against infringers. This is an expensive process, because even when a patent has been granted its validity can still be challenged and therefore it is not sufficient to show that a competitor is using the invention. The infringer can attempt to show that at the time the patent was applied for the invention, or one sufficiently like it to make it no longer novel and non-obvious, had already been disclosed somewhere in the world. In the UK most cases are settled out of court. A convicted infringer may be required to compensate for loss of revenue.

In the US, the consequences of deliberate patent infringement can now be severe. At one time the most severe punishment likely was 'reasonable royalties.' Companies could therefore routinely infringe patents, and treat any damages eventually awarded as a part of normal costs. A ruling by CAFCE - the Court of Appeals for Federal Court - changed this, allowing the specialisation of appeals judges in the arcane and case based field of patent law. They have enforced the law far more rigorously, and some high profile cases have resulted such as one involving triple damages running to hundreds of millions of dollars awarded against Kodak[113]. Judges are also willing to enforce injunctions on the sale of disputed products, and because the costs of licensing of technology are usually small compared to the sums invested in manufacturing, marketing and commercialising the technology, potential lost revenue being risked is likely to be much greater than the cost of licensing.

Of course, universities do not typically patent inventions because they themselves wish to enjoy a monopoly on their use. Usually a patent is filed with a view to subsequent licensing to a commercial organisation on either an exclusive or non-exclusive basis. The minimum criterion is obviously that the licence fees cover costs involved in patenting and licensing. However, a license to use a patented invention is clearly only a good investment for a company if it seems likely that action will be taken against a competitor who attempts to use the same invention without licensing it. If a patent is valuable then the competitors of licensees may seek to challenge its validity. The possible costs of such action are an important risk which must be considered when patenting policy is being formulated.

> ‘you have potential infringement suit problems, and let's face it: if you are a licensee who is selling goods and making money, chances are there is someone else out there who will try and take their business away'. Patent infringement suits are expensive both in terms of dollars expended and the time required from technology licensing professionals and the inventors themselves in dealing with them. In North Carolina a university has incurred more than $5 million from their royalty stream in direct legal costs, in addition to tying up the head of their office for two years doing almost nothing apart from managing the case and requiring the inventors to seek release from their faculty duties for the duration to handle the workload imposed. The latter represent a loss of skilled time and opportunities which is very hard to quantify. These kinds of potential costs can easily be overlooked when considering potential income from patents.[114]

#### 5.2.1.2 **Other Forms of Intellectual Property**

**Copyright** is another important form of protection. This applies to ‘works’, which include computer programs, microcode and cable programmes (including networked databases and the

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[113] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

[114] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

like) as well as more traditional works such as books, films and photographs. Copyright is automatically present in works, without the need to register them or to make an application, and endures until fifty years after the death of the author. Copyright in computer generated works rests with the programmer of the computer.

In most cases, copyright is vested in the author of the work - though if it is created in the course of employment then it will usually rest with the employer. When a university undertakes contract research, copyright is carefully negotiated.

Whilst, in order to be eligible for copyright, a work must be original there is no requirement that it be different from all previous works - merely that it has not been copied. A complicated situation arises with respect to 'derivative works' - some kind of transformation or reworking, which at its simplest might be a film adaption or translation of a novel. A new copyright protects the derivative work, but the work on which it was based continues to posses its own copyright and copying of the derivative work would infringe both.

The status of derivative work can often be an important consideration for universities. Often a piece of software will include material developed under a number of different arrangements, being for example the result of further work on a system originally developed as part of a research contract.

> 'That's a very hard issue to resolve... I am still looking for ways to measure the relative intellectual input to derivative works... simple examination of the code is clearly inadequate.... It's hard to know who "owns" what portion of a program after it's gone through multiple revisions.'[115]

**Other specialised forms of intellectual property** include confidential information, trademarks and industrial designs - which can be registered in a process analogous to patenting. In both the US and the UK, special provisions are made for the protection of semiconductor designs. In the UK layouts are protected under the Design Right (Semiconductor Topographics) Regulations 1989 - protection lasts for ten years from exploitation. In the America the US Semiconductor Chip Protection Act of 1984 introduced a new form of intellectual property - the 'mask work'. Protection is a hybrid of copyright and patent, requires registration and applies only to topographies which have been incorporated into a product.

### 5.2.2 EVALUATING AND MARKETING OF TECHNOLOGIES

The involvement of a university office of Technology Licensing or Technology Transfer with a particular technology usually begins when a researcher reports that an 'invention' with possible commercial significance has been made. A standard 'invention disclosure' form is usually available for this purpose, upon which the researcher responsible for the invention provides a general description of the invention, in a form oriented towards an assessment of patentability, and an indication of its commercial potential.

Because the disclosure of inventions is, in practice, normally largely a voluntary activity, technology licensing offices must make sure that faculty know of their existence and of the way in which they work. The financial rewards are one incentive to researchers, but another priority

[115] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

must be the establishment of procedures which make the process as simple and easy for inventors as possible. [MIT]

Within the offices surveyed, responsibility for each specific field within the university was assigned to a particular officer, who could therefore build up expertise in the evaluation and marketing of particular types of technology and a network of industrial contacts working in relevent companies. Individual officers tend to develop different means of working which are appropriate to their field.

> ‘We all do our [marketing] tasks quite differently - due simply to the difference in technology and the diverse nature of the markets being served.’ In the broad field of physics, for example, when reviewing a new report of an invention and thinking about how he would market the technology, no single "road map" comes to mind. By contrast, he thinks that a colleague evaluating a discovery in, say, the molecular pharmacology field, may well have in mind a "short list" of industry companies that can be approached with licensing in mind.[116]

As discussed in section 5.2.1, in order for an invention to be patentable it must be novel, non-obvious and useful. It is not wise to patent all inventions regarding which patents might be granted, because the costs involved are considerable and so patents should only be pursued for technologies which seem likely to generate licensing revenues which at least cover the administrative and legal costs involved. Evaluation of the commercial value of a technology is thus crucial.

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[116] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

> 'On both sides of the Atlantic you get institutions that patent anything and everything, and in my view this is flawed. Optimally you have to be selective, and admit that you are taking some risks. "Patent everything" is a risk minimization strategy that doesn't work - you spend so much money that it is difficult to show a return, and the managers dilute their efforts across a large number of cases with poor commercial value. The result shows up in poor performance ratios of income per employee, per patent filed, income to expense or non-reimbursable patent expenses... but NOT in simple measures like number of patents filed or gross income. Performance is now a concern in both the UK and USA. We continue to file patents on 50% or less of inventions reported.'[117]

In many cases the decision to patent was based on exploratory negotiations with companies to determine the commercial significance of the technology. Such discussions were usually be non-confidential, a licensing officer having a network of contacts which can be called upon for advice as to current levels of interest in technologies related to a particular area.

> 'If we are find that we're getting a reasonably positive response from a number of companies to this sort of initial test question then that would give us the courage to go forward with the expense of patenting something.' It may be difficult to gain an informed opinion without giving away the nature of the invention, so sometimes an invention in a very promising area must be patented before this is risked.

In some cases it may be possible to use non-disclosure agreements to protect the technology during discussions prior to patenting. Alex Laats at MIT suggested that 'marketing' constituted about a third to a half of his job, and involved '*understanding the markets, trying to determine whether or not the technology will fit, whether someone out there is going to be interested in it.'*[118]

Usually an inventor will have their own idea as to which companies are most likely to be interested in their invention. These are taken seriously - as Jeff Solash at Penn explained, '*Your inventors are often the best sources of information as to who is really interested - though their field of view is limited.'*[119] Because of the severe pressures which exist on the time of technology licensing officers, if these companies can be licensed to in a satisfactory manner then there is little incentive to look for other potential licensees. However, if possible the inventor would usually welcome interest from several companies and an auction of rights.

Don Walker at Harvard suggests that *'In licensing you try and find the industry leader, because you feel that their direction is the most 'real world' as well as most likely to result in revenues which lead to high royalties*.' Such a company is therefore more likely to provide high quality feedback to the researchers involved and so contribute more to the ongoing relationship.

Other sources of information mentioned by Solash include library work and consultation with students at the business school. Technology licensing people themselves network with each other, via professional meetings and electronic systems. Much of the discussion on the Techno-L discussion group (an Internet list server) relates to the utility of different reports and information

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[117] see 9.1.4.2 - Interview with Peter Williams of Harvard Medical School Office of Technology Licensing and Industry Sponsored Research

[118] see 9.1.6.1 - Interview with Alex Laats of the MIT Technology Licensing Office

[119] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

sources, licensing professionals can also seek the advice of their colleagues regarding dealings with particular companies or agencies and regarding new types of agreement.

Less directed methods of technology marketing may also be employed, involving the listing of technologies available for licensing. Many American universities have now set up technology licensing pages on the World Wide Web, and a number of commercial electronic databases with search facilities have been set up on-line to allow listing of technologies from a number of sources.

No empirical value can be assigned to a technology, all that is ever known is the eventual value of the license. The inventor themselves has some idea as to the worth of their invention, but in many cases this may be exaggerated. According to Henry Lowendorf at Yale, '*The inventor usually has a very high valuation of his own invention*.'

Estimation of commercial worth also involves a consideration of the risks involved in commercialisation. A patent which forms the basis of a new drug might potentially be worth many millions of pounds, but this must be set against the relatively slim chance that it will pass through all stages of development and clinical trials, and the huge costs involved in each of these stages.

Lowendorf stressed that the kinds of license which would best suit the technology also play an important part in its evaluation.

> 'We first have to identify companies that are interested in the technology. We have to look at the technology and determine if it is patentable, or is it something that would be licensed without being patented, such as a cell line or antibodies or something like that. We look at whether it would be the kind of technology that would be licensed non-exclusively or exclusively, whether it is a technology that might make sense to encourage a company to start up around, whether the technology can be divided up into fields of use so that we could license exclusively in one field of use to one company, and exclusively in another field of use to another company - or if we might want to divide it up geographically.'[120]

The issue of whether to license a technology to an existing company or use it as the basis of a start-up is one area where important differences emerged between the institutions surveyed. Procedures and policies here are discussed in section 5.3.

Reproduced overleaf is part of a form compiled by David Jones, Manager of Prototype Development at UBC/UILO in Canada which was distributed to technology licensing professionals via the Techno-L discussion group. Whilst not all offices employ formal checklists of this kind, it serves to illustrate the range of factors which must be considered during the technology evaluation process before a decision to patent can be made.

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[120] see 9.1.8.2 - Interview with Henry Lowendorf of Yale Office of Cooperative Research

| BACKGROUND TESTS: | | No Low | Yes High | Rating 1-5 |
|---|---|---|---|---|
| 1. Patent search completed and clean. | | ___ | ___ | ___ |
| 2. Literature search completed and clean. | | ___ | ___ | ___ |
| 3. Invention remains confidential. | | ___ | ___ | ___ |
| 4. No publications pending. | ___ | ___ | ___ | |
| 5. No prior claims to the technology. | | ___ | ___ | ___ |
| 6. Technology protectable by patents. | | ___ | ___ | ___ |
| **TECHNOLOGY TESTS:** | | | | |
| 1. Technology basis of a new industry or company (major breakthrough). | | ___ | ___ | ___ |
| 2. Technology state of the art. | | ___ | ___ | ___ |
| 3. Easy to demonstrate technology. | | ___ | ___ | ___ |
| 4. Identifiable and significant benefits. | | ___ | ___ | ___ |
| 5. Functioning prototype. | | ___ | ___ | ___ |
| 6. Addition to existing UBC patents. | | ___ | ___ | ___ |
| 7. Long product cycle. | | ___ | ___ | ___ |
| **MARKET TESTS:** | | | | |
| 1. Fills identifiable & marketable need. | | ___ | ___ | ___ |
| 2. Market sizeable and growing. | | ___ | ___ | ___ |
| 3. Believable but indeterminate large upside potential. | | ___ | ___ | ___ |
| 4. Absence of direct competitive products. | | ___ | ___ | ___ |
| 5. Definable niche market. | | ___ | ___ | ___ |
| 6. Market accessible (no dominant technology). | | ___ | ___ | ___ |
| 7. Technology has low dissonance. | | ___ | ___ | ___ |
| **COMMERCIAL TESTS** | | | | |
| 1. Result of industry funded research. | ___ | ___ | ___ | |
| 2. Prospective licensee identified. | | ___ | ___ | ___ |
| 3. Improvements / cost reduction >20%. | ___ | ___ | ___ | |
| 4. Low financial risk. | | ___ | ___ | ___ |
| 5. Technology basis for a spin-off company. | ___ | ___ | ___ | |
| 6. Sustainable competitive advantage. | | ___ | ___ | ___ |
| 7. Conforms to relevant standards. | | ___ | ___ | ___ |
| **MANAGEMENT TESTS** | | | | |
| 1. Inventor technology champion. | | ___ | ___ | ___ |
| 2. Inventor has realistic expectations. | | ___ | ___ | ___ |
| 3. Inventor team player. | | ___ | ___ | ___ |

What is the biggest concern/ problem?
What is biggest upside opportunity?
Critical information missing?
Estimated costs: Patenting $ Time:
Estimated return to UBS: $ Timespan (yrs):

RECOMMENDATION:
Return to Inventor Return for Research Patent Application

**Figure 5-2: Example checklist for evaluation of technology prior to patenting decision.**

### 5.2.3 LICENSING AGREEMENTS

Once interested companies have been identified, and protection ensured via a patent if applicable, the details of a licensing agreement must be negotiated. Licensing agreements may be exclusive or non-exclusive. Exclusive agreements are the norm in areas such as pharmaceuticals where development costs are so great as to deter companies unless they are guaranteed a monopoly in the event that a successful product is produced. For computer related technologies and software non-exclusive licensing is more practical, allowing a spreading of costs.

Jeff Solash at Penn emphasises the importance of having a good idea of the realistic worth of the technology to the prospective licensee.

> When companies have been interested, strategy and negotiating positions must be established. 'Even there it pays to do your homework, and that is where I often depart from the company of a lot of my peers'. A case must be made to the company in terms of business opportunity, in a business like way. Companies will have carefully analysed the business worth of the technology, done Net Present Value calculations, formulated marketing ideas and so on. Despite the great pressures of work on technology transfer officers, they need more than a 'vague idea' as to the possible worth of the technology or they will face 'a rather severe disadvantage.'[121]

Whilst it is important to make sure that a reasonable return is derived from licenses, particularly given the licensing officers are the custodians of other people's intellectual property, it is also important to strike a balance between protection of the university's interests and maximisation of licensing opportunities. As Gary desGroseilliers, now working on technology liaison for Daimler-Benz but formerly part of the MIT Industrial Liaison Programme explained,

> 'a few years ago [the Technology Licensing Office at MIT] was run by lawyers, and their main interest and activity was to protect the rights of MIT in any negotiation over a technology. The result of that was that they were so good about protecting it that MIT was never able to license anything or gain any advantage or know that the technology was being used.... They got rid of all the lawyers, the patenting process is something which is handled by outside attorneys now and that's not the major part of their activity - the major part is that when there's a technology that is worth commercialising is to find an outlet for that technology and to structure a deal that is favourable to both parties….
>
> If a company is taking a technology from a university then they're making a major investment... it usually require a large investment of capital to commercialise it and if they're charged too much money or they're not given some kind of guarantee that they have at least a lead time... then they won't make the investment so it could be a very good technology but no-one will use it.'[122]

An agreement will often specify a number of 'milestones' at which further payments must be made. Each of these would correspond to a new stage in the commercialisation of the product, the classic example being the progression of a drug through the various stages of clinical testing. This system provides an equitable handling of risk - the initial payment is not prohibitively large in the event that a technology is not successfully commercialised, but neither is the university tied to a low level of income from what may become a successful product.

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[121] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

[122] see 9.1.2.1 - Interview with Gary DesGroseilliers of DaimlerBenz Research and Technology, North America

Another important part of most agreements are clauses demanding ‘due diligence’ on the part of the licensee. If a company licenses a technology and fails to exploit it then no royalties will be triggered, and if the licence is exclusive then competitors will be excluded from using it, the technology will languish and the university and the inventor will receive no royalties. Clauses which specify acceptable periods for each stage of the commercialisation process, or the investment of a certain amount of effort by the company, allow the reversion of rights to the university if no attempts are being made to exploit the technology.

All the institutions surveyed assigned a proportion of the revenue from licensing to the inventors themselves. Many also assigned a portion to the inventor’s department or research group. In the UK a standard formula exists for inventions funded by the Research Councils. In the US exact policies varied, for example at MIT a fairly complex arrangement gives the first 15% of gross income to the Technology Licensing Office towards expenses, one third of the remainder to the inventors and adjusts what is left to reflect TLO operating costs before splitting it equally between a general fund and the specific laboratory or department. [MIT]. Some institutions adjust the proportion going to each beneficiary according to the magnitude of the royalties. For example, Brown operates a sliding scale from an even split on the first $100,000 of income to a 20%/80% split in favour of the university for revenues over $1 million.[123]

A particular concern is that the university retain rights to use whatever is being licensed as ‘background’ intellectual property for future research. Whilst there is nothing to stop anyone (including the university) carrying out research based on a particular patent, it would be very hard to license the results of such research to another company (and therefore to obtain sponsorship for the research itself) if the original patent had been licensed exclusively and without any special clauses.[124]

To some extent, preferences as to the most appropriate forms of license remain subjective. Perhaps the most important principle is the maintenance of flexibility to deal with each case in the most important manner. As Jeff Solash concluded:

> 'We try and evaluate the best place and spot for the technology.... Who's got the best philosophy? There are some early indications of the best mode if you're interested in maximising in licensing revenue, but in my view it's too early to draw any firm conclusions.'

### 5.2.4 LICENSING AND PROTECTING COMPUTER TECHNOLOGY

Software is usually licensed on an ‘as is’ basis, without support or any guarantees as to usability. Further support and adaptation must be paid for, via consultancy agreements. This policy was stressed by both Alex Laats at MIT and Don Walker at Harvard.

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[123] see 9.1.1.3 - Interview with Bill Jackson of Brown University Research Foundation.

[124] see 9.2.4.3 - Interview with Richard Tomlin of Newcastle University’s Research Services Unit

> The exclusion of support and maintenance from software licenses is one area in which Walker 'will not yield.' Improvements will be considered if they fall naturally within the direction of on-going research in the area and the research interests of those involved, but 'we cannot be a development house.' (At the time of the interview, Walker described a situation wherein a licensee was arguing to reduce royalty payments on the grounds that support from Harvard had not been forthcoming. Aside from the fact that the language of the agreement clearly stipulated the "as is" condition of the program, Walker's counterpoint was that the fee and royalties the licensee had paid were perhaps only a tenth of what it would have cost them to develop the software on their own.)[125]

Although software technologies can be patented in the same way as other technologies, in most cases software is sufficiently protected simply by copyright. The advantage gained through software licensing is usually a saving of time and cost compared with developing similar code in-house, rather than access to any unique technologies embodied in the software. Laats suggests that due to the fast changing nature of the software industry a saving of six months to a year on overall development time would be enough to justify licensing code, especially if the development was for a new platform. Unnecessary patenting would slow the licensing process and so diminish this advantage, a point made by Don Walker.

> 'Seeking patent protection for [scientific] software is rare at Harvard. I may have influenced that policy: I'm convinced that, with few exceptions, copyright protection is both timely and adequate, given the dynamics of the market. The sole patent [filed for software by Harvard] has yet to be licensed. I'm sure that's a coincidence, but the fact isn't lost on me when I consider how to quickly make the technology available to the public.'

In the UK, Roger Needham, head of Cambridge's Computer Lab, agreed that patents were unlikely to be particularly important in computer science.

> 'I think that there is a very widespread view among university people, unfortunately, that what they had developed is worth more than it actually is. In the computer field patents that are worth anything are quite uncommon - I have my name on two or three patents, but they are not worth the paper that they're written on, in my opinion. Much of it is know-how, and know-how resides with people. You get the people by hiring them and paying them what they're worth.'[126]

#### 5.2.4.1 Exploitation Structures for Computer Software

Any research oriented institution which develops software which has significant potential value to a number of other users is likely to consider licensing it to them. This has considerable appeal for both parties - the licensees can receive software at considerably below the cost of development, whilst the licenser is spreading the cost of its own work. They also have the satisfaction of knowing that their work is in more general use.

If a considerable market emerges for the system, there will eventually come a point where increased demands are being placed upon its authors for support, further development, ports to different platforms and other academically uninteresting work. The system is becoming a product, and the university environment is not a suitable place in which to develop and support shrink-wrapped products.

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[125] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

[126] see 9.2.1.2 - Roger Needham of the University of Cambridge Computer Laboratory.

> 'As a research institution you quickly begin to feel the pressures on your normal activities from dealing with software distribution and support in dealing with something that has become popular in the outside world.'

The Jack system for human simulation, produced by the Centre for Human Modelling and Simulation at the University of Pennsylvania, had been licensed to more than 50 sites. Such a system demands considerable support and maintenance - neither of these are jobs which can realistically form the major occupation of academics or of graduate students.

Yale’s parallelism researchers had already successfully established such an arrangement.

> They now have a co-operative arrangement with a local software house for the distribution of their software with a local company who has 'opened the doors to a number of different environments' - providing a point of contact with the financial, petroleum and microelectronics simulation communities and developing finished code for industrial use. 'This company for the most part is the one that takes on the responsibility of doing the serious, commercial grade research and development of the software'. This arrangement is very beneficial, as the group aims to produce software 'which people will use' but cannot practically aim to produce and support finished products itself.[127]

The agreement provided Yale with a share of software royalties, some of which went to the department, some to the researchers and some to a central fund, in keeping with general licensing policy. Because the research itself had already been funded, they were not seeking to recover their own development costs, and these royalties were not a major factor - they see the strength of the agreement in the financial support and organisational structure it gives to commercialisation and continuing development of the systems. The SBIR (see 2.1.2.2) government grants provide support to such companies, in an attempt to ‘bridge the gap’ from research to development.

> Another advantage of the arrangement is that companies are 'less generally interested' in funding general research and 'much more interested, both in their in-house research activities and in their dealings with others, in research projects for which there is not some mysterious leap of faith between that research project and something of practical interest to the company'. If the company deals with another company, rather than directly with the university, they have the feeling that 'they are dealing with a serious organisation that knows and understands' the way companies function, corporate culture and so forth.[128]

Commercially oriented R&D contractors, as well as university groups, can also fell the need to transfer product support and maintenance to another company. The Turing Institute suggested that products may emerge gradually from doing very similar pieces of contract R&D in the same field.

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[127] see 9.1.8.1 - Interview with Nick Carriero of Yale University Computer Science Department

[128] see 9.1.8.1 - Interview with Nick Carriero of Yale University Computer Science Department

> 'It's an interesting question - how often do you do repeat business before contract R&D become a product. If you do the same bit of contract R&D twenty times then it begins to look very much like a product. One way to migrate a technology from contract R&D to being a commercial product, which is a completely different business with almost nothing in common, is to do the same thing over and over again. I say that because the contract R&D business has a culture and a community of people in it whose interests are in "pushing the envelope", they have academic and scientific interests to "boldly go" - whereas in a products company everything's about the bottom line, and it's basically 99% marketing and sales and 1% yesterday's technology. It's likely that our organisation may split in the coming years, because of the cultural problems of keeping the products side in parallel with contract R&D.'[129]

Licensing a software system also allows the involvement of smaller companies which are not in a position to fund speculative research, or to conduct large scale in-house development, but may find the results of university research valuable. Penn's Jack system has been licensed widely, as well as receiving development funding from a number of governmental and private sponsors. Licensing helps to provide further leverage for research funding.

> 'we haven't got that much money off those firms for research, but we do get them for license fees for example.... so essentially they are buying into a research project without the investment... everyone benefits and there's no unknown there'.[130]

It is, of course, by no means certain that computer science researchers will wish to assist the university in gaining revenues from their work. They may feel that the public good, which is after all ostensibly a prime motivation, will be best served by making their work publicly available - and it seems likely that, in many cases, they will be right. Because, as discussed in 4.1.1.2, most computer technologies are non-exclusive, do not have the same degree of risk involved in their development as do, for example, pharmaceuticals and are less likely to make a crucial difference to a product's success in the marketplace if follows that the need to allow a company a monopoly on exploitation to make development worthwhile is less pronounced.

Alex Laats at MIT suggested that a technology which was licensed to a company was more likely to reach users than one which was placed in the public domain.

> 'Sometimes the value to a company is in preventing other people from making, using or selling.' In that case only a patented invention is valuable. Sometimes 'an inventor who thinks they are broadly disseminating their invention by not patenting it and letting it go free to whoever wants it are actually producing the opposite result because they don't have any commercial engine to distribute it. Putting something on the Internet, for example - the Internet is so big and there's so much on it, only those few people who are really keyed up to exactly what they are looking for are going to find it. It's not going to be widely distributed'

Some of the researchers surveyed had themselves made their work available without charge. Speaking of their decision to allow companies to implement their Cambridge Ring network design without paying royalties, Roger Needham said '*Our policy was that we wanted to see it used, not exploited'.* Similarly, Steve Reiss at Brown was adamant that, when he licensed a system to Digital, the charge was for his code, not the ideas and research behind it. Sun and Hewlett Packard were allowed to base their own systems on the same research, and no attempt

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[129] see 9.2.6 - Interview with Peter Moforth of the Turing Institute

[130] see 9.1.7.1 - Interview with Norman Badler of Pennsylvania's Center for Human Modelling and Simulation

was made to patent his ideas. Partly this was because this process would have taken up valuable time, but as he saw it

> ‘I'm in the business of producing ideas... I'm very happy when people pick up on my ideas and use them. If I patent them then that's less likely to happen. It depends how you want to measure success...'[131]

[131] see 9.1.1.4 - Interview with Steve Reiss of Brown Univesity Computer Science Department

## 5.3 UNIVERSITIES AND START-UP COMPANIES

### 5.3.1 POLICIES FOR THE ESTABLISHMENT OF 'SPIN-OFF' COMPANIES

A much publicised part of the technology transfer activities of many universities is the setting up of start-up companies to exploit technology licensed from the university. It was in regard to this activity that the biggest differences in policy between the institutions surveyed was observed.

MIT is well known for the part it has played in the formation of a large number of high technology companies, many of them in the immediate vicinity of Cambridge and Boston. Most of these companies were not set up as a direct result of efforts by the university itself, rather they may have been set up by former students or faculty members or simply attracted by the amount of expertise and specialist support in the area.

However, a substantial number of companies have been set up with the support and assistance of the Office of Technology Licensing. Their records show that over the period 1984 to 1993 technology transfer agreements created or assisted in the creation of a total of 64 companies. Fourteen of these companies were set up in 1988 alone. A number of such companies were based around computer technology, including Cirrus Logic and the now defunct Thinking Machines.

MIT's procedures include the routine examination of technologies to determine their suitability for start-up companies, and between 5 and 10% of all licenses are with start-ups. [MIT b] The ideal technology for a spin-off company has, according to Laats, several characteristics.

- It must offer a considerable performance improvements at comparable or better costs compared to existing commercial technologies.
- It should have at least some applications which can be easily brought to market, so as to generate an income stream and reduce risk. The closer the technology already is to commercial development the better.
- It should form the potential basis of a number of distinct product opportunities, to provide the company with scope for growth and development.

In addition it is very helpful if the inventor themselves is entrepreneurially minded, and has the skills and inclination to play a leading part in the commercial development of the technology. Laats suggests that MIT's track record has allowed the cultivation of a group of venture capitalists who are prepared to meet inventors and '*are willing to come on board because it is MIT*', at least the extent of giving the proposal serious consideration without requiring that elaborate business plans have already been set up.

Technological excellence is not enough the ensure the success of the new company.

> 'You need to have marketing and sales… you need to be able to identify the markets which are attainable for the resources you have and obtain profitability at a quick enough rate that you can capitalise on other markets. Once you have shown that ability then you can raise sufficient equity capital to enter into other markets, but all of the key is marketing and sales - the technology has to make a good sales story but if you can't sell it…'

> Another of MITs strengths is the 'MIT Enterprise Forum' - an organisation 'dedicated to starting new enterprises and helping new enterprises develop'. They provide seminars and training to help provide marketing awareness to technical people. The TLO itself will help an entrepreneurial inventor by drafting their own summary of 'potential markets, what we think the performance improvements are, what we think we can establish as an intellectual property position and use this to identify potential investors.' These investors help the inventor set up a management team - usually including 'someone who is more sales and marketing oriented who can work with the technical inventor to take the product to market'.[132]

MIT does not itself take a management role in the company, or seats on the board. They do not directly assemble management teams, and have no formal incubator site for use by the new companies. The role of the investors in establishing the business on a sound basis is therefore crucial. Usually these investors are specialist venture capital firms.

Licenses are concluded with these new companies in the same way that they would be with any other company, with the same kinds of royalty payments expected and no automatic free access to future MIT developments. However, a minority share in equity may be accepted in partial lieu of the initial licensing fee and the on-going royalties. Faculty have no numerical limit on the size of their personal equity holdings, but conflict of interest policies restrict some subsequent activities - for example they may not then accept consultancy from the company. [MIT b].

Many of the other American institutions studied had also been involved in the creation of start-up companies, although not with the same frequency as MIT. For example, Brown reported success with a closely linked company set up to develop a medical technique to treat Parkinson's disease. They licensed a technology to the company, for which they will receive royalties, have accepted a research contract from the new company to fund additional research in the university and have successfully liquidated their equity stake for more than $1 million.[133]

Yale confirmed the crucial importance of the entrepreneurial nature of at least one of the inventors as a crucial factor in deciding whether to move towards the establishment of a start-up.

> Usually the decision on whether to license a technology or form a start-up around it is easy. When inventors want to start a company, 'in my experience we take that seriously as an important opportunity'. Likewise, if no existing company can be persuaded to license but the technology seems viable then this is a strong option. The hard decision is faced when neither the inventors themselves, nor any existing company, are interested. Venture capitalists might then be approached 'but they're not going to do it unless they can get some kind of help, in terms of consulting or something like that, from the inventors' and so complex technologies cannot easily be treated this way. Yale has not so far started-up companies without the involvement of inventors, though the possibility has been examined on occasion.[134]

Harvard had the most conservative policies regarding the establishment of start-up companies. Its policies regarding acceptance of equity in (partial) lieu of license fees and royalties were in a state of transition from the prohibition imposed by the former President.

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[132] see 9.1.6.1 - Interview with Alex Laats of the MIT Technology Licensing Office

[133] see 9.1.1.3 - Interview with Bill Jackson of Brown University Research Foundation.

[134] see 9.1.8.2 - Interview with Henry Lowendorf of Yale Office of Cooperative Research

> There has been moderate activity with respect to helping launch start-ups, but Harvard's experience is certainly not as great as that of other universities, and nowhere close to MIT's. 'Financial risk issues aside, there's always the spectre of a real or perceived conflict of interest (COI) issue which arises in start-ups, where the involved faculty member's ongoing university research is the sole basis of the company's existence.' Walker believes the best way to minimise the potential for COI is to market the new technology to a firm or venture capital group in which the inventor is a disinterested financial party. Failing that, one might license the invention to a firm in which the university researcher's financial interest is 'not substantial.' Just what this latter term means is subject to a great range of interpretations. There are, of course, problems whatever course is taken. If a technology is successfully licensed to an existing company but the inventor is not prepared to champion the technology and work closely with the company, either for personal or professional reasons, then the discovery may not flourish.[135]

None of the American institutions surveyed were prepared to accept more than a small portion of equity in a company, or to become too closely involved in its management. A principle cause of this reluctance is a fear of the possibility of incurring product liability.

> Product liability is a particularly important issue 'which Yale tries to stay as far away from as possible'. 'The concomitant care is taken that we don't try to be involved in the company's plans - marketing and so forth' although they do ask for a business plan as evidence of the company's seriousness. 'We try to keep out of the company's business, partly because we're not experts in that and that's not our job, but partly to keep the liability question in the company's pocket'. This would be particularly dangerous in the case of a small company, where its limited resources might make Yale a tempting target.[136]

Jeff Solash at Penn echoed these comments. In the US product liability insurance is almost impossible to get and prohibitively expensive, whilst potential damages are likely to be unpredictably high. Risks involved in taking even a small amount of stock from a company must be balanced against the likely returns - which will of course only be realised if the company is eventually floated.[137] The uncertainty of the university's stake becoming liquid is another deterrent - he suggested that some institutions say

> '"To heck with small companies, 90% of them fail, they make all kinds of ridiculous demands, they give me stock, I don't care for stock, it's worthless - the best I can do is stick it on my wall and hope it goes with my colour scheme. I want cash up front, I'm going to license to big companies."'[138]

### 5.3.2 DIFFICULTIES FORMING START-UPS IN THE UK

The situation in the UK is very different. A review of innovation literature in [Bower] reveals that Britain files more patents per head of population than most comparable countries, and British technology is licensed extensively abroad - with the British Technology Group alone receiving $47 million in royalties during 1990, against $45 million for all US universities and research institutes combined. This is taken to suggest that Britain's record of producing, protecting and even internationally marketing inventions is excellent, however the performance

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[135] see 9.1.4.1 - Interview with Donald Walker of Harvard Office of Trademark and Technology Licensing

[136] see 9.1.8.2 - Interview with Henry Lowendorf of Yale Office of Cooperative Research

[137] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

[138] see 9.1.7.2 - Interview with Jeff Solash of the University of Pennsylvania Technology Transfer Centre.

of British companies in licensing and successfully marketing such inventions is far less impressive. The fact that 80% of the BTG's revenue in 1993 came from abroad [BTG] supports this suggestion, although because the BTG no longer has a monopoly over technology licensing this datum probably represents an overstatement of the overall proportion of overseas licensing activity, given that universities are more likely to rely on in-house expertise when licensing technology domestically.

The main limiting factor on the establishment of small, innovative high technology companies, including these based on technology explicitly licensed from universities, is usually taken to be the shortage of investment capital available to such companies. Compared to Germany or Japan the real cost of capital is significantly higher in the UK, meaning that corporate investment in long term projects, including research and development, is less attractive. However, according to the figures cited in [Bower], capital was in general no more expensive in the UK than the USA.

What does differ is the amount and nature of capital available to start-up companies, particularly in technological areas. According to a report by the British Venture Capital Association [The Financial Times, 23rd September 1994] in 1992 just £91 million, representing only 7.4% of total venture capital investment in the UK, representing, was invested in companies working with high technology and the life sciences. Although the overall amount increased substantially in 1993, most of this went to buy-outs and later stage expansion - and the total start-up and early stage investment fell further to just £69 million. This erosion of early stage funding is caused by the companies' preferences for larger investments in order to minimise overheads and where venture capital is available for high technology start-up companies, it often comes from foreign sources. The same article suggests that venture capital funds specialising in high technology companies themselves find it very hard to raise money. The UK's tax regime is such as to make pension funds a very attractive investment mechanism - and pension fund managers are understandably unwilling to invest in start-ups.

A survey conducted by the US Small Business Administration, and cited in [Bower], reveals that private investors, often refereed to as 'angels' are the major source of external equity capital for start-up firms - investing '*at least two or three times the $4bn invested annually by US venture capital managers*'. Such investments are usually in very small firms, and are spread between a few individuals who hold their investments for around five years and also make their business expertise available to the company.

[Bower] also includes a comparison between the availability of public development capital for small to medium firms in the UK and US. This concludes that trading volumes and liquidity were far lower on the British USM (Unlisted Securities Market) than the US NASDQ, and the range of listable companies smaller, making the main potential method of liquidation of equity the private sale of the entire company. This obviously limits the attractiveness to investors of holding such initial stakes.

Britain has been addressing these problems, with the imminent replacement of the USM by a new mechanism, the Alternative Investment Market (AIM), and relaxation of rules for listing so that a forecast of profit within a year, impossible for companies which have not yet brought products to market, is no longer required. Another new initiative establishes Venture Capital Trusts (VCTs) with special tax status to encourage private investment in unquoted companies. The VCT itself is fully listed, providing liquidity to the private investors involved. Another scheme, the Enterprise Investment Scheme, launched in 1994, provides tax breaks to direct investment in trading companies but has so far met with little success in encouraging start-ups.

[The Guardian, 30th May 1995]. The government's SMART scheme, described in section 2.2.2.4, provides funding to support innovative small companies. A European market tailored to small companies, comparable to NASDAQ in the US, is currently under discussion.

There may also be a cultural element at work. Because start-up funds are harder to raise, potential academic entrepreneurs are less likely to be aware of successful ventures by their colleagues. This might contribute towards a greater reluctance to take risks and cause involvement in an unsuccessful company to represent a greater stigma on future careers.

These general problems is raising start-up capital were reflected in the experiences and attitudes of participant institutions. Cambridge University is well known as the centre of a major concentration of around 1,200 small, innovative companies.

> The Office deals with a 'steady trickle' of start-up companies, and is usually involved in two or three at any given time. There are two local seedcorn venture funds - the Cambridge Quantum fund and Cambridge Research and Innovation Ltd, which 'I'm afraid in Britain this is almost a unique resource - the shortage of funds needed to get over the so-called development gap is as bad as ever.' A number of companies have been set up with the help of these funds, with stakes also held by Lynxvale on behalf of the university and by the individuals themselves. Equity stakes are now held in around ten companies, and the rate of activity is increasing.[139]

In as much as it was possible to assist in start-up activity, Jennings' considerations seemed similar to those of his colleagues in the US.

> 'You need a platform of technology within a company which you can spin products off from - you can't base your companies around a single product approach. It's always been the problem in Cambridge - you set up a company with a nice bit of technology, well what do you do for an encore? That's one of the major weaknesses of many high-tech companies.'

In particular he identified biotechnology, an area where Britain's industrial presence has conspicuously failed to reflect its strength in academic research or pharmaceuticals in general, as a field of growing strength, to some extent replacing the computing and communications companies of the 1980s as the major source of local growth.

> Currently attitudes towards biotechnology in the UK are 'optimistic but realistic' and there has been a lot of interest in the area recently. An advantage of the shortage of venture funding in the UK has been that those companies which have managed to raise funding are in general well conceived and attractive to investors - in contrast to the American situation where during a period of optimism and hype large number of companies were started without good prospects in the longer term. In his view 'we are getting increasingly more intelligent investors, it's fairly slow but it is onwards and upwards' - and people now realise the need for companies to have a strong technological base.

Peter Schaefer, of Manchester's exploitation company Vuman, suggested that conditions were so different between the UK and US that, interesting as the experiences of American universities were, there was little chance of applying them directly.

[139] see 9.2.1.1 - Interview with Richard Jennings - Cambridge Industrial Liaison and Technology Transfer

> 'it's very hard to draw analogies... there's such a different culture, especially in the investment community, that's it's very difficult to apply that over here. People there are very much less concerned about risk, they realise that risk is necessary and that if you're going to risk then failure is inevitable in a number of cases - you play the percentages. Universities don't like risk, venture capitalists don't tend to like risk, there is not much of a market in start-up funds. Making the investment and managing the investment is out of all proportion to the return which you are likely to make in the early stages.'[140]

### 5.3.3 UNIVERSITY OWNED TECHNOLOGY EXPLOITATION COMPANIES

Such a lack of available private investment for start-up companies restricts the options available to British universities.

As noted in section 3.2.1, British universities have established their own model of technology licensing in which a wholly owned university company takes responsibility for all technology licensing activities, and in some cases establishes subsidiaries to market university expertise and to exploit university technology. This is in direct contrast to the American institutions surveyed, none of which were prepared to consider licensing to a company in which they held a substantial stake.

> 'In the model emerging the university will set up a separate wholly owned subsidiary company that will undertake technology transfer - the people in that company will be working full time on technology transfer and in many cases it will mean that they are paid a living wage, they won't be tied to academic salaries. Sometimes those companies try and raise their own seed-corn venture capital funds. It's interesting that perhaps the universities doing this, following the US pattern by employing full time professionals, are in some ways more adventurous than some US universities. We have more of a free hand in deciding what is worth licensing to industry - if you like we're more commercially driven....'[141]

Section 5.3.1 made clear that a major motivation behind the reluctance of US universities to own, or become directly involved in, spin-off companies was the risk of incurring product liability. Due perhaps to differences in the legal situation in the UK (including the general tendency to the award of much lower damages) and a culture which is in general less litigious, no such fear was in evidence at the UK institutions surveyed.

> 'Legal entities are legal entities... and unless there is fraud, dishonesty or anything else like that then the liability remains with the company.' [142]

Manchester's exploitation company, Vuman, had set up ten subsidiary companies, all but one of which retained the University as the major owner. Most of the companies were set up to exploit university expertise and facilities rather than particular technologies, though one was based around a set of patents and another around a suite of software. Another divergence from American practices came with the minimal involvement of faculty as stakeholders, which occurred in only one of the subsidiary companies. Surplus profits from the companies were transferred back to the departments involved.

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[140] see 9.2.3.1- Interview with Peter Schaefer of Vuman (University of Manchester)

[141] see 9.1.4.2 - Interview with Peter Williams of Harvard Medical School Office of Technology Licensing and Industry Sponsored Research. (Formerly of Newcastle University).

[142] see 9.2.3.1- Interview with Peter Schaefer of Vuman (University of Manchester)

The Turing Institute in Glasgow has been through several incarnations, including a spell as a commercial, for-profit, company and is now a non-profit contract R&D organisation owned jointly by the University of Glasgow and the Glasgow Development Agency - the University's investment takes the form a repayable loan for a fixed sum. This dual status allows it the flexibility to gain the advantages associated with being part of the university as well as those reserved for companies, giving a considerable advantage in the marketplace.

> These advantages include cheap accommodation, low cost network access and IT infrastructure and access to graduate students. 'We're a small company - at the moment we only have seven members of staff, although there's quite a number of PhD students.' Their links with the university give them advantages comparable to those enjoyed by members of a huge corporate research lab, such as access to experts in a vast number of fields, but with none of the massive cost overheads which such organisations entail for their parent companies.
>
>> 'Depending on where you're coming from you can see the organisation in different ways. One way of reading the articles and memoranda is that we are a part of the University, and that is very important because it means that success that we have in winning R&D moneys, in publishing papers and running PhD students are counted within the University's success, and as such they get a better score in comparative studies with other universities... and they get a larger block grant. That's the main benefit that they see out of it. As far as we're concerned we have this access to cheap labour and cheap infrastructure, it's symbiotic - quite mutual.'
>>
>> 'However, when we talk to commercial companies it is very important to stress that we are an independent, commercial company and we tend not to stress the university involvement. I'm not talking confidentially here, because a lot of other organisations do this, but when we talk to suppliers about getting equipment and they say "Are you part of the University?" we say "Oh yes, we're part of the University", because you get your academic discount. There are other sums of public money which you can only get access to if you're a commercial company - universities don't have access to that, we do. Basically you're dealing with an organisation which has a big hat rack: some commercial and some academic. Every new situation that comes along you adjust your presentation to optimise the amount of resources that you get. It's very simple.'[143]

This also serves to expose what is perhaps a more fundamental difference in attitudes between the British and American approaches. As shown earlier in this chapter, American policies (and legislation) stress that technology transfer should be undertaken for 'public good'. The American emotional commitment to the appearance of a free market makes private investment in small, innovative firms based round university technology very much a Good Thing - these firms then create jobs, wealth and demonstrate returns to the nation from its investment of public funds in universities. Universities are already involved in political lobbying to preserve their IPR assignments, and do not wish to be seen as employing their public funding to gain competitive advantage for subsidiaries, not least because this might compromise their non-profit status.[144]

In Britain, by contrast, universities, like hospitals and schools, are being asked not only to serve the needs of the market, but are themselves forced to participate in pseudo-markets designed to engender the relentless seeking of opportunities to maximise resources. Signs that universities

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[143] see 9.2.6 - Interview with Peter Moforth of the Turing Institute

[144] In conversation with me, an MIT professor not involved in the study itself suggested that this motivation is in fact more important than the fear of profit liability in detering many universities from owning their own comanies.

are becoming entrepreneurial and seeking profits are therefore politically desirable rather than inflammatory.

This is undoubtedly a simplification of the range of attitudes which exist within the two countries - discussions on the Techno-L electronic forum suggest that some institutions will go much further than others in terms of ownership and management of start-up companies, and indeed this is the subject of the next conference of AUTM (the professional body for technology transfer officers in universities). However, at least with regard to the participants in this project it does seem to be a generalisation with a degree of validity.

# 6. CONCLUSIONS

This chapter is intended to briefly outline general conclusions which can be drawn from the material presented here and to go some way toward evaluating and setting in context the utility of the results obtained. Because of the large numbers of different topics addressed during the course of this report, and the diversity of participants involved in its research, no attempt to summarise all of the observations during the course of the report is made, and so in this sense conclusions are also distributed through the previous chapters. Suggestions for future research are made, and some of the more general aspects of academic and industrial organisation on which future development of research interaction rest are identified.

## 6.1 LIMITATIONS OF METHODOLOGY & POSSIBLE FUTURE WORK

As can be clearly seen, the methodology employed in this project was qualitative. Wherever possible findings have been supplemented with the results of other studies, particularly where these involve quantitative data, but this can only be a partial substitute. In particular, there seems to be a lack of hard evidence relating to research interaction between universities and industry in IT in the contemporary period. Recent studies seem to address themselves far more towards the chemical and pharmaceutical sectors.

The selection of academic institutions which participated in this study was somewhat restrictive. A policy of concentrating on well known and successful research institutions was vindicated in as much as it revealed a wide range of well established systems of research interaction and led to the participants of a number of individuals and offices which are highly respected by those working in the field. However, these participants were, for that very reason, clearly not representative of academic institutions as a whole - many of them enjoying considerable advantages in terms of prestige and quality of research which probably had a profound effect on the kinds of involvement which appear attractive to industrial partners.

Building on the broad insights into research interaction derived from this project, a complementary approach which would address this weakness might be to concentrate on a number of institutions of different types to be found in geographical proximity - for example in and around Boston, London or Manchester. Such institutions all share the same base of potential industrial partners, and the range of different styles of interaction which different classes of institution had evolved could be profitably compared. More specific conclusions might then be drawn as to the models most appropriate for specific institutions.

Similarly, the range of companies participating was limited, although approaches were made to a number of smaller companies during the course of the project. A more geographically focused study would permit the examination of a wide range of different firms operating in a specific areas, and might include a questionnaire based survey to form the basis of a rigorous attempt to identify different industrial models of interaction.

Basing original research on loosely structured interview, and making use of direct quotations, might be seen as introducing an unfortunate degree of subjectivity and individual personalities into this study. This may, however, be seen as its primary strength - participants were intelligent, educated people whose professional communities are (primarily in some cases, secondarily in others) deeply concerned with issues arising from university industry research interaction. By investigating not only participants' personal experiences and formal institutional polices but also their opinions as to more general issues it has been possible to indirectly include the experiences and attitudes of these wider communities and so to provide a richer and more substantial account than would have been possible had a less flexible methodology been adopted. Furthermore, the findings of any research based on a sample of this size must inevitably be shaped by the personal experiences and particular quirks of its participants - by systematically quoting them and rigorously referring back to the approved summary this has been made explicit and transparent.

Allowing participants the option to modify, and indeed censor, their comments after the conclusion of the interview might be argued to undermine the independence of the research process. This view is mistaken: not only was this essential to obtain involvement of many of the participants, but it also has in many cases increased accuracy and coherence of the summaries presented here, and where participants have had cause to remove controversial comments this has, at least, had the virtue of better presenting institutional policy. Given that the interviews were conducted 'on the record' and interviewees were therefore aware when speaking of the need for diplomacy, such distortion was in any event present in the original exchange itself.

## 6.2 OVERALL FINDINGS

The most general conclusion to be drawn from this work is the primary importance of long term and informal cooperative links and active research collaboration to successful research interactions between universities and industry in the computer science field. Many areas of computer science research can, by their very nature, benefit from the involvement with 'real world' concerns and demands which collaborative research brings, and the most successful relationships would appear to be those in which both partners concentrate on doing the things which they are best at within a framework which has been designed to make explicit and satisfy (possibly with different end products) the needs of both. Because much computer science research is simultaneously both fundamental and has direct potential for application, there are at least some fields in which real and under exploited potential exists for mutually beneficial interaction.

It must also be recognised that some valid and necessary fields of academic computer science research do not offer the prospect of likely returns on industrial investment and so cannot be expected to be funded by industrial sources; also that many R&D activities perused by companies are not suitable for contracting to university development teams. A widespread shift towards secret and proprietary development work in universities, seen by American participants as a possible future scenario and by some British participants as a goal of current government policy, would not serve the long term interests of either partner and seems unlikely to occur in recognised centres of research excellence. Whilst there are factors in traditional academic culture which might mitigate against even rewarding and valuable collaboration with industrial bodies, concerted attempts to impose industrial culture on academics are likely to prove counterproductive for a variety of practical reasons. A career in academic research can only be embarked upon by an individual talented enough to obtain considerably greater remuneration in the industrial sector, but temperamentally unattracted to, and quite possibly unsuited to, such a role. Forcing universities to become cut-price contractors of industrial research would only serve to drive such individuals into genuine industrial careers.

Because cooperation with firms involves the establishment and maintenance of a wide range of personal, and often informal, relationships there is an increasing overlap between industrial liaison and development roles. All industrial spending is becoming more tightly focused, and donations will often be made to support specific research. Although the kinds of contacts with industry cultivated by researchers might seem very different from the alumni-centric approach of much traditional development work, as both come increasingly to rely on long term, mutually beneficial, relationships the gap is narrowing. Furthermore, although activities might be viewed in different ways, I suspect that on a practical level what is perceived by a development officer as systematic exploitation of alumni loyalties is not always so very different from the way in which an academic might maintain contact with a former student or colleague working within industry via the normal processes of professional networking. Motivations and labels are different, but results might be similar.

In general the degree of similarity observed between the opinions and experience of UK and US participants was startling. This convergence has perhaps become more pronounced during the last decades as universities in both counties have gained responsibility for their own technology licensing and British universities have become more reliant on project based research funding. Policies regarding the role and ownership of start-up companies, and the importance of university ownership of IPR to sponsored research were the main areas of divergence, and as explained previously, these policies are reactions to differing conditions in the wider environment.

The formal licensing of patentable technology does not seem to be of great importance for computer science. Whilst software licensing is quite widespread, this provides the recipient with savings in development times and cost, rather than being a payment for the rights to use particular research findings or concepts. Rather, sponsored research, recruitment and consultancy would appear to be the main vectors for the transfer of technology, which is in most cases substantially composed of tacit knowledge and expertise. This is to some extent due to the difficulties in protecting and licensing algorithms and basic computing concepts, and to some extent to cultural traditions of the free distribution of software and ideas, and so it is possible that the formal licensing of IPR might in future become more important and legal mechanisms become better established.

Thus although computer science is like that paradigm of technology transfer, biotechnology, in that university research may have potentially important and immediate commercial implications, it differs in that mechanisms for licensing and exploiting the most important findings are only weakly established. In addition, the computer industry has now matured to the point where greater divergence is apparent between the kinds of research being conducted in universities and that conducted in companies, and because computer systems are so complex and involve many interdependent technologies the importance of any particular piece of university technology is likely to be marginal to the commercial success of a major product. The proportion of overall computer research and development conducted within universities is now such a small proportion of overall activity (compared to the expenditure of firms such as Intel) that key future technologies cannot reliably be expected to develop to a patentable state within universities, and this consideration also strengthens further the suggestion that university research maximises its utility by complementing, rather than by substituting for, industrial research and development activity.

## 6.3 BROADER ISSUES AND LIKELY FUTURE TRENDS

Participants had differing views as to whether changing patterns in corporate organisation were likely to lead to an overall greater contribution to the funding of university research via a greater reliance on ‘outsourced’ work, or simply to a similar or diminished total spent far more carefully. Empirical studies of the implications of the process seem to be sparse, and as discussed previously the computer industry is undergoing a particularly profound set of transitions which have changed it beyond all recognition during the past decade.

The future importance to universities of industrial research interaction will be determined by more general changes to the nature and role of the university. Politicians on both sides of the Atlantic no longer accept that universities repay society simply by delivering trained individuals and an output of research papers. In Britain, of course, the government has far more control over universities and is engaged in a process of fundamental change the outcome of which is still far from clear. It seems likely that greater specialisation of institutional roles will result, with some institutions specialising in teaching, some in traditional research, some combining both roles and perhaps some reliant on industrial funds for applied research and development to preserve even minimal research activity

Current debate as to the acceptability of restrictions on publishing and on ‘secret’ industrial research seem likely, at least for non-elite institutions to be settled by market forces. However, it cannot be assumed that universities are a particularly suitable place for most such research to take place and, whilst pragmatism on both sides might lead to the consideration of such arrangements, any regular need for development expertise on a contract basis might be better handled by private research organisations which are oriented solely to such work. The continuing development of university owned technology and expertise exploitation companies might give universities a substantial role in such organisations.

US participants felt that the university sector was likely to see a general ‘shakeout’ in coming years, the current rate of tuition increase being unsustainable and student numbers insufficient to cover costs in a climate of governmental cuts. Weaker institutions may close or merge, and general cultural changes spread across the system. However, leading departments viewed modest shrinkage (especially in numbers of graduate students) as a possible fate but did not envisage a need for radical changes of direction. Some suggested that unrealistic expectations of industry as a saviour of research funding were held in some quarters. In the UK, a more radical reorganisation was underway, and some participants speculated that many institutions might be forced to reorganise along corporate lines and to adopt an entrepreneurial and market driven approach at the highest level.

Research funding, from both government and industry, has become far more focused than previously. The former, although still very much more important, was perceived by participants as in decline - in the US this decline is relative to the previous rapid growth of computer science and may do no more than to put its funding on the same basis as that of other scientific fields. In the UK this decline is, for many institutions, absolute. A result of the emerging funding patterns is an increased perception of the importance of industrial funding: whilst amounts involved may not increase they are seen as relatively more important and, perhaps more importantly, governmental funding directed towards ‘relevant’ and ‘exploitable’ areas of research can be obtained much more easily with proven industrial funding as proof of virtue.

It seems likely that these new patterns will require more flexibility from researchers and institutions. Whilst most of the institutions which are most successful in this new climate are likely to be those which already enjoy a strong reputation for research and a good degree of name recognition - these qualities being attractive to industry just as they are to other funding bodies - there may be opportunities for institutions which react faster and with more flexibility to whatever opportunities present themselves to improve their relative standing. As several participants observed, both former and emergent patterns of funding represent the rules of a game which must be played. Different strategies and organisational patterns constantly evolve to maximise returns from this game, but under neither set of rules is anything as abstract as ‘academic freedom’ the prime concern of those signing the cheques.

# 7. ABBREVIATIONS

| | |
|---|---|
| AI | Artificial Intelligence |
| AIM | Alternative Investments Market (UK) |
| ARPA | Advanced Projects Research Agency (formerly DARPA) |
| AT&T | American Telephones and Telegraph International |
| AURIL | (Successor to UDIL - UK group for technology transfer and industrial liaison managers within universities). |
| AUTM | Association of University Technology Managers (US) |
| BTG | British Technology Group |
| CASE | Cooperative Awards in Science and Engineering. |
| CBI | Confederation of British Industry |
| CEST | Centre for Exploitation of Science and Technology |
| CS | Computer Science |
| CS&E | Computer Science and Engineering |
| DARPA | Defense Advanced Projects Research Agency (now ARPA) |
| DEC | Digital Equipment Corporation |
| DOD | Department of Defense (US government) |
| DOE | Department of Energy (US government) |
| DTI | Department of Trade and Industry (UK) |
| EC/EEC | European (Economic) Community. (Now EU.) |
| EPSRC | Engineering and Physical Sciences Research Council (UK) |
| ESPRIT | European Strategic Programme for Research in IT |
| EU | European Union (successor to EC, EEC) |
| EUREKA | European Research and Co-ordination Agency |
| GAO | General Accounting Office (US) |

| | |
|---|---|
| HEFCE | Higher Education Funding Council for England & Wales |
| IBM | International Business Machines |
| ICL | International Computers Limited |
| ILP | Industrial Liaison Program (at MIT) |
| IPR | Intellectual Property Rights |
| IT | Information Technology |
| KBS | Knowledge Based Systems |
| KSR | Kendal Square Research |
| LINK | (Although LINK is always capitalised it does not appear to stand for anything.) |
| MIT | Massachusetts Institute of Science and Technology |
| MOD | Ministry of Defence (UK) |
| NASA | National Aeronautics & Space Administration |
| NASDAQ | National Association of Securities Dealers Automated Quotation national market system (US) |
| NRDC | National Research and Development Corporation |
| NSF | National Science Foundation (US) |
| ONR | Office of Naval Research |
| OST | Office of Science & Technology (UK government) |
| PARC | Palo Alto Research Centre (Xerox facility) |
| R&D | Research and Development |
| SDI | Strategic Defense Initiative ('Star Wars') |
| SERC | Science & Engineering Research Council (precursor to EPSRC) |
| SMART | Small firms Merit Award for Research and Technology |
| TLO | Technology Licensing Office (at MIT) |
| UDIL | University Directors of Industrial Liaison (replaced by AURIL) |
| UFC | Universities Funding Council - precursor to HEFCE |

| | |
|---|---|
| UGC | University Grants Council - precursor to UFC |
| USM | Unlisted Securities Market (UK) |

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# 9. APPENDICES

## 9.1 UNITED STATES INTERV IEWS

### 9.1.1 BROWN UNIVERSITY

#### 9.1.1.1 Eugene Charniak - Computer Department Chair

**Interviewes: Eugene Charniak**
**Job: Chairman, Computer Science Dept**
**Organisation: Brown University**
**Interviewer: Thomas Haigh**
**Date: Monday, 19th September 1994**
**Location: Brown University**
**Revision: 1**

The bulk of the CS department's funds still come from the government, which is able to take a 'more long term' view than companies, and unlike them is not looking for an immediate return on its investment or for exclusivity agreements to create competitive advantage 'which of course is completely anthietical to everything which universities believe'.

However, there are attractions to industry in investing in universities. For example,

> *'although it's not ethical to say to your students "Go to company X", if company X has a bigger presence in your department, with their people coming round more often, then that presumably has something to do with attracting students... they get this idea that company X is doing really interesting work.'*

Some of the work done at Brown, particularly software, is directly applicable enough to attract industrial funding.

> *'The company feels that even if they don't get exclusive use of this stuff they will be in a better position to commercialise it than any of their competitiors would be.'*

> *'Industrial money does come, but it's not a huge source. One of the key reasons, from my vantage point, for encouraging industrial relations is that it means to the governement that you're not some ivory tower intellectuals. That's probably the core benefit that a university gets out of industrial funding - it helps them to look legitimate. I would say that the second most important thing is that it helps them to be legitimate - and we actually do get some feel for what's worrying people in the "real world". Even if you choose not to work on those, I think you should at least be aware of what you're choosing not to work on. The last and least important benefit is the money.'*

The most important direct benefit is donation or subsidised purchase equipment. *'It is certainly very helpful if a company like Sun will make special deals with universities... in general terms equipment and maintainence are probably most of what we get out of industry.'*

Is this compatible with Bill Jackson's comments that equipment grants are usually undesireable? The contradiction is

> *'more apparent than real... We've actually gone through several interations on this question - at one time we were really looking to build up our equipment, so we would take pretty much anything that anyone would give us. This turned out to be a bad idea because it meant that we were operating on five or six different operating systems and the maintainence people were just going nuts.... We then went to the other extreme which is basically saying that "There's only one platform that we will allow in this department" - we obviously couldn't expect any one vendor to give us enough machines for the entire department but we could and did try to organise a sort of competition among the vendors so that we would get the best possible deal... and that tended to work very well.'*

Currently a modified version of this strategy is in place - the departmental support and administration team only work on Suns but '*if you have anything else then firstly you've got to get approval, and secondly it's up to you to maintain it.'* In practice other platforms are found in specialist areas - for example the graphics team use Silicon Graphics machines; the system also allows the flexibility, for example, to ensure that IBM sponsored work can be ported to an IBM machine. '*The net result is that by and large we're pretty much a single vendor site and when people offer us equipment we politely say "No thank you.*"'

One advantage of industrial funding is that there may be '*fewer restrictions'* on its use. '*There's more restrictions on making sure that it's spent on that project that the sponsor cares about, but within those projects there's often less restrictions on precisely where it goes*.'

How much does Brown's reputation help it in its dealings with industry?

> *'That's a good question and I'm not sure what the answer is. First reaction is that it's probably secondary - mostly these sort of things work because of particular individuals rather than group reputation. If you have an individual who is super-dooper at X, and further more is a good sales person, that works a lot - and that person can then bring in things even if the rest of the department is medicore. Obviously it helps if the rest of the department... is also very good.'*

Would he agree with the observation, made by several interviewees, that whilst the proposed deal itself may be judged on its merits the reputation and contacts of a prestigious institution are very helpful in being able to contact the right people in the first place.

> *'I would agree with that, but at the same time I would make a distinction between how a development office views this sort of thing from how the department views this. Development offices are used to thinking in terms of alumni, and what they are selling is benefiting the university on the basis of shared experiences. Computer science departments don't think in those terms, but in a way they do the same thing. It certainly doesn't hurt, in fact it helps a lot, if your alums are at this particular company - they are your natural entry point. Sometimes you'll get money from a company just because you do have alums there - a company says "Gee, we've had a lot of really good people from X, maybe we should throw a little money at them."'*

Whilst academics view the making and maintaining of contacts as an intergral part of their professional life, rather than primarily as a source of funds, they may build up similar relationships to those cultivated by development officers - though of course alumni working at a company with no interest in the department's work will be unable to help.

Has Brown found itself in situations where companies have sought to negotiate research agreements involving unacceptable terms? '*Yes... they want us to do some research and basically give them control over the results, and we had to say no. A lot of of companies seem to be aware that you're going to say "no" and adopt slightly different policies*.'

Is it likely that growing financial problems may cause weaker institutions to modify their policies in such areas?

> *'I would say even stronger ones might, it's easy talking to you to take a holy position, but if someone waved a very large cheque in front of me I might reconsider. In my experience, though, companies don't wave cheques that large anyway - so probably it's not a situation that's ever actually going to occur.'*

Is it possible that change could be forced on universities as radical as that undergone by corporations in recent years?

> *'If funding really dried up, what would that mean? It would mean less PhD students, it might mean that universities would have to teach more, it might mean that departments would shrink. Probably it's not going to mean anything like what happened to IBM - Brown University is not going to shrink by a half. If funding really dried up enormously, perhaps a science department go from sixteen to fourteen... money is a shade harder to get these days but it's still out there, my guess is that there is still as much out there, it's just that there are more people going after it.'*

Some specific sorts of funding, such as support for academics during the summer, are becoming much harder to find.

### 9.1.1.2 Maurice Herlihy - Computer Science Department

**Interviewee: Maurice P. Herlihy**
**Job: Associate Professor (research in concurrency, etc.)**
**Organisation: Brown University**
**Interviewer: Thomas Haigh**
**Date: Monday, 19th September 1994**
**Location: Brown University Department of Computer Science**
**Revision: 1**

Maurice Herlihy is familiar with University/Industry interaction from both sides - having spent five years as a professor at Carnegie Mellon University before spending time at Digital. At Digital, support for academic research was primarily through grants of equipment - to support a research team in a university his organisation '*needed to come up with 5% of the book value*' of the equipment. The remainder was made up by a central subsidy - though as actual costs are secret the extent of the subsidy was unknown to the group, and tax-writeoffs are based on the book-value. '*By and large this wasn't considered very expensive*' - though it has now been cut severely. Groups supported in this way would be carrying out research relevant to that being carried out by his own group. Some engineering groups at DEC also made similar grants - '*perhaps more so because we were a research laboratory, so there was a presumption that we should be doing our own research.*'

Was there a bias towards in house research?

> *'It had to do with what people thought was interesting to do. If it was of strategic long-term importance then the in-house research laboratories would have the resources and time to work on it' - for example Multimedia. 'If you really think it's of strategic importance then you don't give a handful of workstations to an academic somewhere with high hopes. In some senses we felt we had our hands full doing internal technology transfer. The support for academic research was viewed as a long-shot that you don't put much money into, but it was somewhere where a little bit of money could have a big pay-off.'*

How distinct are different types of research activity? '*The perspective within industry is that a lot of what people in industry call research is actually more advanced development.*' This kind of production quality work is hard to do in a university, not least because of shortage of labour for such work. '*The National Science Foundation and so on have over the past few years had an increased emphasis on deliverables, which has had the effect of pushing research into a more applied area - it's hard to get funding for pure theory these days'* without at least a suggestion of an application. This increased emphasis on applied aspects of work has not primarily been a direct result of industrial research funding.

How fundamental are the changes produced?

> *'It is producing a real culture change in computer science, because for a long time computer science was going through this almost inflationary growth... now it's hard for students to get jobs when they graduate. [Academic] departments are full... and with the exceptions of companies like Microsoft and Intel everyone else is in deep trouble or heading that way very quickly.... Computer science is going to become much more like mathematics or electrical engineering.... so there's going to necessarily be a lot of readjustment and belt-tightening.'*

Has there previously been a stigma attached to industrial projects in academic circles?

> *'I think here, if you look at the parts of academic computer science that are most prosperous and happy, they tend to be things like hardware systems work, operating systems - the very applied engineering work with very little mathematical basis. Theoreticians, people who design languages and so on are very much viewed as poor relations. At Carnegie Mellon people used to go on about the "theory tax" as theoreticians didn't bring in enough money to support themselves... and I don't think there's any stigma attached to bringing in large amounts of money.'*

How will the changes in corporate culture and organisation alter the way in which they perceive the value of university links?

> *'Well it's always been a value for money thing - but the question is how can you evaluate this. In places like Digital and IBM there are two conflicting forces at work - one is a very strong pressure to contain costs in the short term, the other is the sincere realisation of top management that the only hope of these large companies of surviving is to discover these high-overhead applications and to be in that market before everyone else is. On the one hand research is expensive and hard to evaluate - but if you don't do research then basically you're going to end-up building washing machines. The profit margins on building PCs are so razor thin that you can't support a company of the size of Digital or IBM. Research is at least touted as being the best way to do this - whether it is or not is somewhat mysterious.'*

Is there a simple distinction between basic (pure) research which universities can conduct, and applied research (development) which companies should undertake? Actually the situation is not this simple - '*Universities clearly cannot do serious development work, because they don't have the resources, but they can certainly do research in engineering areas - things that are not pure at all, you might produce a prototype of a system which isn't of production quality*.' For example, '*the people who made RISC famous were working primarily at Berkeley and a few other places in California*.'

Massive collaborative projects such as OSF have been attempted in the industry recently - can universities provide additional leverage of research funds? '*OSF1 is kind of a mixed bag.... I think it's still in some sense up in the air.... It looks promising but the jury is still out.... On the whole MCC doesn't seem to have been so impressive. US Memories seems to have worked out well.*'

> *'Companies like Digital and IBM are going to be increasingly concerned with survival. Companies like Microsoft do have research laboratories, but it's uncertain how much is genuine research and how much is advanced development.... Unless big companies find some way to make big money in a way that isn't going to be over-taken by the next generation of personal computer then research may end up being thrown out along with everything else in a desperate attempt to stay solvent so it's very hard to tell. People I know at IBM are getting a lot of pressure towards the applied and to justify themselves.... Research is such a high risk undertaking that nobody really understands how to make it work right - it's pretty much that people work and hope that they do something right. It's very hard to evaluate - you can retroactively point to things that went well and were successful, but the successful things don't always make money for the company who did it.'*

> *'At Digital I wish I had a dollar for every meeting I had to sit through about technology transfer and evaluating the effectiveness of research. People come up with these theories - they claim that every researcher on average has to increase the revenues by some millions of dollars to be cost effective. One of the things which research can do is go around telling people that the company's going to make a big mistake. There are a couple of instances, for example, where Digital wanted to do something and researchers went around saying "you shouldn't do this, it's not a good idea"... but it's hard to say how much money you make by not doing something which would be disastrous'.*

However, the situation may change. '*Prosperous companies will do research, and the more prosperous the company the more basic the research will become - and the less prosperous the tighter the constraints on the research will be. As far as effectiveness goes it's very hard to tell if a place where they don't ask tough questions produces better research than one where you have to account for every moment of your time*.'

Is it reasonable for researchers to expect industry to 'make up the gap' in government funding?

*'I think that's naive - industry is not going to come to the rescue of academia. The places that have large research organisations have their hands full managing internal technology transfer among people whose salaries they pay and who they can fire if they're not happy with them - and so the likelihood of these people going to decide that it's better to talk to a bunch of independent minded, remote academics seems extremely remote.'*

*'Jim Morris, who was head of the department at Carnegie Mellon and used to be at Xerox PARC, claims that successful companies have always stolen their technology, and that Apple was a big success because they stole Xerox's technology - if they had developed it in house they would have had to take the good along with the bad and it never would have worked, but because they could ruthlessly select the good parts the Macintosh was a success. You might make an argument that successful, lean, companies aren't going to do research and it would make sense for them to hire out research the same way a lot of companies now hire out a lot of stuff that used to be done internally. It sounds sort of plausible - but I'm sceptical. I'm willing to believe that they will take successful ideas, I'm not so convinced that they're willing to actually pay to develop them in the first place.'*

#### 9.1.1.3 Bill Jackson - Brown Research Foundation

**Interviewes: Bill Jackson, PhD**
**Job: President, Brown University Research Foundation**
**Organisation: Brown University**
**Interviewer: Thomas Haigh**
**Date: Monday, 19th September 1994**
**Location: Brown University**
**Revision: 1**

Brown University Research Foundation has a contract to manage the Intellectual Property of Brown University, including patents, copyrights and trade secrets. Brown has a separate office of 'Research Administration' which handles all external research contracts. '*I get involved in the negotiation of the terms of those contracts if it involves industry.*' Outright gifts are handled by a separate Development office, with which he is only involved when Intellectual Property rights are expected in return.

The technology licensing and sponsored research functions, although assigned to different offices, not wholly distinct - *'The licensing part often leads to a grant or contract.'*

> *'The philanthropic side can very often lead to the largest amounts of money available to a university, but they are the most difficult to obtain and somewhat difficult to keep going, and they tend to be in areas other than technology.'*

During the fiscal year ending June 30th 1994, they received $3,797,000 in 'corporations and industry support' - from total external research support $57,800,000. Of that $2,527,000 was to the medical sciences groups - much of it from major companies. $800,000 came from the New American Schools as part of the Coalition for Essential Schools programme, this money is not 'quid pro quo' in any direct sense.. Other grants went to chemistry, computer science, engineering and policy development. These figures include only cash payments, not gifts in kind.

> *'We try to avoid those, the in-kind stuff is a favoured trick of computer companies and electronic gizmos and so on, "We'll give you ten of our gizmos, which are worth $30,000 a piece and you'll do this or that", well we're not accepting those, because in fact what you wind up with is in fact a liability. One has to house them and feed them, so we generally don't like that and we're able to get what we want otherwise'.*

The *'most aggressive approach'*, which Brown followed with a technique which looked promising against Parkinson's disease, is to seek venture capital for a new company. '*We became an owner of a corporation, we have a licence agreement with the corporation in which the corporation has rights to the technology that we developed, and we have a research contract from that corporation back to Brown to do continuing research work in that general area*.' This is not considered as posing potential product liability problems, because *'the entire product development is being done by the company*' in which Brown is only a minority shareholder. The university's stock was worth over one million dollars when it was recently cashed in, and royalty payments will follow when products reach the market.

A blanket grant of rights to the results of sponsored research is usually avoided in favour of a '*first right of refusal to take an exclusive licence to any invention made during the course of the investigation'*. Sometimes pairs of linked arrangements are entered into, where a piece of existing technology is licensed along with a 'Research Support Agreement' to fund continuing research in the same area.

> *'What one has to be very careful about in that process is not ever to feel that the granting of a research contract to an investigator is a suitable substitute to payment for the intellectual property rights granted. That's why we like to keep them as separate agreements and negotiate them separately, otherwise you under collect.'*

What makes a technology licensable? '*It's normally fairly intuitive... you know it when you see it. Clearly it has to be an invention that could lead to a product that could be sold to customers for money, it also has to be something that might have a fairly broad market.... unless there's a clear and distinct advantage of new technology over old technology it's very hard to license*.' An invention might be a process or a product. 'The nature of the market might play a large role', for example a technology involving a vaccine for a tropical disease is hard to license, and so may not be worth patenting. There is no specific checklist. A positive intuition can be tested via 'non-confidential conversations with potential licensees, which might involve calling up someone in one's network of potential contacts' and asking if any commercial interest for that product area is likely to exist. *'If we find that we're getting a reasonably positive response from a number of companies to this sort of initial test question then that would give us the courage to go forward with the expense of patenting something*.' Sometimes it is difficult to gain an informed opinion without giving away the nature of the invention, so sometimes an invention in a very promising area must be patented before this is risked.

What characteristics would a technology need to make it suitable for a spin-off company? '*The first thing that one has to be certain of is that it is a business, not a single product. So, for example, if one had a new compound that was useful in treating a particular disease it's unlikely that that would form the basis of starting a company - it's too narrow, it's not a technology, it's a thing*.' In contrast, a technique with multiple applications is a potential

> *'core technology' - a technology which can be used to support a number of different products... using the same basic technology.... The initiation can come either from the faculty member or from the university, in some cases you'll find that the university would find it attractive to put together a team to carry this forward, even if the faculty member is not interested, but you'd have a tougher test at the front end... you've got to be very certain that you've got something that's saleable to a venture capital firm.....'*
>
> *'On the other extreme you might have a group of faculty members who are very anxious to start a company, and they have a technology that under some circumstances might not represent a core technology, and under other circumstances might not be capable of supporting a corporate endeavour. If that's the case, you still may go forward because the knowledge of the faculty members who are coming forward and their participation in the development and start-up of the business may be sufficient to overcome the obstacle of narrowness of the invention, and they may make other developments as they go along which will ultimately constitute a set of core technologies, so sometimes you bend the rules.... In every case, one of the key elements to making anything happen is that there must be a champion, who will promote the cause and drive it forwards, and do all of the incredible number of things that are necessary to bring a company into being.'*

Would licence fees be required as cash? *'We've been happy to receive equity in some cases... if we feel that it's a company which would have considerable up-side potential, and that the company would be convertible to cash within some reasonable time-frame then we would consider such a trade-off*.' However, equity in a smaller scale company which never grows beyond a few million dollars or offers stock is *'not worth having, in my view, our objective is to generate cash*....' An alternative would be the spreading of cash licence payments over a period time, or a '*royalty structure with minimum payments*.' Most income is covered by the 'patent policy' and '*is divided between the university and the inventors. The first $100,000 is divided equally between the inventor and the inventor's department, and over $100,000 to $1 million the inventor receives 25% and the university 75%. Over £1 million 20% goes to the inventor and 80% to the university.*'

*'One of the great frustrations of this whole process is that on the one hand the easiest technology to license is new, novel and useful medical technology... the medical industry in this country is quite happy to acquire technology from the universities... but you have an incredibly long wait to see any fruits of that....'* To offset this, where possible, a drug would be licensed with a series of milestone payments corresponding to each step of the trials and approvals process. '*We do not want to burden the licensee with an obligation to make big payments unless and until it's proven that the stuff works.*'

Researchers have sometimes joined consortia involving other universities to seek funding for joint research projects. Research groups have also sought 'multiple industry support', for example the Laboratory for Man Machine Systems which has

> *'succeeded in bringing in industrial affiliates of one sort or another who sit on an advisory board and help define directions in which the laboratory may go in studying these problems. These are very hard to keep going at anywhere other than the largest, most technically oriented, leading edge institutions'.*
>
> *'MIT in my view is unique in all the world... even Stanford doesn't hold a candle to MIT's leading position in many developing technologies. People there are willing to join their industrial liaison programme at a considerable price... and many, many, many companies are members of that affiliate programme, and they get nothing other than some glossy newsletters and the right to sit for a little time with faculty members when they come to campus and invitations to seminars which are put on specially for them, but there's no technology transfer other than discussions.'*

What is the policy on consultancy and conflict of interest? Well, people do consult -

*'it creates a dual interest situation, in which one must be very careful to avoid interests on the one hand which are in conflict with one's interests on the other hand. I would say that being vigilant monitors of and paying attention to that kind of thing is the simple price that you must pay for being a good citizen, it is my view that the simplistic approach of simply banning consultancy and doing research in your laboratory, or being a stock holder and doing work in you laboratory and doing work related to that company... I think that that's a mistake... Brown is willing to tolerate these dual interest situations and to put in place appropriate monitoring mechanisms to assure that there are no conflicts that actually do occur, but it is our view that this is conducive to good economic development in the region and good transfer of technology from university into the public sector, and we want it to happen, we want to encourage it.'*

Full disclosure to colleagues and the head of department is expected, and so far *'no messy situations have developed*', although as a small institution they 'feel happy' with a less formal system.

*'I think that American academics have come a long way from where they were in the 60s... the idea of collaborating with industry was not considered to be particularly attractive. I think that there's a much higher interest in that - for some it's a matter of tolerating it, for others it's a coveted position to be in.... I think there's been a shift, but there are still many people who do not want industrial support, they'd much rather be supported by a federal grant or contract.'*

### 9.1.1.4 Steve Reiss - Computer Science Department

**Interviewee: Steve Reiss**
**Job: Professor (programing environments research)**
**Organisation: Brown University, Dept. of Computer Science**
**Interviewer: Thomas Haigh**
**Date: Monday 19th September 1994**
**Location: Brown University Department of Computer Science**
**Revision: 1**

Steve Reiss does research into programming environments. One of his research projects, the FIELD environment, has seen considerable exploitation, with the ideas being used by HP in Softbench and Sun in Tooltalk. DEC said *'we're falling behind, we have to do something here'* and licensed their research code directly as the basis for their project. However, DEC were not willing to fund his own further development of the system - *'you'd think that they'd want to fund ongoing work as it's closely related to their stuff'*. The software is still being sold.

The agreement was negotiated with the help of the Brown University Research Foundation. *'It was the first time the University had really licensed software, so the university set up all the procedures based on this'*. Negotiations took around six months. He is adamant that the charge was for the code and not for the ideas behind it - *'we're not in the business of selling ideas'*. Although some of the concepts might have been patentable '*I'm not in that job, I'm not in that market. HP tried to get a patent on the message sever ideas - obviously because we had developed it first they tried to include us in it. We said "Well, you want it basically to charge Sun for ToolTalk - we're good friends with Sun these days, what's it worth to us to alienate Sun." It is possible that this idea was patentable, but I do the research, I don't worry about such things.*' Partly this is pragmatic because patenting would impact on his available time, but also '*I'm in the business of producing ideas... I'm very happy when people pick up on my ideas and use them. If I patent them then that's less likely to happen. It depends how you want to measure success...*'

Computing companies have had to cut back on their research budgets - '*probably even more than the Government has - I used to have funding from IBM, Digital, Sun - now I have funding from none of the above.... There are two ways of getting industrial funds - one is to promise to do something, the other is to get them interested enough to fund basically whatever you feel like doing...*' His own agreements has involved deliverables, but of the kind '*copies of our research papers, access to our software (because we give everyone else access to our software), we'll meet with you three or four times a year'* - there were no exclusive deliverables.

'*I keep trying for industrial money.'* One problem with trying to target work at the interests of companies would be when *'you commit to actually build something. I have no idea, as I'm in research, whether what I'm working on is ever going to work or not.*' If money was forthcoming it would probably be spent primarily on graduate students - details would depend on the level of funding. '*I tend to pool all my money - I say "I have all these grants, let the secretaries and or administrative staff worry about how I'm going to spend so much on this, I want to fund this student and this student and this student, find the money out of my pots as appropriate.*"

Grant proposals are time consuming. One factor is that an industrial grant proposal might be only one page, whilst a federal one would tend to be 20 or 30 pages. Response time is also important - currently federal grants are taking something like a year to be determined,

> *'they say six months, but normally it's nine moths until they get the reviews in, and another month until they make a funding decision, and another couple of months before you actually see the money.' ARPA can be 'a lot worse than that.... They say "Yes, we're going to fund this - let us figure out how". They don't fund directly - they go through channels - and they have to set up all the channels and everything else. Last time it took a year from them saying "Yeah, we're going to give you the money" until the money actually came to Brown, and it took them a year to say "We're going to actually give you the money"..... Companies aren't any worse than that, and sometimes they can be better and turn it around very quickly'.*

How does the future look?

> *'I see the government continuing to cut back, not that much because there is some knowledge of the need to continue funding education. I think funding will be available from the government, but not at the level which that we are comfortable with - at the level of supporting the faculty member and one grad student say. If you want more than that it gets a little trickier. Applied funding is there - if you want to work with the government on a specific problem or with industry - but if you don't want to do that then it's going to get harder and harder to get funding. If the computer industry gets out of the slump, it still doesn't look likely that they'll get back to the point where they were in the 80s when that had a lot of money to fund researchers.'*

Does he support the argument that decentralised companies are more likely to look to outside bodies for their research?

> *'The companies that could afford to fund research were the bigger companies. They could pool research money, and say "If we fund 20 projects and two of them pay off then we get our money back". Smaller companies can't afford to fund 20 projects, if they only fund one or two then they need more of them to pay off, they're going to fund fewer and more concrete research projects which have more direct benefits to them, and only if they have a direct bearing on what they're currently working on.'*

Previously he had five graduate students, now there is enough funding only for one. More generally - the number of PhD students is down - '*as much due to lack of funding as it is to lack of jobs. The current market trend is that companies aren't hiring PhDs*'. Previously industry would hire something like four or five hundred from a total of seven or eight hundred of the graduates, now only around one hundred jobs exist. Except for exceptional candidates and those working in systems, the likely impossibility of finding work has acted as a deterrent to applications.

He says that there are different reasons why people work in a university rather than in a company. *'One is that we are doing things which aren't of interest to industry ..... In my case whilst I'm a systems person and what I'm doing is of interest to companies, the reason I'm here is because I like doing what I want to do. I like the freedom, and I'm going to stay here for that reason.*' He doesn't like giving pre-published papers to companies, but accepts that they may wish to protect their own trade secrets if they have supplied some of the material being worked on. '*They can't stop you because they don't want to research that you are doing to be public.*'

He does accept consultancy work. How specific is the expertise he is being hired for? '*I've had some very specific. DEC wanted me to consult on FIELD - I know the code intimately because I work with it. I've had people who just want me as a general systems consultant. I don't solicit work - I take what comes along*'. Interestingly, although the license to DEC on the FIELD system was with Brown, the follow up consultancy was a private agreement - this is a common pattern..

### 9.1.1.5 Andries van Dam - Computer Science Department

**Interviewees: Andries van Dam**
**Job: L. Herbert Ballou University Professor. (head of Graphics research group)**
**Organisation: Brown University Dept. of Computer Science**
**Interviewer: Thomas Haigh**
**Date: Monday, 19th September 1994**
**Location: Brown University**
**Revision: 1**

The work of the graphics group is supported both by the governmental NSF and ARPA agencies and by industrial sources which currently include Autodesk, Sun Microsystems, Microsoft, a called called Tako and IBM. Digital, IBM and HP have all provided equipment - Digital used to sponsor with cash, but this has *'dried up recently*.' Although some research sponsorship takes the form of 'hands off' grants, much involves

> *'active collaborations where we work with people on joint problems, and they may put in a minor amount of time and we put in a major amount of time, but it's still a two-way communication - I thank that's the best; it's even better than research sponsorship because that way you really learn from the other party.'*

The group avoids proprietary '*work for hire'* - students must be able to work on the projects and their findings and ideas are placed in the public domain. The group itself negotiates its own contracts - their Office of Research Administration is '*not proactive - they're really competent bureaucrats who make sure that the paperwork is good and they deal with the terms and conditions...*' '*Basically I'm responsible for hustling the money - and that is generally true in American universities*.' These contracts are different from the kinds of contracts companies enter into between each other because they do not stipulate deliverables with particular characteristics or constraining time scales.

> *'The difference is between grant and contract - a grant is simply "here is a bunch of money, have fun, do something useful (and presumably publishable) with it" whereas a contract tends to have more boilerplate about what the problems are that are to be studied and to have language that makes it clear that the sponsor will learn something from the exercise.'*

Some companies sponsor the overall work of the group, whilst others are 'targeted towards a specific research project'.

> *'Over time I think companies are getting more specific about what they would like to see, even though they are not supposed to use terms like "deliverables"'. Our policy has been that any software which we produce any of our sponsors can get. In point of fact they typically don't because it's idiosyncratic university software, and what they're really interested in is the ideas, the algorithms. What we emphasise is idea transfer rather than specific software transfer.'*

The advantages to companies lies in the chance to gain more rapid access to new technologies and techniques.

> *'We have certainly over the past 25 years given things to companies that they were able to exploit commercially, but it's been relatively rare. It's been more likely that they've been able to leverage ideas (and, more importantly, well-educated students with project experience).'*

When approaching a sponsor, he would try to show

> *'that we have technology that could benefit them, either in the relatively near term or more likely in the long term - that we are investigating a research area that they are not themselves investigating which I believe can have pay off for them. Certainly there is never a philanthropy argument - philanthropy is dead, basically. In my particular case, just to make it very concrete, what I pitch is that 3D graphics is going to become very very big and it's going to augment, and at some point possibly replace, familiar 2D graphics and what we offer is experience and insight into how that's going to happen...'*

Have the recent levels of hype surrounding Virtual Reality influenced people's perceptions of this field?

*'I would say that most people who know something are pretty sceptical of VR at this point, and it's easy to see that we are going to have a "VR winter" not unlike the "AI winter", a backlash, so I resisted getting into VR for quite a while. But I think we are now at a place where the technology is coming to be somewhat useable and one can do some fairly interesting experiments and I think that in the next five years we will in fact have an explosion of VR applications and we may even have some money-making ones - the technology is coming along extremely rapidly. And by the way, the UK is one of the leaders in this technology.'*

Does he see a clear distinction between basic research and applied technology in this kind of area?

*'I think in general the field is getting more applied, and I was part of a committee sponsored by the National Academy of Sciences National Research Council which produced a very controversial report called "Computing the Future: A Broader Agenda For Computer Science and Engineering." We advocated that computer scientists should be less inwardly directed and should reach out more and broaden the research agenda. Not get rid of basic research - not in the least - but think of basic research as being involved with other disciplines or even, God forbid, applications - which is something that computer scientists have disdained for a long time. I'm not in the least worried about whether computer science is a science or isn't a science or is an engineering discipline - any attempt to pigeonhole it is stupid.*

van Dam sees consultancy as an important part of an academic's work. '*I consult for Microsoft - I'm on their technical advisory board.'* Multiple companies have spun-off from Brown in the Providence area, he consults for '*one in particular known as Cadre Technologies which is the leader in CASE tools.*' He also consults for Electronic Book Technologies which '*capitalises on research which we did here, interestingly enough, primarily in the seventies and eighties.*'

*'I think it's very important and I've done it all my professional life. I started consulting when I was still a graduate student and I found it a very, very useful way of keeping anchored in reality - a source of problems and also a way of learning what the really important issues are. Plus there are a number of very smart people who you come into contact with through consulting who you wouldn't otherwise meet, it keeps you from getting in-bred.... It's also a way in which academics can afford to teach.'*

In his work for Microsoft, sponsored rearch and consultancy

*'kind of overlap, because some of the things that I'm consulting for them on are also topics that they are sponsoring as research, but that's not so common.... I think typically companies are looking to bring in a heavy-hitter from outside who has expertise in a particular area that they don't have in-house, or they use it to check the expertise that is in-house, but it's a way for them to get somebody on a temporary basis that they otherwise would have to hire and pay a lot of money to - temporary employment basically.'*

His personal speciality has been *'the setting up and running of technical advisory boards... technology input and oversight into companies both large and small.'* Inevitably this implies a very high workload - typically seven days a week of which one is spent consulting.

*'If you want weekends to yourself you don't have time to consult and still be a contributing academic - you're allowed a day a week for consulting but if you took it on a regular basis, it would destroy your research and publishing productivity... if you're going to do consultancy then basically it has to come out of your spare time'.*

How does he see the future progressing?

*'I'm certainly very, very keen to have colleagues everywhere get some industrial experience.... I think it's very good for faculty members to have industrial ties, both of the research sponsorship and preferably collaboration type and also of the consulting type. It broadens and enriches, gives you perspective and helps you see the world through non-academic lenses.... Both parties put something into the team - so instead of running "open loop" it's a little more "closed loop". The sponsor has the opportunity to offer advice and, in effect, consulting - so we find it very constructive, it makes us more focused and it does two way technology transfer - we get ideas from the sponsor and they ideas stuff back.'*

Is it realistic to expect industry to shoulder an increasing proportion of the overall research bill in universities?

*'I have had to work enormously hard to build up my base of industrial sponsors and keep that portfolio constantly changing as old sponsors drop-out in the process of cost-cutting, and must be replaced by new sponsors. It has been enormously disruptive of my time, and I think trying to make ends meet for a reasonably sized group today is almost a full time job for whoever takes on that responsibility. I think it's a way of surviving and it's something you've got to do - you've got to have a broad portfolio, you can't rely on either government or industry because they're both downsizing and you've got to change who your industrial partners are.... It's constantly looking for opportunities - to support a group with a research lab in it you really have to be very entrepreneurial. And all that time spent being an academic entrepreneur does interfere with research, publishing and other professional obligations. Senior faculty have trouble doing justice to all that they are responsible for, including working with their students. It is not a job for those who want a calm, "scholarly" life as the layman frequently pictures it.'*

## 9.1.2 Daimler-Benz

### 9.1.2.1 Gary DesGroseilliers- Daimler Benz Research & Technology

**Interviewee: Gary DesGroseilliers**
**Job: Technology Liaison Manager**
**Organisation: Daimler-Benz Research and Technology, North America, Inc.**
**Interviewer: Thomas Haigh**
**Date: Wednesday 21st Septemeber 1994**
**Location: MIT Industrial Liaison Program offices**
**Revision: 1**

Gary DesGrosilliers was a graduate student at MIT and also received a degree in business administration from Stanford University, going on to work as part of the MIT Industrial Liaison Program for some years. The Daimler-Benz technology liaison office consists of two people, one German, and had then been in existence for about two years. Its purpose is '*to establish and maintain technical contacts in the US for the research and technology organisation of Daimler-Benz. We have contacts at universities, government laboratories and we have established contacts with other companies as well'* - a very general programme.

Daimler-Benz is a holding company, with four operating divisions. Mercedes-Benz, AEG Daimler Benz Industries, DASA and DEBIS - an information systems and services organisation. The holding company employs about 3,000 people - roughly half of them associated with the central research organisation. Their office is an arm of the Technology Strategy group and reports on a level *'a couple down from the top*' inside the research organisation. This group ' *co-ordinates the research activities of the holding company to be sure that our company is working in areas which are important to our operating divisions and to take advantage of synergies between the different operating divisions and to try and co-ordinate the research programme*'. Technology Liaison offices have also been established in Moscow and Tokyo to '*provide a window on technology throughout the more important parts of the developed world'*. As a European company, Daimler-Benz already has a good knowledge of European opportunities.

On a practical level, the office might '*respond to a request for specific information*'. For example, they might conduct a search to identify '*people, products and contacts at universities and companies that are of interest'*. They also manage ongoing relationships, such as those with MIT. 'We have a list of about ten universities which we consider key universities because of the importance of the academic research in fields that are of interest to us'. This interest is obviously scoped by commercial considerations to areas such as microelectronics, materials, electro-chemistry and so on. Contacts are maintained in different ways - '*MIT is the only university where we have a formal, established, contractual relationship.... The main reason that we have not entered into that kind of a relationship with other universities is that there are very few other universities which have the breadth and scope and importance of research that MIT has.'* Because their office is located in Massachusetts, they can maintain a higher level of contact and have regular meetings with MIT faculty, making the agreement good value.

> *'Another reason that we do not pay other universities for this kind of access is that it's not always necessary - most universities are relatively open places, and we can call a faculty member at any university in the US, and if they are working on a project that is of interest to Daimler-Benz, and if we have people who are working on that same subject then it is very easy to schedule a meeting and to have discussions with anyone at any university in the US....'*

Even at MIT faculty members would usually be willing to talk to a representative of any major company. '*The access that we gain through the ILP is really quite general - what we get is an hour or two of a person's time to discuss to discuss a general interest in a topic.'* Even though faculty members 'receive a small payment' from the ILP for taking part in meetings, their primary motivation is the chance it might lead to something more significant.

In this case, his office would have a role in follow-up. One programme they run involves the donation of $30,000 p/a to universities doing work of interest to them to sponsor graduate students. This programme is new and expanding - to perhaps 10 or 15 universities throughout the US by mid 1995. Contacts made through the liaison programme can also result in 'visiting scientist' status for Daimler-Benz researchers - 'three or four' have come to

MIT over the past two years. The TLO helps with or conducts negotiations, but '*often once the contact has been established it works more efficiently if the communication occurs directly from the faculty to the researcher at our company'* as far as technical information goes. They have an initial role to play in '*making sure that the parties understand each other*' - especially important in international collaborations.

What kinds of qualities would need to be apparent in a university to make them attractive as partners in a sponsored research arrangement? '*It's always the same things - people are always concerned about the proprietary rights and the licensing agreements, and exclusive access to the information....'*

The Technology Licensing Office at MIT is now working well -

> *'a few years ago that office was run by lawyers, and their main interest and activity was to protect the rights of MIT in any negotiation over a technology. The result of that was that they were so good about protecting it that MIT was never able to license anything or gain any advantage or know that the technology was being used.... They got rid of all the lawyers, the patenting process is something which is handled by outside attorneys now and that's not the major part of their activity - the major part is that when there's a technology that is worth commercialising is to find an outlet for that technology and to structure a deal that is favourable to both parties.... If a company is taking a technology from a university then they're making a major investment... it usually require a large investment of capital to commercialise it and if they're charged too much money or they're not given some kind of guarantee that they have at least a lead time... then they won't make the investment so it could be a very good technology but no-one will use it.'*

One faculty member who invented several important materials processes in the 1970s joked to him '*"the problem with my patents is that no-one ever uses them until the patent expires" and that's probably a result of the strategy of the TLO back in the 1970s'*.

How about the technology under consideration itself?

> *'It needs to offer a unique advantage to a commercial technical problem at a reasonable price.... Technology licensing is a good thing, and I think it needs to be considered, but I don't think it's the primary mechanism of technology transfer. I think the primary mechanism for technology transfer is direct contact between researchers in similar fields where they exchange information and know-how.... It's normally exchanged freely on the basis that it's of benefit to both parties. It doesn't cost anyone anything.... it's an informant network.'*

This is more important than the protective legal approach.

Since the early 1980s, there has been a substantial shift in the perception of university/industry relations. At that time

> *'most companies had large central research organisations and they were able to spend a portion of their budget as a goodwill gesture toward universities. A lot of the memberships of programs like this one at MIT were goodwill gestures on the part of the corporations. In many cases the payment came from the philanthropic side of the company. Around 1980 there was a legal ruling in the states.... that a company's philanthropic organisation could not make a donation to a university and receive a donation in return. This was considered a violation of the gift tax laws... All the memberships in this industrial liaison programme had to be converted from gifts to actual research co-operations paid for out of the research budgets of the companies.'*

During the same period, the trend towards corporate mergers reduced the number of member companies.

> *'There is another change that I would say has taken place over the last seven or eight years, and that is the stream-lining of companies' research organisations - they are relying more on external sources for basic and long term research, in some cases medium term research.'*

Hence, any programme '*has to have some real benefit for the company*'. In the case of Daimler-Benz, membership of the MIT ILP is paid for from a central research budget, '*we expect to receive a return on that investment - information about research which is beyond the scope of what we might be doing in our own research organisation. We use it as a mechanism for supplementing our own research*.'

No company can today hope to do all its research and development internally.

> *'There's quite an active debate going on in most companies as to what is the proper balance of internal development to external development. I believe that some companies like Chrysler, no longer do any internal research - they rely on their suppliers to provide them with the technology that they need for implementation of their vehicles. That's a strategy that seems to be working, at least in the short term. It's a low price option - instead of having a research laboratory doing research you have a smaller number of people whose job is to reach out and access available technology in the public domain. In the long run that might be dangerous.... It's difficult for a person to be an expert in a subject merely by reading the papers and the research of other people in that subject. Sometimes the only way to be in a position to evaluate what is available externally is if you are trying to do some of the same things internally - and then you know what is difficult, you know where the road-blocks are and when you see someone who has achieved some results you are able to recognise that'.*

Does the impossibility of doing confidential research within universities limit the amount of research work which can be 'outsourced' to them?

> *'It's not as big a problem as you might think - universities will not only not do secret research, but they also tend not to do very much applied research. If they aren't doing very much applied research, it doesn't matter that the work which they are doing is not secret. There's a whole field of research, pre-competitive basic research, the idea I think is that universities should be doing pre-competitive, long-term, breakthrough kinds of research and companies then will access that for their own applications... what's important is how [companies] implement that research.'*

A big problem facing companies is thus *'how do you access technology and where does the value occur in the technology stream - and there are many examples where the technology was developed in the company, was wholly owned by the company, but they failed to generate any economic benefit*'. One local example is Raytheon's development of the microwave oven - by the time the commercial potential became clear they had left that market. In the computer industry the famous example is of course that of Xerox PARC and their string of breakthrough developments.

Are basic and applied research still clearly distinct in the kinds of areas Daimler-Benz works in? '*Even though there might be some examples where the distinction blurs, or the time difference between application and the basic technology shrinks so that it becomes harder to see the difference I think in many areas it is still possible to distinguish between a basic research activity and some kind of applied research activity*'.

The activities of Daimler-Benz are typical of those pursued by similar companies, but are perhaps more formalised. Daimler-Benz has a strategic research alliance with the United Technologies Corporation - 't*he two companies have agreed that there are common interests in basic research, but not very much competition, even in areas where we have similar businesses we are operating in different markets, so there's not so much competition*.' Several strategic pre-competitive basic research projects are underway. '*It's a very formalised program which was negotiated at a very high level between the companies*'. Another example is the US Cooperation on Automotive Research - CAR between the three automotive companies on about a dozen research projects, made possible by revisions of anti-trust agreements in the mid 1980s. Until then, even meetings between competitors were forbidden. Very large scale research programmes have been undertaken in areas such as electric vehicle technology.

## 9.1.3 DARTMOUTH COLLEGE

### 9.1.3.1 Mark Woodward - Thayer School Development

**Interviewee: Mark Woodward**
**Job: Assistant Director of Development for Corporate Relns.**
**Organisation: Thayer School of Engineering, Dartmouth Col.**
**Interviewer: Thomas Haigh**
**Date: Thursday, 15th September 1994**
**Location: Thayer School of Engineering**
**Revision: 1**

Dartmouth is a small, liberal arts college with a strong focus on undergraduate education. There are about 4,000 undergraduate students, joined by 1,200 graduate students mostly centred in specialised areas such as the business, engineering and medical schools. Engineering has existed at Dartmouth since 1871, and the Thayer school today offers an Engineering Science major which usually takes an additional year and is unusual in giving full engineering skills to students with a liberal arts background. Graduate programmes include M.Sc. and M.Eng. degrees and a doctoral programme in research or design. The Thayer School is financially independent from the college - overheads are shared and a tuition stipend exists but revenues are raised directly.

The Thayer School development office has responsibility for all development, sponsorship and industrial relations activity in the Thayer school, but also works together with the Foundation Relation office and the Grants and Contracts office which represent the entire college. '*It's a peculiar system'* reflecting the internal structure of the college - *'at Dartmouth we are schizophrenic about not knowing whether we are a college or a university*.' Both the Alumni and the administration are keen to avoid 'trying to turn into a mini-Harvard' but at the same time excellence must be sought in the activities which are undertaken.

> *'Development is a term which achieved currency, in this country anyway, over the last quarter century. It embraces fund raising and institutional planning in various proportions - the raising of money from all the sources from which a college raises money: alumni, foundations, corporations, the government... The planning of how that money gets raised and how it gets allocated when it is raised.... and, in industry especially, where are we going and what do we need to do in terms of physical plants development or expansion.... though in college it is used to mean primarily fund raising. It is a growth profession in the non-profit sector'.*

The Thayer School office employs three people in its development office. The director handles major gifts and oversees generally, Mark Woodward who handles foundation and corporate relations, and a third person who deals exclusively with the 'Annual Fund'. They work together very closely - '*we have the same databases, we talk, we know who's talking to whom about what, we give each other leads....*' so that someone initially approached as, for example, a member of the corporate advisory board might also be persuaded to contribute to the annual fund. '*This system - which to my way of thinking is how it should work everywhere - is hardly how it works anywhere. There are a lot of corporate and foundation relations people who are not considered to be integral with the development function in the same way that [we are], there are out there a lot of miscommunication and bad communication and just bad reporting relationships among the various sectors of development functions.... Everyone is envious of me when I talk about how we do things and I don't understand why other people don't*.'

'*Where you are going is the cream of the crop. When you get out into the second tier of colleges and universities, and then the third and fourth tiers, you will find that things go down-hill quite rapidly*'.

Corporate relations is '*considered a development function, though it isn't entirely, and the college has one of the most sophisticated development systems anywhere - our alumni relations and alumni fundraising offices are considered to be models by many places*.' The college has a '*gift recording system*' to allow follow-through and acknowledgement, and a computerised system exists to support '*stewardship - the term we give to the care and feeding of our donors*' in terms of regular progress reports on the results of donations.

> *'Corporate relations, as we practise it here, encompasses a little more than development - my function is not measured solely by bottom line, though that is a component of it. What I view my task as being is to encourage any and every kind of mutually beneficial relationship or interaction or transaction between the corporate sector and the institution..... It encompasses to a certain degree student placement and internships with companies (there is a separate officer who helps students get jobs, but I work with her quite considerably because I'm out there talking to companies), it involves establishing a relationship with an engineering or technology oriented company such that members of the company who would make good speakers to classes about their professions and the real world out there are encouraged to come here and be guest lecturers, establish relationships such that classes that might have an interest to go out to a facility can do so, the establishment of various advisory panels and boards to provide a window onto the real world for both students and faculty and we know we're teaching the right things that are going to be useful.'*

These activities are integrated with activities such as fundraising, solicitation of gifts in kind and of equipment and the establishment of consultancy for faculty members and sponsorship for graduate students. '*It is the totality of what an industrial association with a school should be*' - though faculty obviously have their own contacts - '*I consider myself as much as anything a switchboard operator.... trying to match people together to see if anything comes out of it.*' The job also involves the writing of grant proposals, but little direct technology transfer or sponsored research - this is handled directly by faculty and the college Grants and Contracts office.

Mark Woodward runs the fairly recently organised Thayer School Corporate Advisor board - about 20 *'high level management people from various companies that have a relationship, or should have a relationship, with the Thayer School'*. Most, but not all are alumni, there are two meetings a year - one involving career advice for students, another including research presentations. They 'mix and mingle' with students, and subcommittees are working on curriculum matters, particularly the Masters of Engineering degree and a new 'structured internship programme'. Some are very keen, for example a division manager with Ford who is '*extraordinarily enthused about the kind of people we produce.... who has personally seen to the hiring in the last few years of five or six of our best students*' helped in a major grant of lab equipment and *'leaned on a supplier of CAD software to donate a considerable amount of their software*' and encouraged divisions to donate problems for students to solve. Looking after the board and 'selling' the idea to faculty is one of his major tasks. The importance of computer modelling and visual presentation of data has meant that considerable software and hardware resources must be obtained to work in the area, particularly if it is to be integrated into the curriculum. As a small school, they have to select areas for specialisation and attempt to keep up to date in them, and so grants - particularly of equipment - are crucial.

How extensive is industrial input into courses content? There is a body called ABET which grants 'Accredited Engineer' status to courses. '*Our curriculum is totally the responsibility of the faculty... however that doesn't stop us establishing boards that can give us advice.*' A board of overseers, who exercise 'a fierce independence' govern the school according the charter, although since its establishment was agreed the CAB has '*within certain broad confines'* been allowed to define its own role. *'The faculty hasn't needed a lot of convincing that the board should exist.... some of them feel a little bit of disdain or just benign neglect, but there hasn't been a great deal of resistance'*. For example, when the Masters of Engineering degree, involving business content and industrial relevance, was readdressed five years into its life advice was sought from the board, 'which had the effect of opening what might be a Pandora's box... and it is very busily doing so'. However, the advice has no 'force of law', but as many on the board have personal experience of earlier programmes at Dartmouth their views carry some conviction. The role of the board was agreed as to '*offer some curricular advice, provide periodic oversight updates.... help bring in corporations who might establish an internship program which might be integrated into the degree itself and might even raise money for it.'* He suggested that at larger engineering centres, programmes with industrial involvement would run more formally and on a much larger scale.

As a result of the changing climate following the end of the cold war, '*it is felt that a significant amount of government funding for research is going to be drying up over the next few years*'. Because of the role of Federal Government agencies such as the DOD and NSF in driving basic research in universities, this '*turning inward and contracting'* means that engineering is coming to be driven *'not by the defence and aerospace sectors, which it has been since World War II, but by corporate competitiveness issues, by perhaps health care, by perhaps national infra-structure (though this hasn't really happened yet) and that basic research in general and engineering in particular are going to be funded differently. The government has attempted to do some 'funny book-keeping' and keep the money flowing by means of Technology Transfer grants - which is a fancy way of saying we take money that we've allocated to the Defense Department for defense related things and use it to fund things that have less of a defence need and we'll call it technology training and retraining and transfer... the equivalent of winding down the war effort at the end of World War II and turning it into consumer products and things'*.

*'There is some sense that the money is going to dry up, and there is some hope that industry will pop in and help - it may be a forlorn hope. What we find here in this small school is that because our faculty are eminent at what they do they prefer to rely quite heavily on government funding, and because they are eminent, although the competition is fiercer for government funding they haven't seen much of a drop-off in it yet, so they haven't become convinced that they need to deal with industry more than they have done. The fact is that it's easier to get a couple of hundred thousand dollars from the government with a vague idea of where you're going with it and be set loose to follow your own agenda then it is to have a very specific contract with a company which has to be renewed every year, with time lines and checkpoints and the necessity of moving forward to a goal which that company wants over a specific period of time..... There are faculty members who enjoy that kind of challenge - that's what engineers do - but it's easy to be spoiled and over the year's we've been spoiled*'. Hence is necessary to motivate faculty as well as companies '*and they are moving - slowly but surely. It's like pushing a glacier, but it's happening. At the last meeting the members of the board sat down with young faculty members and each side tried to explain to the other side what its concerns were and how it worked - which was an eye-opener for many people. Faculty asked some stupid questions and got some straight answers about what they could expect and not expect.... though there is one faculty member who is almost a wholly owned member of a medical products company.'*

*'Engineering by definition is supposed to be applied, but a lot of the people we have are doing basic theoretical research that has dividends on the applied end, but where any given faculty member falls in relationship to that very fuzzy dividing line is peculiar.... There is probably, in terms of academic politics a little bit of uncertainty and friction between the computer engineering people and the computer scientist people up campus because that dividing line in computers is so hazy - what is engineering and what isn't?'*

'Adaptability is a particular strength of Thayer, there are no departmental boundaries and specialisation is left as late as possible - reflecting the fact that '*in the real world engineers tend, ten or fifteen years out to be doing something totally different from what they started with*'. To this end a broad mix of faculty are required, '*encouraged to follow their muse wherever it takes them*' and to exchange ideas and work with faculty in other parts of the college. Funding such interdisciplinary projects has proved possible 'by hook or by crook'. Because of the small faculty '*everyone winds up teaching something which they didn't know anything about at some point during his career*'. Those faculty from an applied background have tended to have much closer links with industry.

What kinds of return were companies looking for? Increasingly they seek bottom line returns. '*Corporate philanthropy is a tradition in this country... it goes back to the Robber Barons... but back in the 80s there was a sea change in the way corporates viewed their missions. Some of it had to do with the business climate encouraged by the Reagan & Bush administrations... there was a reaction to what was viewed as softness, a too great a concern on the corporate level... toward things other than shareholders - which in one very large area of business theory is viewed as the only constituency a corporation should have a responsibility to.... There was a pulling back from a lot of the things which happened in the 1960s and 70s...the major mergers and acquisitions, the restructuring of companies, the assumption of debt equity and leveraged buy-outs - which had the effect of increasing share value not necessarily to the benefit of anyone but the shareholder.... There was a lot of downsizing, and the catch phrase has been 're-engineering' which is a polite way of saying cost cutting and increased productivity any way you can get it... so one end of that was a rethinking of what can we get out of corporate philanthropy, and it has become much more narrowly focused..... Some of them are geographical - let's focus our money on the region from which we draw our employees... some companies deliver homeless shelters and things like that... focusing on what they perceive as societal needs that they can help address and get good PR from - a major thing now is focusing away from universities and into kindergartens through grade 12 education.'*

*‘What gets dispersed to colleges is increasingly limited to specific grant and fellowship money to aid minorities or women... or specific research interests that have a specific relation to the corporate product and might provide some output to it. With gifts in kind, such as computing equipment, it is slightly different... but the big focus in the computer industry has been equipment gifts which will not only help certain research interests but will provide computer infrastructure within the institution.’* Dartmouth has a 'most favoured buyer' relationship with Apple, putting them on 90% of desks, and the computer centre received gifts of mainframes and workstations from IBM and scientific computing equipment from DEC over the years - and of course the idea of timesharing was pioneered at Dartmouth. DEC, HP and Sun have provided scientific computing equipment to the Thayer school.

*'The general feeling... is that by providing outright gifts or steep academic discounts one establishes one's hardware product in an environment where people who are going to be future users and buyers of your equipment are going to be exposed to it, and will be predisposed to want to import it to their companies. We trade on that... I don't know if we're being disingenuous by so doing because the environment being what it is and workstations being outmoded*

*every three to five years anyway, and the major players changing as people with new ideas come in, it's hard to know if five years down the time the people you're accepting equipment from will even be in business...*' However, a company naturally bases its decisions on the assumption that it will survive.

As a small school with a good reputation, Dartmouth has a relative advantage in this field. However, with the re-engineering of 'human resources departments' they are '*more and more narrowing their focus, saying "Why don't we limit our recruiting to just a few campuses where we know we can get a large number of the people we need to fill the positions we have open*"' and fill their vacancies at a few schools. '*We have to convince them that the one or two people they will get here are really top flight people, who will be in management positions within a few years and among the best they will have - and because they are narrowly focused that's hard to us*.' They face a similar struggle in competing with larger institutions for equipment donations - '*you have to convince people on a company by company basis'.*

Some programmes are run with joint input from the CS department and the Tuck business school. 'T*he situation has waxed and waned over the years*'. The business school is one of the best in the US, and has achieved this by concentrating on its MBA. In contrast the Thayer school offers a much more diverse range of programmes, so it can be hard to integrate the elements of a joint programme - not least because the 'applicant pools have diverged', with business schools seeking people with several years business experience and engineers tending to go straight to further study after their first degree. The faculties, especially the Deans, of both schools need to be convinced the co-operation is mutually beneficial. Currently an M.E. degree is offered - including some specially designed courses from Tuck school faculty which are less detailed than the MBA courses. A Total Quality Management course designed for engineering students also proved popular with business students, *'so there's a level of collaboration, but not as great as I think we need'.* A building physically connecting the two schools was opened about 20 years ago, holding an engineering and business library with the intention of bringing the student bodies together - but there remains significant distance between the engineering and business students. '*There are right now a lot of hybrid courses - there is a trend towards what is called a techno MBA which is an MBA with some technology courses grafted on to it*.'

Is there a policy on consultancy? It happens, but is not closely supervised or monitored. For example one professor consults with nuclear power companies, and a number of small engineering companies have grown up in the region, partly around the college who sometimes hire faculty as consultants. The time allowed for consultancy is specified in their contracts. '*We like to promote it because it helps to develop contact between the school and outside corporations which may lead to other things*'. The potential for conflict of interest is recognised, especially with regard to technology transfer and the ownership of start-up companies, which 'they scrutinise very carefully' in the Grants and Contracts office. '*The college here tends to err on the side of being conservative and very careful about things'. 'Trying to determine what is whose property and who should be paid for it can be a very touchy thing*'.

What kinds of long term effects are the changing patterns of funding likely to have?

*'It's hard to know - you'll find as many theories as there are people you speak with, because no one knows. It's been 'conventional wisdom' that government funding will dry up and that industry will assume a larger role, but it is not an apparent fact yet. Industry, and some other people who claim to speak with voices of authority, say it's not a slack that industry can pick up, and I'm not sure that they're wrong, but it's so hazy now. My guess is that the government will find ways to 'cook the books' so that sufficient money will go into basic research... from different directions than it has before although there will probably be less of it because they're dealing with major deficits and a rethinking of what government in this country should do. There are competitive issues... how to maintain whatever momentum we have in the technology development field.... I don't see industry research money drying up too much, philanthropy is achieving a steady state, but as the economy expands that may do so also. My best guess is that there will be more rather than less university/industry partnership - if only for economic reasons... the corporate downsizing trend and the trend to virtual corporations... would encourage going outside...'*

*'My sense here is that, of the small faculty we have, there are maybe a third who are quite willing to do industrial work, another third who couldn't care less and probably would be unwilling unless they absolutely had to and a third in the middle who are sitting on the fence but recognise that they may have to change. Some of that breakdown occurs along generational lines, with younger faculty members tending to be more openly working with industry than older ones. There is an element of non-tenured versus tenure, with people who are struggling to achieve tenure tending to be open to more ways to achieve it.... I don't know if those proportions are a nation-wide phenomenon, but it wouldn't surprise me if there was a similar breakdown at other institutions.'*

*'There is a very real concern that... there may be a shaking out of financially less strong institutions. Demographically the number of students is going down... the cost of higher education has far outstripped the inflation rate... the middle class... is increasingly strapped to afford higher education.... so it is likely that some universities will fall by the wayside.'*

Uncertainty as to the future of industrial ties must be seen as part of the wider uncertainty as to the future shape of the educational system.

Would an increased reliance on sponsored research, technology transfer and consultancy change academic culture significantly?

*'Probably not a lot, though... it would bring academics more in line with the real world and out of the Ivory tower... there would be more of a scramble for fewer dollars and it might increase productivity. I think you would wind up with less basic research being done, except as directly applied to a programme that one is working on.... More practical solutions... because what industry tends to sponsor are solutions rather than knowledge creation - but knowledge creation comes from going out for solutions.... My guess, from my limited perspective, is that on a school like this it will not have a significant impact....'*

*'With corporate philanthropy it's harder to tell - it depends on the individual corporate culture and corporate climate. I was at a conference six months ago at which a number of corporate foundation people gave talks.... it was amusing because each of them had their own priorities.... They all said "Our priorities are much more specific than they used to be" and they listed some. One of them - a large well known food processing company - from the examples given seemed to limit its philanthropy almost entirely to named public spaces and facilities that had absolutely no use to the university at all except as a gathering place for students. Maybe it means something to the company to have its name on courtyards and student lounges and gazebos and fountains, but I can't imagine what.... Many of us there laughed afterwards, because we thought "How does that help us at all?". It was an example of a corporate priority that had no match to an institutional priority what so ever.'*

*'One hopes that private foundations will pick up some of the slack... the question is as much now "who you know" and "what you know" and establishing a good, productive long term relationship with a company is in the minds of many development people.... To cast a narrower, deeper net, pick out a small number of companies (small can mean anywhere from a handful to fifty depending on the institution) and concentrate on establishing a very broad relationship with those companies that encompasses all the aspects of corporate philanthropy.'*

*'The general sense would be that industrial funding is less remunerative than government and is more results oriented, is unfortunately less long term focused. A corporation establishes its research budget on an annual basis and whether one's grant gets renewed or not each year depends on both the budget which comes from up top... and secondarily the results that you're getting - if you've met the checkpoints and have proved that you're moving things ahead in the direction that they want on their timetable then you're more likely to get funding... it means that people have to break up their projects into smaller attainable goals... it probably increases one's adrenalin levels.'*

### 9.1.3.2 Peter Knox - Dartmoth College Development

**Interviewes: Peter G. Knox, Jr.**
**Job: Associate Director, Foundation & Corporate Relations**
**Organisation: Dartmouth College**
**Interviewer: Thomas Haigh**
**Date: Thursday, 15th September 1994**
**Location: Dartmouth College**
**Revision: 1**

Many major projects are underway at Dartmouth, including a new psychology building, a new cancer radiotherapy building, a renovated library for special collections and a new computer building. '*There's a big focus throughout the entire campaign on the liberal arts aspect, which is probably the toughest kind of money to raise. Very difficult*'.

> *'It's really been a major shift over the last ten years or so. Whereas previously they would give unrestricted funds to colleges and universities in this country, because they just looked at education as a good thing and it was very wide open, now we find it's really a quid pro quo situation - they want some kind of payback and in most cases a direct payback, whether it's in the form of recruiting, or sponsored research as you just mentioned, or advertising - whatever they can get out of it. It makes it more difficult from a fundraising standpoint, but at the same time even at a small college like Dartmouth there is so much going on here that we are usually able to find some kind of match.'*

Has the move from traditional philanthropy towards an increasing targeting of corporate funding of universities and research come about as a change of strategy within particular branches of the company, or has the change resulted from one budget being slashed and another entirely separate function expanding?

> *'It's really a mixture of both I'd say.... Many companies, as you know, have their own private foundations set up, their own private by-laws and board of trustees, set up for the express reason of giving away philanthropic dollars. But then within the corporate structure itself there's often pockets of money that we can go towards, whether it comes out of an advertising or public relations budget, or out of a technical marketing budget, or from a technical area - that's where you get more involved in technical arrangements as opposed to the straight philanthropy. We're always looking for any pool of money, wherever we can get it, but the competition for those dollars is really fierce.'*

Given the mass layoffs and harsh economic conditions, being seen as major donors might even damage companies from a PR viewpoint. Money has been directed towards local communities, '*and we've seen a switch away from Higher Education and towards some of the more basic things like the social services - and it's a tough argument to make that Higher Education is more important than these starving people*'. One current programme, Prometheus (formerly CLIPP) teaches high school teachers computing and Internet skills - corporate giants and communications firms have been targeted *'It's probably going to be a very tough sell, frankly. Because we don't have a corporate base here... Ameritech would probably be more inclined to give their philanthropic dollars to organisations in Chicago as opposed to hand it over to Hampshire where they don't have a presence and don't need one*.' One problem is ensuring that new programmes will be viable when their initial funding expires - the Prometheus programme ran for ten years on a foundation grant which has now expired '*and we're scrambling for money to try and keep that programme running, and if we can't find it then it's going to disappear.... Somebody should have foreseen this a couple of years ago...*' One problem is that proposals might take nine or twelve months to be assessed.

Except for the professional schools, '*recruiting is probably a tough one for us*' since because of the geographic isolation and small size of the potential intake. A specialist office exists for student placement. Professional schools take *'the lion's share*' of sponsored research, because there is relatively little liberal arts research and it is less obviously relevant to corporate priorities.

How does Dartmouth compensate for these disadvantages?

> *'The quality of the education clearly is an advantage. Being part of the Ivy League there's a name recognition there.... it's already got a stamp of approval, if you will. That's probably the primary strength that we have to offer. We're also a leader at this point in curriculum revision and in revising the grade structure... But still, when you get in to trying to get a corporation to fund a history department or an English department it's virtually impossible.'* Some language work has been successfully funded.

Does this mean that the more technical departments are effectively subsidising the liberal arts? To some extent possibly, but departments would expect to hold onto money which they raised and so such a process could only happen very indirectly. Programmes are reviewed periodically to see if they will continue - for example the 'Executive Education' programme was recently shut down because the shift away from corporate philanthropy had deprived it of its funding.

> *'Corporations, because of the financial pinch that they've found themselves in over the last three to five years, and the restructuring that they're gone through to become more competitive and more profitable, have cut back on those things and the executive education courses that colleges like Dartmouth would offer them, and realised that actually they can do it cheaper in-house, or they'll even in some cases hire a Dartmouth professor to go down and train their people, and that's cheaper than having fifteen of their people come up here for two weeks.'*

Is there a potential danger that a department which becomes totally dependent on industrial funding might be locked too closely to the short term goals of that company?

> *'Absolutely, we have a situation here where companies are really facing a direct payback. We have a situation with one of the drug companies, where we were approaching them for a straight grant to fellowships for the medical school and the company basically said "Well that's great, but what do we get out of it? Now we want a direct payback". The proposal which we eventually put on the table... is a combination of them funding fellowships for our students but then we would also plan and produce a program where their employees could come through and get medical education.'*

> *'Increasingly in this country, stockholders are taking a much more critical view of corporate philanthropy. They're basically saying "Look, I'm a stockholder, why are you giving away my profits, without even talking to me and getting my opinion on it.... You mentioned that there's more focus on the short term, I would definitely agree with that, and in a sense it's almost the nature of the beast, you know - make as much money as you possibly can. Organisations such as IBM, which was this country's largest corporate donor, when they ran into problems - a lot of which were probably because of that sort of short term almost myopic vision of things, and when the money was coming in great - but when it stopped they had to reinvent the entire corporation, and part of that re-inventing was slashing their contributions budget.'*

> *'Even after the changes of the last ten years, it's absolutely astounding to me the amount of philanthropic money which is still there. New companies starting up all the time... there's just a phenomenal amount of money if you can tap into it. But having said that, there's whole industries too which have never been terribly philanthropic, the pharmaceutical industry is very tough and they tend to get more involved in sponsored research than in anything philanthropic.'*

So, what potential does the changing pattern of funding have to alter the nature of universities? *'I think it will favour the more technical oriented universities, the engineering schools, there ought to be a good level of support for the business schools and the medical schools, but your general Liberal Arts college is going to run into trouble. Dartmouth is in an enviable position in that regard, in that we have something like $750 million in endowment, which for a school our size is quite good.*' His previous university had an endowment of only $40 million - and tuition cannot be increased further. '*They just won't be able to survive - I wouldn't be surprised if you started seeing over the next ten or twenty years a lot of these smaller schools either folding or merging.*'

Will Dartmouth's tradition reliance on reputation, alumni and contacts serve it as well in this climate?

*'Absolutely, we rely a lot on alumni contacts in the corporations we deal with, it's the name of the game. Dartmouth being a very small school has an intensely loyal alumni base, it's really quite extraordinary.... Many of them are the heads of corporations or very high up. Even that doesn't guarantee that you'll get a gift... One of the things we have to constantly guard ourselves against is going in academic directions which are dictated by the dollars that come in. We have a vision here, and we can't allow ourselves to change that because there's more money over here in this pocket.'*

*'It's going to make it tougher, no question about that. There's a whole other issues, for years colleges and universities have been ratcheting up the cost of their tuition to the point where now they're really pricing themselves out of their traditional market.... A lot of families are dealing with that by saying "Well you're not going to be able to go to a private school, because we can't afford it....". It's a combination of that and the potential for a lot of cases in recent years of investigations into federally sponsored research, and they've found cases of real fraud on the part of universities... really gross misappropriation of the funds. The attitude from the general public is more one of suspicion than it used to be. "What guarantee do I have that if I give your organisation money that you aren't going to really misuse it?"'*

*'One of the primary aspects of the job is the use of keyly placed alumni, and it is very much a who-knows-who game. Ultimately, though it's a corporation giving to a college - and though those are two separate entities, it still comes down to people giving to people. It's the relationships that I establish, the relationships that the provost establishes, the deans establish, that they are then able to translate into actual funding support. A large part of successful programmes like Dartmouth's is a stability in the fundraising operation. Development, by its very nature... is a long, long term process - and a lot of smaller colleges and universities I don't think understand that, and they have extraordinary staff turnover over a five or ten year period... and that's just not conducive to developing relationships... it really does have a negative impact on fundraising.'*

## 9.1.4 HARVARD

### 9.1.4.1 Donald Walker - Office for Technology and Trademark Licensing

**Interviewee: Don Walker**
**Job: Technology Transfer Officer**
**Organisation: Office for Technology and Trademark Licensing**
**Interviewer: Thomas Haigh**
**Date: Wednesday 21st September 1994**
**Location: Harvard University**
**Revision: 1**

The Office for Technology and Trademark Licensing (OTTL) is staffed by three technology transfer professionals, a working director, and a half-dozen support staff. Walker has been assigned the technical fields of software and certain applied sciences. One of his colleagues handles chemistry and molecular biology and yet another colleague handles the biological sciences. *"We all do our [marketing] tasks quite differently-due simply to the difference in technology and the diverse nature of the markets being served.*" In the broad field of physics, for example, when reviewing a new report of an invention and thinking about how he would market the technology, no single "road map" comes to mind. By contrast, he thinks that a colleague evaluating a discovery in, say, the molecular pharmacology field, may well have in mind a "short list" of industry companies that can be approached with licensing in mind. Inventors report their technologies "pretty much on a voluntary basis" and sometimes the office needs to engage in "outreach" to make sure that faculty are aware of their services.

Another role for OTTL is the licensing of Harvard insignia for use on various products, including coffee mugs, folders and clothing. (Boston was flooded with Harvard t-shirts during my visit.) Revenues from trademark licensing can fluctuate sharply with some universities, often tracking the success or failure of the college's athletic teams. If a national manufacturers can be convinced to produce authorized university-emblazoned sportswear, sizable royalties-around $25 million for the University of Michigan-can be reaped by the institution. Harvard takes in about $2.5 million yearly, and whilst this is not significant in light of Harvard's investment income from a nearly $6 billion endowment, "*the trademark [royalties] are important to us, among other things, because they are used to fund student scholarships*."

The university's technology licensing and insignia licensing functions have been grouped into a single office because they both involve the negotiation of intellectual property (IP) agreements. The overall role of the office is to serve as a centre of expertise in IP for the university. (A noticeable exception to this rule is the Harvard Medical School, which has its own Office of Technology Licensing and Industry-Sponsored Research (OTL). Even so, OTL's licensing activities are reviewed and approved by OTTL.). The functions of this latter office parallels that of OTTL, bringing in substantial license fees and royalties. As the name implies, this office handles sponsored research and technology licensing in an integrated fashion-not surprisingly, the world-class Medical School is responsible for a great many of Harvard's total invention disclosures each year.

Harvard does not have a central Industrial Liaison Office (ILO) programme such as that found at the Massachusetts Institute of Technology (MIT). Walker's opinion is that this is so because Harvard has not stressed the engineering sciences (the base of MIT's ILO constituency) for a number of years.

This university also has an Office for Sponsored Research (OSR) which handles all incoming grants-whether from foundations, government agencies or industry. They work closely with OTTL, which must review and approve the intellectual property terms in proposed grants or research agreements with industry. OTTL will, on request from OSR, negotiate with industry on the IP terms in these agreements.

Harvard's Development Office-tasked with the responsibility of seeking donations from alumni and other benefactors-is located in the same building, and the same storey, as OTTL. Yet contact between the two offices on marketing matters is rare. This may not be surprising since a supposed key marketing tool of the two entities (respective computerized data bases of companies, individual contacts, etc.) may be incompatible for each other's purposes.

Walker believes that most aspects of technology transfer, as currently practised at Harvard, are similar those employed by other institutions, "*although each university believes there are better ways to deal with the growing administrative burden attending technology transfer*." One favorite, and apparently common, "solution" is the design of the computerized database mentioned earlier, one aspect of which would be the linking of potential licensees to newly reported licensable technology. This system, in addition, would also facilitate the necessary government reporting, patent expense tracking and royalty disbursement chores. Stanford University has developed a similar program. However, its effectiveness-if employed by other universities-might not be optimal.

One area where policy differs between institutions is the formation of start-up (often called spin-off) companies where university educators and researchers may have a close financial interest in the new firm. What is Harvard's current policy and experience there? There has been moderate activity with respect to helping launch start-ups, but Harvard's experience is certainly not as great as that of other universities, and nowhere close to MIT's. "*Financial risk issues aside, there's always the spectre of a real or perceived conflict of interest (COI) issue which arises in start-ups, where the involved faculty member's ongoing university research is the sole basis of the company's existence.*" Walker believes the best way to minimise the potential for COI is to market the new technology to a firm or venture capital group in which the inventor is a disinterested financial party. Failing that, one might license the invention to a firm in which the university researcher's financial interest is "not substantial." Just what this latter term means is subject to a great range of interpretations. There are, of course, problems whatever course is taken. If a technology is successfully licensed to an existing company but the inventor is not prepared to champion the technology and work closely with the company, either for personal or professional reasons, then the discovery may not flourish. "*My co-workers in this office, and the tech transfer people at the Medical School, are better qualified to comment on this COI-management question. Thankfully, in my stay here, I haven't had to deal much with it.*"

While OTTL does its part to monitor university conflict of interest situations involving technology licensing, the best watchdogs, believes Walker, are the various senior faculty and peer committees which review and act upon questionable professional faculty conduct. Walker feels that such bodies "*often don't have enough information to consider a case until the fire is well under way.*"

Faculty consulting is another area where COI situations could arise, but OTTL is "*not really in the picture on such matters. The faculty are expected to be self-monitoring. If asked, we can provide a sample consulting agreement.*" When a formal technology transfer agreement has been concluded, "*it's almost inevitable that the inventor will become a consultant to a licensee-and that's fine as long as the independence of their academic research is not compromised*." Faculty are not allowed to use university facilities or time for their consultancy, or to steer the academic pursuits of their students towards the objectives of the industrial licensee.

At Harvard, software is licensed strictly "as is" with no support, maintenance or bug-fixes. It is quite likely that a company will seek consultancy from its author at some point.

One Harvard software program, out of many created at the university, has been granted a U.S. patent.

> *"Seeking patent protection for [scientific] software is rare at Harvard. I may have influenced that policy: I'm convinced that, with few exceptions, copyright protection is both timely and adequate, given the dynamics of the market. The sole patent I mentioned before has yet to be licensed. I'm sure that's a coincidence, but the fact isn't lost on me when I consider how to quickly make the technology available to the public."*

The exclusion of support and maintenance from software licenses is one area in which Walker "*will not yield.*" Improvements will be considered if they fall naturally within the direction of on-going research in the area and the research interests of those involved, but "*we cannot be a development house.*" (At the time of the interview, Walker described a situation wherein a licensee was arguing to reduce royalty payments on the grounds that support from Harvard had not been forthcoming. Aside from the fact that the language of the agreement clearly stipulated the "as is" condition of the program, Walker's counterpoint was that the fee and royalties the licensee had paid were perhaps only a tenth of what it would have cost them to develop the software on their own.)

The legal status of software which is derived from licensed material is problematic-the U.S. copyright laws suggest that the right to create derivatives remain with the original copyright holder and would have to be specifically granted to the licensee if they are to own the results of its commercialisation.

> *"That's a very hard issue to resolve... I am still looking for ways to measure the relative intellectual input to derivative works... simple examination of the code is clearly inadequate.... It's hard to know who "owns" what portion of a program after it's gone through multiple revisions."*

Walker describes the threatened erosion of the U.S. Bayh-Dole Act as an ongoing concern of his office and of its director, Joyce Brinton. She is president-elect (1995) of the professional association which serves university technology transfer professionals, serves on several other national-level collegiate committees, and has helped draft material for presentation to congressional staffs. Brinton is "quite vocal" in discussing with government the new programmes for technology transfer which

> *"curiously, leave the intellectual property ownership with the industrial partner rather than the university. That is difficult for us to grasp because the rules with which the university operates are different from those of industry, particularly the issue of confidentiality. Universities need, and must reserve, the right to publish freely."*

Another current issue for Harvard is *"the University's acceptance of equity in licensee companies in lieu of (or in addition to) license fees and royalties .... In the past, the conservative nature of Harvard led to policies which avoided that kind of involvement for fear of compromising its academic principles for financial gain.*" Derek Bok, Harvard's former president, felt this very strongly-but under new university leadership "*we're moving towards a point where greater university ownership is possible*" with regard to start-up licensees.

Inter-university agreements can be another problematic area. "*Frequently, institutional partners which jointly own a piece of intellectual property cannot agree among themselves how best to license the technology, pay the patent prosecution costs, and share royalties. And, with the movement of faculty inventors from one institution to another, the ownership and royalty sharing rules become quite complex.*" Policies laid down by different federal agencies or foundations which have funded the research can also add to the mess. Differentiation of the ownership of software derivative works, according to Walker, can be particularly vexing.

As previously mentioned, sponsored research agreements are handled by a separate office, OSR, although they work closely with OTTL on intellectual property clauses. Often, such agreements include some kind of priority access or option to license the results of the research; few companies are willing to make outright grants without some condition of having a look at the researcher's results, *"but there are no guarantees ... that by funding the research they automatically become licensees.*" There are some companies that hope to, right from the beginning,

> *"establish licensing terms as conditions which are buried in the grant document; [Harvard] won't participate in that ... it is inappropriate to lock in and make captive the research activity of a university laboratory. The faculty could then become indentured researchers for the companies supplying the money ... the influence can become quite pervasive."*

On a project lasting several years a company which saw work moving in a direction unlikely to benefit them commercially might seek to redirect it-occasionally by withholding money-but usually in more subtle ways.

What the company would get, in addition to a right of first option, would probably be a chance to read papers produced from the research before their competitors-though not before they are sent for publication.

> *"Many companies, in their proposals for industrial research, will require the researcher to submit the paper to the sponsor before they submit it for publication. That, of course, is not acceptable-not in my cases. Maybe others in the University would find that acceptable, but I don't."*

One of the other benefits which companies see from such an agreement is the increased prestige gained from "a*ffiliation with the university and with a particular researcher*." Given the high profile of many Harvard faculty, this can be a significant incentive. Interestingly, the Japanese "*take a long term view of it: they will often impress you with their long-range plans, as well as the size of their pocket books."*

Academic networking is a valuable source of contacts for potential agreements, and Harvard makes its alumni "*part of the family*." "*But, I haven't found having an alumni champion inside the company for a technology license of very significant importance. It could be that the CEO is, in fact, an alumni and is more approachable, but business decisions are made on very rational grounds*." However, industry can tend to be more tuned to the "*cult of personality*" and therefore, a world-renowned principal investigator is a major asset when seeking research funding. Even so, a degree of "vision" is still required on the industrial side.

Firms are prohibited from capitalising on the Harvard name when promoting products based on licensed technology. For example, Harvard reserves the right to inspect material mentioning Harvard which is to be used in a national magazine. On the other hand, due recognition of their contribution is also expected-in the case of software this might be an acknowledgment message on the title screen.

Harvard benefits from the cluster of high technology companies in the Boston areas attracted by, or spun-off from the many universities, particularly MIT. "*Within a radius of twenty or thirty miles of this campus there are literally hundreds of firms that owe their existence to the universities in this area .... We have a huge talent pool of consultants available.*" Although MIT's departments, as a whole, can tend to overshadow Harvard's in many applied science areas, not least in terms of size, many Harvard faculty in these areas are very strong. This can mean more of a concentration in particular areas. Harvard's policy is to bring in the best available faculty, although this may mean that many bright, junior Harvard faculty may have to look elsewhere for tenure.

Walker agrees that many areas of computing are inherently applied, and can benefit from industrial contacts.

> *"You need a lot of feedback. In licensing you try and find the industry leader, because you feel that their direction is the most `real world' as well as most likely to result in revenues which lead to high royalties .... One of the benefits of licensing is that the faculty and the graduate students working on it get to go beyond the theoretical-they never loose sight of what it is that they are doing, they are doing basic research for educational purposes and they're going to write their theses about it-but all the more valuable that the thesis will be widely read and not just by academics, but by those who are in the field. It certainly doesn't hurt in applying for work to have on your resume that you have written something which is fairly widely accepted in the industry in which you are trying to find a job."*

How important are the revenues raised from licensing? Walker believes the main purpose of technology transfer at Harvard is to disseminate knowledge and ensure that university discoveries are promptly placed into public use.

> *"That's a very real, as well as idealistic, goal for this office. Although nobody [in the university's central administration] looks at our small group with a totally 'green eyeshade' viewpoint, they have been known to ask us to project what our royalty revenues will be next year.... It's my observation that universities themselves quietly note their relative technology transfer 'rank' among peer institutions. It's natural to compare which school had the most [invention disclosures], or had the highest royalty income-to-staffing ratios, and so forth. However, technology transfer professionals readily admit such comparisons are specious: The broad licensing of a single `hot technology' can make even the most inept office look productive. But, as a group, we need the 'comfort' of quantitative reckoning."*

Will the reorganisations of large corporations such as IBM and DEC alter the technology transfer landscape?

> *"I think that most of the best work done in applied computer science today has not been done in universities at all-it's being done by the large commercial organisations with well staffed research groups [such as] IBM, Digital, and Silicon Graphics .... The reason they've been able to do this is that their profits were, or are, large enough to support this. Furthermore, they are driven by competitiveness and anticipation of market changes. Universities seeking knowledge don't have the 'commercial hunger' seen in for-profit companies."*

Walker has seen "the pendulum swing three or four cycles over the last twenty-five years" with regard to industrial attitudes towards research. Policies change and new approaches are tried. At one time aerospace companies such as Raytheon Company and TRW used to sharpen the wits of its research people by posing the same design problem to two groups, one significantly larger (and better funded) than the other, to gain the benefit of different approaches. (It is reported that Apple Computer has used this same internal competitive style.)

One trend on the university side has been towards the re-labeling and restructuring of group activities into "centres" and "institutes." For example, Walker mentioned Harvard's Center for Textile and Apparel Research. These initiatives represent a re-focusing of university talent to allow its application to national economic needs-while steadfastly maintaining the university's academic research goals.

How does Walker see the situation developing in the future? First, reduced federal funding of research at institutions of higher education forces universities to consider alternate sources of revenues. Walker believes that economic necessity may cause some universities (but, certainly not Harvard) to re-examine their "freedom to publish" policies with the possibility of imposing limited confidentiality on results of industrially-sponsoredresearch.

Second, there is a real possibility that, under certain circumstances, universities may loose permission to take title to certain future federally-funded research discoveries. Walker concludes,

> *"In recent years the creation of a new `advanced technology program' by federal agencies effectively counter key provisions of the [Bayh-Dole Act]. There is also another 'technology reinvestment program' which, while not precluding university ownership of intellectual property, nonetheless places control of the research in the hands of the for-profit partner, and places the university in a disadvantageous negotiating position. And, there is draft legislation being considered by the U.S. congress that would create a government-operated corporation to centralise and control all federally-related technology transfer-including, perhaps, university inventions."*

#### 9.1.4.2 Peter Williams - Harvard Medical School

**Interviewee: Peter Williams**
**Job: Senior Manager, Licensing & Business Development**
**Organisation: Harvard Medical School - Office of Technology**
**Licensing and Industry Sponsored Research**
**Interviewer: Thomas Haigh**
**Date: Wednesday 21st Septemeber 1994**
**Location: Harvard Medical School**
**Revision: 1**

Before coming to work at Harvard Medical School, Peter Williams had been involved in technology licensing at Newcastle University and so is well placed to comment on differences between approaches

*'This office is the office of Technology Licensing AND Industry Sponsored Research. I would argue that [the cultivation of industrial research funds] is an important activity which should be handled by the licensing office because the targeting has got to be done in science and technology terms, so you're trying to match up an interesting piece of work with a company which has an interest in that field. They don't give broad brush funding anymore, so that's an essential activity - otherwise research which might be industrially funded will never see the light of day. What industry will want in return of course is intellectual property rights, so you should have a licensing office dealing with that'.*

*'There is a school of thought that says that if you have any contact with industry then that should be handled in one office and that office has one label that anyone in industry can recognise, and you tell industry "Within this office we do the following things: technology licensing, sponsored research...". I can see arguments on both sides. I think a lot of that issue is about 'outreach' as we call it here - what label do you put on it, how do you get in understood'.*

A sucessful overall programme of industrial interaction requires certain capabilities, however these are packaged.

*'What Bayh-Dole does is give universities title in inventions that come out of government funded research. It's not quite as simple as that because we have to elect title - title is not automatically invested, unlike the UK where you can be passive and comfortable that if SERC or MRC has funded the work in your institute then you automatically have the rights. Under the public laws we have to notify the government that we wish to retain title in a specific invention.'*

The government has 'march in rights' to inventions which are not being properly handled.

*'There's quite a lot of reporting required to the government - if you talk to any tech transfer office they will tell you that they have one or two people doing this as almost a full time job.'*

*'There's a body that lobbies Capitol Hill on behalf of the non-profits, the Committee on Government Relations - COGR. These are still very much live issues. An awful lot of time and effort is put into this.... An important piece of this is that there are congressmen who are very concerned at the relationship between non-profits and industry with respect to intellectual property rights and whether US industry is actually getting a fair crack of the whip.'*

Congressman Whyden has been very vocal in examining specific industry deals and questioning whether the current framework is appropriate. The Department of Commerce is also involved in this area.

With regard to the patenting of software, it is not under current law possible to patent software in isolation. However, as an essential component of a larger system - such as a point of sale retail system or a genetic mapping technique it can be patented. An advantage of this is that '*the coverage you get is very good - it means that if somebody comes along with a system including software that does pretty much the same thing you can enforce your monopoly*.' Patentability requires industrial utility for the larger system and so is a complex and specialised activity.

Does the lack of a local base in most high-tech industries handicap the efforts of British universities?

> *'To the extent to which research in Britain continues to be four or five star rated, I think that the infrastructure argument is of secondary importance because it is a world market, and people in tech transfer offices in the UK are going to be speaking to as many American, German and Japanese companies as they are UK companies. Overseas companies are willing to invest.... if the science is good then the UK can sell it.'*

> *'I think the government in the UK is paying attention to what the universities are doing, which universities have been successful in getting licenses and sponsored research for the job.... There are rumblings that if a university isn't too successful in it's tech transfer programme, maybe the government won't allow it to go ahead for ever more taking all the rights'.*

The question of 'What is technology transfer good for'? is another big issue. On the economic side, 'it allows small companies to get off the ground' *and specific funding to allow them to work with non-profits has been made available by the US and EU.'*

> *'There is another model for technology transfer emerging now in the UK. In the old model somebody in the administration would handle technology transfer, and that person probably had a hundred other things to do, so that was a very busy person. In the model emerging the university will set up a separate wholly owned subsidiary company that will undertake technology transfer - the people in that company will be working full time on technology transfer and in many cases it will mean that they are paid a living wage, they won't be tied to academic salaries. Sometimes those companies try and raise their own seed-corn venture capital funds. It's interesting that perhaps the universities doing this, following the US pattern by employing full time professionals, are in some ways more adventurous than some US universities. We have more of a free hand in deciding what is worth licensing to industry - if you like we're more commercially driven....*

> *On both sides of the Atlantic you get institutions that patent anything and everything, and in my view this is flawed. Optimally you have to be selective, and admit that you are taking some risks. "Patent everything" is a risk minimization strategy that doesn't work - you spend so much money that it is difficult to show a return, and the managers dilute their efforts across a large number of cases with poor commercial value. The result shows up in poor performance ratios of income per employee, per patent filed, income to expense or non-re-imbursable patent expenses... but NOT in simple measures like number of patents filed or gross incomme. Performance is now a concern in both the UK and USA. We continue to file patents on 50% or less of inventions reported.*

The British Technology Group (BTG) was the successor to the National Research and Development Council. At one time they would acquire rights to SRC and MRC funded research, and they were the clearing house for all inventions. Today universities can use BTG if they wish and the BTG is now privatised. *'There was a time when BTG could actually put up venture capital money, and I don't think they have that activity anymore - so really what BTG used to do is being done to a great extent now by the universities themselves.'* BTG has now closed its regional offices in the UK, though its presence in the US has expanded.

At Harvard formal declarations of interest are required. Most UK universities have less formal mechanisms. *'It's not an issue that the tech transfer office on its own can deal with.*

> *'Conflict of interest policy is, I think, very well managed in the US and is looked at in a very formal way. The policies are written and the investigators are made aware of them. Very often there might be a committee or an office that would consider specific cases of conflict of interest'.*

Both government and private funding have similar objectives.

> *'They both want money to go to centres of excellence, and I think industry long ago gave up open-ended funding where they just said "Here's ten million dollars, that just goes in the lab, we don't care what comes out of it but if anything does we'd want to take a look at it". They want to give money to focused programmes where they have at least some idea what might come out of it. I think that because the government now has less money they have given up spreading the funding around thinly. They're more likely to say "this is a centre of excellence for particle physics so we're going to give them a larger slug of money for the lab".'*

### 9.1.5 IBM - Hoecker & Greis - Higher Education Business

**Interviewees: B.M. Hoecker & Michael J. Greis**
**Jobs: Manager - Business Development/**
**Computing Research Specialist.**
**Organisation: IBM North America / IBM US**
**Interviewer: Thomas Haigh**
**Date: Friday 23rd September 1994**
**Location: MIT Industrial Liaison Offices**
**Revision: 0 (No feedback obtained from interviewees)**

As Business Development Manager, Bernie Hoecker formed part of a team with Michael Greis within IBM's newly organised *Higher Education* business. IBM had recently reorganised, but despite recent downsizing was still planned to employ around 200,000 people at the end of 1994. Internal organisation into divisions is now vertical by market - a fundamental restructuring prompted by the need for '*a new way to bring products to market'* and education is structured as a business sector in the same way as health, insurance or manufacturing.

The Higher Education (HE) business is grouped under the '*education businesses umbrella*', but '*we deemed it very important when we made this change that HE should be a separate industry within IBM*'. IBM has strengths to share with higher education, for example in the joint testing and development of software technologies under *'shared university research programme*'. Such partnerships complement the marketing, consultancy and support functions also delivered by the HE business to provide 'transparency' to customers whilst identifying and meeting their needs. '*To be successful we need to understand what goes on in a university*'. The general reorganisation of IBM was pushed for by those working in HE, and they were '*ahead of the pack*' when it came.

IBM looks at a university from several perspectives. One is that of a customer who will buy products and services. However, the university is also a talent pool who will come out of that university and work possibly for IBM or for one of our customers - they need to be impressed by the service IBM offers.

> *'We see a research partner. IBM Research's view [is that] our mission is to do world class science and be relevant to IBM's business..... We can no longer do all the research we need to do ourselves.... we just don't have the resources to. Doing a 64MB chip is a hell of a lot more expensive than doing a 4 MB chip or 1MB chip. [They] look Universities and say 'I have a talent pool, a pool of people doing quality research. I'd like to have them do research for me, and with me.'*

The nature of a collaborative research arrangement could range from a simple grant of money or equipment, to a mutually supportive joint project where *'we're not buying a piece of work*' - rather IBM is seeking to '*get the jump*' on others by working along with research teams.

Because universities are always at the 'cutting edge' of technology, they also have an important role to play as a test bed - technologies such as TCP/IP, scientific computing in general and UNIX would never have been industrialised without the support, testing and feedback they received in Universities.

Given the multi-faceted role of the university, how can IBM best organise to '*take advantage of this?*'. The job *'cuts across IBM research, IBM Manufacturing Development, Headquarters...*'. It is important that both sides work as partners and '*know what they are going to get out of it*'. Contacts '*on the ground*' maintain the business relationship, and oversee other aspects as well as they can.

Education in general is of interest to IBM, and in more general terms IBM's huge corporate philanthropy budget has been directed towards primary education. HE was traditionally looked for to solve national problems in the cold war - they can now work along with IBM to help improve the '8 through 12' educational system and benefit indirectly from this.

Confidentiality is a major issue in a collaborative research situation. *'Most companies don't go to universities and say "I want you to produce this confidential piece of work that only I will ever see" because that's just not practical*.' However university may be given confidential corporate information to work with - which is itself problematic. '*The last thing I want is having some guy who spends all his time surfing the Internet having my information with no restrictions on it*'. An arrangement acceptable to both sides can usually be found. '*What you get... is a role in how* *the research goes - you're helping to direct it and you're going to be the first to see the result*'. This produces an environment where researchers are happy *'doing what they want to do, but with interlock between what they do and what we need*'.

Companies 'just don't have the money' to give away large, open-ended lump sums anymore, and '*you look at the way the US government is heading, a lot of the programmes that support research are being much more tied to technology getting to the marketplace*'. Many government grants now demand a corporate partner, for example the Advanced Technology Programmes.

Links between IBM and university researchers are generally made professionally, through student relationships, publications, conferences and so on - rather than through a more formal grant application process. Research groups undertake the support of groups, in the shape of post-doctoral grants and so on, directly. IBM's new structure means that this kind of support is not undertaken with centralised corporate funds - *'the people who pay for it should be the ones who get the benefit*'.

However, initiatives such as the Shared University Research (SUR) programme involve the selection of a group of 'premier' institutions - each of which is allocated a designated campus representative and '*a large chunk of money to be used toward IBM equipment*'. Projects are jointly identified and submitted - the programme is now in its second year.

As hardware costs have dropped constantly, the most expensive part of a support agreement is the provision of a '*resource person to work with the university*' - essential if any hardware donated is to be used effectively. '*A lot of universities have discovered - they get a lot of free equipment from people, they end up with this huge mess that costs them more to maintain than they would have paid for it*' in terms of networking, software updates and training. '*Because you get something for free, it doesn't mean it doesn't cost anything.*'

When Brown decided to standardise their computer science department, '*they made themselves such a visible target that they got all the companies involved, including IBM to offer this incredible good deal.... You won, you got the rights to basically give your stuff, but it would be all over computer science at Brown*.' This route is proving increasing attractive to universities - especially given the need for a long term relationship with a (surviving) supplier to allow a smooth 'roll over' onto the next generation of technology. Universities are having to pay '*more and more*' of the true cost of their machines, as an increasingly competitive marketplace forces companies to recoup costs. '*We see a lot more in software and consultancy and the services, if we can do it right*'.

Will the new patterns of funding necessarily favour institutions which are already highly successful?

> *'You hit on a very interesting question... to some extent the quality which they represent will help them a lot, I think what they've had to do is be a lot more flexible and responsive than they have been. I think that most of the prestigious universities their attitude really, historically was, "We are here, you have to come to us and do business the way we want to do business" - which really isn't doing business, its kind of "you need to give us stuff and we'll give you the benefit of our wisdom". That doesn't work any more...'.*

As they learn mutuality then they will continue to be successful, but opportunities may exist for 'hungrier', institutions which say '*we understand that we're not the big name, but we've got some good people, and we help you so you can help us*'. However, only if more prestigious universities fail to exploit their opportunities will corporations turn in large numbers to research groups of lower perceived quality. They are becoming more willing *'to say "how can we work with you", rather than "what can we get from you"*'. Many of the problems faced by universities are analogous to those affecting industry itself.

What attributes would an institution need to attract a significant amount of industrial funding in the current climate? '*High quality research, and a reputation are probably the most important ... but after that would be willingness to work co-operatively'*. More specifically, in the field of object oriented technology, IBM works with universities in several ways to bring product to market - for example by approaching an elite university which produces graduates of proven quality and offering equipment to help teach new techniques in the classroom. Even if the graduates do not work for IBM, they will carry their experience of IBM technology into the marketplace. The advantages to universities of having access to state of the art technology is obvious. Universities increasingly want to produce people who will 'go out and have an impact'.

For this kind of project, IBM would seek out a university with strength in one of their own areas of research and development - such as ATM communications, virtual reality or VLSI.

IBM has a very diverse range of research interests, including engineering and computer science, materials science, chemistry, high energy physics and some areas of biology. As well as technological products, IBM also works to jointly develop '*teaching and learning techniques*' such as distance learning.

How does the value of IBM's overall contribution break down? Ten years ago, hardware was probably the most significant part of IBM's overall donation. '*When you're putting together a proposal, spending the time, I'm not sure that anyone adds up the total dollar value of the people involved in collaboration'*. Another general trend has been away from cash and more towards equipment, some grants involve a matching of donations - 1:1 if taken as cash, 3:1 if taken as equipment. Cash is still available for specific purposes - for example postdoctoral grants to support research teams. '*Everyone recognises that you can't do research just with equipment*'.

Because of the variety of different forms co-operation can take, and the different sources of funds, evaluation of results differs greatly. *'I think sometimes there isn't as much as anyone would like there to be...*', but as responsibility is now placed as locally as possible within IBM individual research teams will look for value in projects funded from their own budget. '*If they can't justify in their own mind why they spent that money, they won't do it again*'. More formalised programmes have their own reporting mechanisms.

So, will the trend towards 'virtual organisations' and 'outsourcing' change the research relationship? *'I think in general, overall, I wouldn't say it will change the way we do collaborative work*' - the research groups having already recognised the advantages on offer. Within IBM, the role of research continues to be respected - however in smaller companies with less of a tradition, it might be better 'to just have a small group who go out and find the technology'.

However, *'no one can afford any more to design their own chip*' and a complex web of 'strategic relationships' has grown up within the computer industry. 'They're kind of like mushrooms in the rain - some of them disappear after about a week' and over the long gestation period of a new technology companies can grow apart.

Software licensing is another '*extremely complicated*' area - '*some universities used to like to develop algorithms and code and put it out, but then they realised they had to support it*'. Increasingly they seek development partners. One approach is to develop an algorithm which will not be proprietary, but its developers will be in the best position to help a company develop it. '*Copyright law is very difficult*'.

'If you look at the history of computer science departments in this country, you'll see (and I'm sure somebody's written a paper on it) but they came out of different areas... in fact you'll see great difference in the personality of the department, depending on its ancestor. If it came out of Math it will have a more theoretical cast, if it came out of engineering it'll be more practical.'

How does technology transfer occur? As a *'marketing and relationships*' organisation, the HE business is a single point of contact. Just as they channel maintenance requests from customers, so they can direct others within IBM towards universities with potentially valuable technologies - although usually established research groups have their own relationships. Technology transfer officers cultivate their own corporate contacts, and where appropriate can direct faculty members towards interested companies.

How special is MIT? Michael Greis had worked with MIT for six years - '*very special, MIT has had a long history with IBM - some of it very contentious. They were two organisations that both believed at different times that they were at the top of their game, at the top of the world, pretty strongly believing that they knew what they were doing. I would say that, over time, it's kind of gone back and forward*', but a lot of strong relationships exist. On IBM's CEP - Campus Executive Programme - sixty six campuses have been allocated an IBM '*pretty top*' executive contact. The executive who works with MIT is the Senior Vice President of Technology and Research (top man in IBM research) who visits regularly. MIT's president is now a member of IBM's board, a pointer to further strengthening of the relationship, and the relationship also benefits from the number of MIT graduates working at IBM. Both IBM and MIT are *'struggling with this new world.*'

How about the specific 'Industrial Liaison Programs', exemplified by MIT's? For a company like IBM it is useful to provide another way of maintaining relationships, but *'for a smaller company it can be very beneficial for smaller* *companies that don' necessarily have the resources or the relationships, because these folks at the ILP can really help a company negotiate the MIT maze and find out where things are of interest*.' Would the approach work for anywhere apart from MIT? '*If you identify a very motivated, bright group of people to do it then I think other universities could do it, but I think the less visible and the less known they are the more they have to get out there, and they might need to be more flexible about what they ask from the companies.*' The best approach might be to identify corporations, work with them for a year on a trial basis and then ask them to help support the costs involved. '*Good seminars*' are invaluable, to '*show companies what they're getting*'.

Is IBM's world-wide HE strategy strongly co-ordinated? The HE organisation has a global structure, with sister organisations overseas, and obviously many of IBM's research centres are also overseas. A pan-European organisation to co-ordinate research co-operation is now in place. So would a British university find the lack of locally based research companies made it harder to attract industrial support? Conceptually not, but *'there are still companies that don't understand that research is international, may not be looking beyond the borders*' - although IBM's long established international base helps them here. The international migrations of top researchers helps to spread corporate relationships, as does the increased number of international collaborations between universities.

In conclusion, *'businesses will continue to evolve'* but no dramatic change is expected in IBM's relationship with universities - which overall is *'very good*'. Because corporations have to focus strongly their more limited resources, they are looking to '*better understand what they are getting*' - though a spectrum of different attitudes exist here. IBM is seeking to

> *'be as flexible as possible, because we haven't always been - we had a reputation for being very inflexible, which we are having some success at overcoming - trying to look at both sides. We want university benefit, but we also want them to realise that we need to benefit, and be able to say what that benefit is - for out stock holders and the people we work for. Universities are coming to realise this.'*

## 9.1.6 MIT

### 9.1.6.1 Alex Laats - Technology Licensing Office

**Interviewee: Alex Laats**
**Job: Technology Licensing Officer**
**Organisation: MIT Technology Licensing Office**
**Interviewer: Thomas Haigh**
**Date: Friday 23rd Septemeber 1994**
**Location: MIT Technology Licensing Office**
**Revision: 1**

MIT has both an Office of Sponsored Programs and an Office of Technology Licensing, in addition to the Industrial Liaison Program which is also run separately. The OSP provides the mechanism whereby companies sponsor research at MIT, and the TLO serves to transfer MIT's intellectual properties to companies via license agreements. MIT owns the rights to industrially sponsored research, but the company typically has a 6 month period following the identification of patentable technologies to elect to license them - either exclusively or non-exclusively. If rights are not taken, the company can claim 25% of royalties which are eventually derived from licensing the technology elsewhere.

MIT typically retains the right to decide whether or not to file a patent application, with the TLO responsible for such decisions. If MIT does go forward with a patent application, then the sponsor will typically have six months to elect to take a license. As a practical matter, the TLO's decision to file a patent will often be based on a preliminary expression of interest from a sponsor. In cases where there is no sponsor, then the individual technology licensing officer will be faced with the decision of whether ' there is anyone else out there who is interested in it for other commercial purposes'.

> *'The real difficulty in terms of taking technologies and getting them from an embryonic stage to a product stage, and then from a product stage through a scale up to a large market is funding along each step of the process. Whether it be an industrial sponsor or the US government that is funding research here at MIT, MIT is not in the business of delivering products - its role tends to be more open-ended - taking the technology to a very embryonic stage'.*

The first stage is research - '*MIT all the way*', followed by development - generally also funded by the sponsor and carried out at MIT. However, the government rarely goes beyond these to the next stage - '*the creation of prototypes on a bench in the lab'*. Still more rarely will it fund trial manufacturing of a product. Industry by contrast, is usually much more interested in an idea if it can be presented in the form of a manufacturable prototype which they can then investigate the scaling up and marketing of. '*The problem is in the gap between R&D and the things that industry is interested in capitalising on*'. Sometimes the gap is bridged sufficiently by government to allow the production of a prototype, and the manufacturing can be outsourced - for example in the design of aeroplanes for the government, something which led to a new industry. A current example today at MIT is '*a supercomputing technology which can fit in a box the size of a PC and give you more power than a Cray super computer for mathematical operations, but cost a hundred times less*'. Because no such technology was available in industry, the government was willing to fund the development of the product - which will '*probably start a new industry*'. The government also funds some medical research to the product stage to satisfy its social responsibilities.

Laats stresses the central importance of this process of '*bridging the gap*' from R&D to products to successful technology transfer.

MIT is interesting here because of its historical mission - it has always been oriented towards 'problem solving' research, particularly manufacturing related and *'students and faculty have always been encouraged to have an entrepreneurial side*'. This is reflected in the acceptance of faculty holding equity in start-ups and consulting - '*many many companies*' with high net values have been founded around MIT, and graduates have gone abroad.

*'Sponsored research is industry saying "we have a general problem - we think that we can sponsor additional research in the area that may ultimately help solve our problem*"'. Universities cannot be expected to produce products as part of their normal work.

The TLO works '*when the results of sponsored research*' begin to become known. They are governed by contractual obligations which will have been laid down in the agreement reached with the OSP. Knowledge is sometimes shared between the TLO and OSR, for example, he currently has a number of pattern-recognition technologies and the contacts of the OSR would be very useful in marketing them. The ILP can be similarly helpful, although as the TLO has grown and become internally profitable it generates sufficient contacts and opportunities. Usually inventors will have their own contacts, and as time pressure is severe these are usually followed up in preference to searching for multiple potential licensees.

When negotiations are underway with a company which appears '*credible and has the where-with-all to take a technology to a certain level*' a particular field of use is defined for that licensee. Technologies are thus licensed as widely as possible, but the aim is to get the technology 'out' as soon as possible. All agreements contain 'due diligence' trip-wires and the performance of licensees is monitored to make sure that the commercialisation is proceeding - if these conditions are not met then the OTL can terminate the agreement.

Most inventors are realistic as to the worth of their inventions, and recognise that the market may be small or in the distant future. Perhaps a third to a half of his job is marketing - '*which means understanding the markets, trying to determine whether or not the technology will fit, whether someone out there is going to be interested in it*'.

A technology which has '*bridged the funding gap'* is often suitable for a start-up company, as no major '*leap of faith*' is needed here. This is balanced by the fact that a technology creating a number of distinct product opportunites is the most suitable basis for a company. For example, a technology offering a substantial performance improvement at a comparable or better cost to existing products and can be relatively easily brought to market is ideal for a start-up. If the inventor is entrepreneurially minded, then fundraising is likely to be successful as the financial risks involved seem reasonable. The super computer project mentioned previously has as its deliverable the basis of a commercially marketable product. In this case manufacturing can be outsourced, a clear market is identifiable and the product has price/performance superiority. Because of MIT's previous success, a group of venture capitalists has been cultivated who will meet inventors and *'are willing to come on board because it is MIT*' - at least to the extent of considering the proposal seriously without elaborate business plans having already been drawn up.

By the same token, technologies which are more embryonic are usually more suited to licensing to existing companies. The companies must have long term development cycles, and be prepared to invest in a technology which they are prepared to ensure will be saleable '*four or five years down the line*'. *'It's a low cost way for them to get valuable R&D ... $100,000 as a down payment license fee is cheap, considering that MIT has spent in any given case two, three, five years with a budget of millions of dollars developing the technology to that point*'. Not all technologies have a clear suitability for start-ups or existing companies - in many cases the entrepreneurial nature of the inventor is what will decide the matter.

Is the inventor ever wrong about the worth of their technology? Perhaps, but a lot of 'pooling' of industry contacts goes on to determine the marketability of a technology - as inventors are highly intelligent academics whose primary purpose is not *'to make a ton of money*' they will usually accept this.

How far does technical excellence go in assuring the success of a start-up?

> *'You need to have marketing and sales ... you need to be able to identify the markets which are attainable for the resources you have and obtain profitability at a quick enough rate that you can capitalise on other markets. Once you have shown that ability then you can raise sufficient equity capital to enter into other markets, but all of the key is marketing and sales - the technology has to make a good sales story but if you can't sell it ...'*

Another of MITs strengths is the 'MIT Enterprise Forum' - an organisation '*dedicated to starting new enterprises and helping new enterprises develop*'. They provide seminars and training to help provide marketing awareness to technical people. The TLO itself will help an entrepreneurial inventor by drafting their own summary of '*potential markets, what we think the performance improvements are, what we think we can establish as an intellectual property position and use this to identify potential investors*.' These investors help the inventor set up a management team - usually including '*someone who is more sales and marketing oriented who can work with the technical inventor to take the product to market*'.

How clear is the distinction between basic research and technology? Is research in some areas, such as computer architecture, inevitably applied? Often it is blurred - for example an algorithm can be implemented as hardware or software. Software can be basic research, or - if in a finished or usable state - has '*already bridged the gap*'. 'I*t's something you can sell, and not only that - you can protect it with copyright so you don't necessarily even need to file a patent*'. Similarly in the bio-medical area the products of research - strains of viruses or animals - may have direct commercial value. Sometimes computer research in areas like architecture can '*be far ahead of current technology*' but most companies have shorter term horizons. Thus a company is unlikely to come looking to '*establish the standard for high speed computing in the year 2000 or 2005 - they're working on next year's chip*'. The focus is on year long, evolutionary projects. Because of the nature of the industry, a long term project to produce a technically superior product is of no use if the industry moves towards different standards on a year-to-year drift. For example, nobody would have designed the modern PC architecture in its current form if it had been derived from first principles with a long-term view, but it dominates the industry.

Universities license software 'as-is' - any further consultation on the software must be paid for. It is impossible to *'patent software as software - you have to patent software as a process or method'*. An algorithm is not patentable in itself, but the idea of the process which it conducts is. Like any other idea for a process, if the process performed by the algorithm is 'new, useful of non-obvious' then it can be patented. '*I think copyright protection is a viable system ... with all software someone else could develop it, but in business, as you know, if I have something and it would take them a month to develop it then that month is time, and that month is valued - there is some value to be obtained.'* Usually six months or a year would be a viable time-saved period to justify licensing, especially on software for a new platform. Hence, '*licensing software, even when it's not patentable, is a way of making money*.'

'*A lot of people who have developed software in the past have just thought that everyone should get it....*' so it is not universally protected. X-windows is MIT copyrighted and can be licensed, although it was not fully commercialised at MIT. '*Sometimes the value to a company is in preventing other people from making, using or selling*.' In that case only a patented invention is valuable. Sometimes '*an inventor who thinks they are broadly disseminating their invention by not patenting it and letting it go free to whoever wants it are actually producing the opposite result because they don't have any commercial engine to distribute it. Putting something on the Internet, for example - the Internet is so big and there's so much on it, only those few people who are really keyed up to exactly what they are looking for are going to find it. It's not going to be widely distributed*'. There are, of course, exceptions - such as the Mosaic programme, which in the absence of any alternative was very widely used and allowed its inventors to develop the idea commercially.

How important is the continuation of legal and government provisions, such as those of the Bayh-Dole act.

> *'The main thing about the Bayh-Dole act is that it provides incentives for researchers or educators to take what they develop and look for commercial applications and take equity in other companies. If you were to take away these incentives ... then the funding gap, I think, would get larger. The directors of this office have spoken to congress on many occasions about the issue of whether the current statutory provisions are appropriate - the act could be repealed and the whole thing go out of the window, but in the near future? I doubt it. The whole US government is working towards this technology transfer as a means to keep the US competitive.... [what technology transfer is doing is] taking all the technology that has been developed with government funds and turning it into jobs, the last thing the federal government would do at this stage is take away mechanisms which have been established to do that.'* This is particularly important in a climate of shrinking defence spending.

In patent law '*you can get a patent for anything if you make it narrow enough*'. The patenting of software is now better understood, and is possible if claims are well drafted. *'In my opinion the market will dictate real economic value - if you get a patent, fantastic, but if people in the market don't recognise its value then it has no value, and to try and enforce it unjustly is a real burden.*' A patent which is unreasonably broad can be challenged and invalidated on these grounds when an attempt is made to enforce it.

Could any university hope to set up a successful technology transfer programme? *'You need good people, because the resource in the technology transfer office is people who believe that technology transfer is the way to create jobs and to improve life, and it's a pretty direct correlation, who have contacts in industry, experience with business and who are dynamic enough to be able to market technologies. If you have those, and you have a resource of good research.... '* His office benefits greatly from MITs reputation as a premier scientific and technological research institution, and with seven full time technology licensing officers '*you can get a great deal of technology out to the world*'.

Has the trend towards 'virtual corporations' and decentralisation within large organisations helped the acceptance of technology transfer within industry?

> *'Absolutely, the companies no longer think .... if they don't develop it internally then it's bad. Companies are recognising that with everything from legal work to menial work to R&D that they can piggy-back off R&D that is being funded by the government or they can cheaply, by funding MIT research, take advantage of all the MIT overhead and equipment and experience to take a technology and move it forwards.... companies will start to recognise that it's the same thing, by giving up a little bit of a big pie you have more than if you try to keep all of a small pie. That's the way to make money. Industry is looking to be flexible in its R&D and to capitalise on opportunities to collaborate, not only with universities but with other companies.'*

Was he less cynical than those who suggested smaller business units were likely to forgo long term planning and research altogether?

> *'I don't think those are contradictory, I think in fact that contracting out is the way that companies think that they can be flexible about getting what they need now... When I say they can come to universities and do the same thing, the OSP is more long-term, like a three year research programme to do X,Y or Z. What my office does is to look for companies that are interested in finding technologies today, taking those technologies and turning them into products. Even companies that are interested in licensing, it's short term - now in 1994 companies are planning their products for 1996 or 1997 and are looking for technologies that fit in with those plans'.*
>
> *'More than anything else, whether you really believe in it or whether you're cynical about it - it's more popular, it's the buzz. Licensing out is acceptable, it doesn't mean that you're weak - it means that you're nimble and competitive.... It's seen now as smart business. '*
>
> *'In Japan what's seen as conservative is the sharing of ideas ... and the very close alignments between various industries and technologies.... Sub-license to others, spread things around that way. I'm all in favour of it - it costs money but the idea is you make everyone better of, so although everyone is paying everyone else what you end up with is more than what you would have otherwise'.*

Will individuals become very rich? '*You don't become very rich off royalty payments....* [but in the future] *you get the ramp up. On our income graph, look at the difference where there's a cash-out. On a ten million cash-out, you've made a millionaire with an inventor where we take 15% off the top, and of the remainder one third goes to the inventor...*' When companies go public and equity is realised, very large sums result. A very successful license can also generate large sums in royalties. 'T*his is going to go up, not only because of all these new agreements being put in place here, but because of* [previous agreements] - *when these come to fruition with more being created there'll be a steady increase overall, but with blips*.' As yet in computers there have been no 'jackpots' when equity has become liquid. Often equity holdings are significantly diluted by the time they are realised.

So far many offices have derived a large portion of their income from a few isolated successes - for example the 'Gatorade' (check spelling) sports drink developed by the University of Florida. MIT has a more even distribution of revenue, but the potential for a hugely successful license is always there.

> *'I have a business plan on my desk for a technology where I'm seeking a 5% royalty, and the business plan calls for revenues $26 million in a couple of years. I'm making $1.3 million, and that's if the company doesn't take off. That's a lot of money - it's not Michael Gates of Microsoft, but 5% of sales for any good company could be huge. It* [technology licensing at MIT] *has only been around in its current form since 1984 or so, a lot of the pay-offs are in the future'.*

How does he see the situation progressing in the future? For MIT specifically, the Lincoln Lab is run by MIT but is a government laboratory, primarily for federal defence projects.

> *'In the future that will either become more nimble, in terms of seeking industrial sponsorship, or it's going to die'. 'MIT will continue to be an education institution, and fund itself by endowment and from alumni contributions to the endowment and from student's tuitions. MIT will not have a hard time holding very solidly to its educational purpose; for nothing else if it varies from that purpose and brings in money then it has to pay taxes on that money.... I don't think you'll see MIT driven towards making money from sponsored research. I think sponsored research is developing more as a phenomenon driven on the side of industry - seeing this a chance to target research opportunities of the future.'*

Does an increased emphasis on applied research necessarily work to the detriment of pure research?

*'I'm an optimist... some of it will decrease, it could have a tendency to "corrupt" the academic environment - in a worst case scenario some people who are worried about the corruption could impose limitations, you cannot hold equity, you cannot consult'.* However *'none of the sponsorship agreements today provide for the provision of any particular product or prototype or anything, it's just research in the area of, and I think there's pressures to continue that. I think that you've captured what the issues are and you know what the possibilities and the worst case scenarios are - and there are people like me who hope that those scenarios won't be realised.'*

### 9.1.6.2 John Leech - Industrial Liaison Programme

**Interviewee: Dr John Leech**
**Job: Industrial Liaison Officer**
**Organisation: MIT Industrial Liaison Program**
**Interviewer: Thomas Haigh**
**Date: Monday 29th August 1994**
**Location: MIT Industrial Liaison Program Offices**
**Revision: 1**

The major function of MIT's Industrial Liaison Program (ILP) is *'to link the university to industry and to act as a partner with industry in research*.' The ILP was established in 1948 and was the first of its kind in the US - today it remains the largest and best established. Flows of ideas and expertise are not one-way, as the support for researchers provided from industry goes beyond the merely financial. Separate offices handle both sponsored research (the Office of Sponsored Research) and formalised technology transfer (the Technology Licensing Office). Since 1988 the ILP has been merged with the traditional Corporate Development function and is a part of the Office of Corporate Relations. The ILP runs a small office in Japan with a *'client base which is quite strong... we have had ties there for many years.'*

The programme enjoys widespread support among the faculty. Corporations come to the ILP which approaches faculty on their behalf, although occasionally the initiative comes from the faculty member seeking industrial contacts. *'There is an interpretative function, but the linking function is the one you really want to emphasise.*' In practical terms, this usually involves the direction of interested groups within the company towards faculty members working in relevant areas. When faculty make travel plans the ILP may suggest meetings with interested companies which could be incorporated into them.

The ILP also provides specialised information services, including a seminar series which is free of charge to member companies. In 1994 topics included 'Designing the 21st Century Organisation' and 'Global Communications Networks: Corporate Visions'. A monthly newsletter is distributed including details of ongoing research at MIT and outlining findings and new inventions.

Companies pay an annual fee, determined by their size and revenues, and over two hundred are currently members. The programme produces an internal surplus which is returned to MITs general revenues rather than being earmarked for particular industrially linked projects - although some 10% is returned to faculty members on a pro-rata basis in return for their participation in activities such as company visits.Further revenues are indirectly generated through sponsored research and other agreements coming about as a result of the contact. Consultancy agreements are another common outcome of industrial contact. Individuals keep fees for such work - the arrangement is purely private.

As far as industrially sponsored research goes the role of the ILP is secondary. '*The ILP is involved in research but it's not a full time occupation*' and specialists in the OSR can assist during detailed negotiations between faculty and potential sponsors. A project would normally be sponsored by a single source, although sometimes a consortium of several companies might support it. A company would receive a 'sponsored research contract' and would be looking for a 'direct return' on their investment. They would also have to reach an agreement with faculty over the publication of results - though a brief delay might be reasonable in the case of commercially sensitive details. The focus at MIT is not on applied research. Intellectual property rights would not be automatically granted to a sponsoring company, though they would 'receive some preferential treatment.'

Will an increased reliance on industrial funding lead to more emphasis on applied research? '*Yes, I think it will.*' This is not necessarily a bad thing, and in a climate of decreasing government funding there is little alternative. Rules forbidding on-campus applied research may be revised. Traditionally, one way that MIT has applied its research is through the creation of spin-off companies by faculty members and this will continue 'one year we actually started five companies.' A spun-off company could take advantage of MIT's facilities in the same way as any other, and the personal relationships of its members would probably be maintained. MIT also enjoys close relationships with many of the computer companies in the area, and forms part of the nucleus of resources which attract high technology firms to the area.

At the time of the interview 'this office is undergoing a series of changes' designed to improve the service provided to industry and to faculty members. Change had been underway for about a year - involving a re- evaluation of '*what we want to do and how we do it*'. The basic job remains the formation of links between faculty and industry but '*methods of communication*' and '*new structures to the relationship*' are under consideration. One example of recent change is the rethinking of the directory of MIT research activity, which is now structured by lab and research group: 'a list of the expertise of all our faculty at the Institute - we used to put out a book which listed all the research projects at the Institute'. The new volume is entitled ‘MIT Expertise’.

## 9.1.7 THE UNIVERSITY OF PENNSYLVANIA

### 9.1.7.1 Norman S. Badler - Center for Human Modelling and Simulation

**Interviewee: Professor Norman Badler**
**Job: Director, Center for Human Modeling and Simulation**
**Organisation: University of Pennsylvania**
**Interviewer: Thomas Haigh**
**Date: Thursday 8th September 1994**
**Location: University of Pennsylvania**
**Revision: 1**

The centre has as its goal '*to do the best job that we can do in understanding humans and simulating them by computer'*. There are three more specific subdirections - '*human factors - how can we build a synthetic human which can be used as a subject in experimenting'*, for example in vehicle research, '*distributed interactive simulation*' - putting people into dynamic environments in real time and medical work which looks inside the body and builds functional model of its internal functioning.

Research of this kind has been going on at Penn since his arrival 1974. Around 1980 the growing volume graphics equipment was split between two labs and it *'became convenient to call ourselves the computer graphics research lab*'. The motivation to become a 'centre' came from the fact that '*increasingly the status of something called a laboratory inside a university is very informal*' and so to gain formal recognition status as a centre - between department, or an institute - between schools. 'Technically the Center for Human Modelling is a joint venture between the Computer Science, Computer Information Science and Bio-Engineering departments', though at the time of the interview the bio-engineers had not been fully brought in as the centre was founded only eight months previously.

> *'The advantage to being a centre is that you have this legal status and there's a director that is appointed.... there's a faculty committee - basically the faculty who are associated with the centre and there's an external advisory committee.... who provide external insights about what we're doing and its perception to a much wider degree than just academic'.*

When dealing with potential sponsors, the overall goal of the centre is remembered.

> *'It never hurts to say to them "These are our overall goals, and you can help us move toward them and along the way we will provide back to you the fruits of the labour and your investment.' The centre is fortunate in that its work has many applications, and to repay sponsors and satisfy their own 'engineering' instincts they are happy to 'turn these things into useful tools and deliver software to sponsors'.*

Is there a clear distinction between basic and applied research in this kind of area?

> *'It's very fuzzy here - because I think that very few of the students working on Ph.D.s believe that they're doing applied research - they all expect, and I believe for the most part that it's true, that each one of them is doing basic research in the sense that we don't know how to solve these problems. It just so happens that, as a by-product,when they do solve them frequently there is an application or code which actually works. Applied research has a slightly different flavour... we do see this from corporates - they outline a problem to us, "Can you help us solve that problem?" and usually the problem is fairly specific and instead of saying "Yes, I'll solve your problem" my preference is to say "I'd like you to fund us to help solve a slightly more general problem of which we hope some of that you really need to solve will be a special case".... I believe that strategy (though it might just be the area that we are working in) has paid off.... We've got a lot of interesting specific problems from sponsors but have built general solutions'.*

So, how far does this dictate the work carried out at the centre? Because the overall goal is so big, a lot of flexibility as to specific work naturally follows. A distinction can be made between the overall strategic goal of human simulation and the particular tactical research areas which are undertaken to move towards it. As so many of the latter are available to decide them with sponsors is reasonable.

> *'I think it's a mutual exchange of desires - we want to meet our goal and the sponsors want to meet their goal, and then we decide what we can both be happy with.... personally I like very much to know what people want - I don't necessarily need to promise them that but I like to know... people with money are like any other people, they want to be listened to, they don't want to be sold to.... it's not a push situation, it's a pull situation'.*

Do they actively seek out corporations who might fund them, or is the process less directed and more passive? Usually they are approached by the companies since it is hard for them to have a sense of 'the internal directions of the company' whilst the work of the centre is more 'exposed' to those with an interest in the areas. With the government, a 'proposal' oriented approach is normal -'one of my main tasks in life is writing proposals', and these are more likely to be successful if slanted towards the approach of the particular governmental body.

All sponsors, even the NSF, attach money to particular projects and other sources tend to specify deliverables. How do companies evaluate the worth of what they receive?

> *'The answer to that question has changed over the last fifteen years. It used to be that government agencies wanted to know how many Ph.D.s you produced, how many publications, how fat is the final report that you submitted, and "Oh yes, is there any software that we might be able to try". Increasingly it's turned the other way around - most of our sponsors, not all, expect that they will be able to use, literally use, the software which we produce as part of a research project. It's not so important to some of them whether we generate Ph.D.s or write papers - though if we do they like the attribution..... We have found that these are good drivers .... to codify our ideas and research in a way we might not have done previously.'*

Writing useful software can be a valuable education experience.

The university does not allow classified research, so even military funded research is public. There has not so far been problems with obtaining private funding for publicly published research - though so far only about 10% of funds come from private companies. So far this funding has been to provide features and enhancements from which '*everyone benefits, so there's no reason to suppress or delay publication. That too may change in the next few years when we start to get specific funding and they want to get product advantage. We'll worry about it when we get it.*'

How does a large organisation decide whether to perform particular research in-house or fund an external group? Companies with large research groups, such as Bell Labs or IBM may see an advantage from internal work because they own the results. Small and medium sized firms which lack large dedicated research teams are likely to see university research as being more attractive - '*we haven't got that much money off those firms for research, but we do get them for license fees for example.... so essentially they are buying into a research project without the investment... everyone benefits and there's no unknown there*'. Software is sold in its current state - enhancements can be purchased but the enhancement is then provided to all customers. *'Everyone leverages up everyone else... putting into a pot and getting back more than you put in.*'

In the long term 'we have serious concerns about how much we can actually do within the university - a good place where the system breaks is in software maintenance' which isn't really a job for students or even paid staff. With more than 50 installed sites, 'Jack' - their more important system - threatens to overwhelm their direct ability to support and some kind of transfer to a private company may be required.

The situation is changing constantly. For example, this year '*the problem has not been in the total amount of funding, which has been very generous, but in actually getting the money from the government*'. Money due in March had still not arrived by September - but students cannot be laid off during the interval. All funding is insecure and this is very hard to deal with. '*This country basically has trouble figuring out how it should make long-term investments in research. It's on an extremely short, volatile cycle right now which is very detrimental to progress.... I shouldn't have to worry about when my money is coming... it's very difficult to plan*'. The administrative load and stress which this imposes is itself detrimental to research. Fortunately the centre is large and diversely funded enough - with about a dozen sources - to be able to hold back expenditure and transfer money internally - '*that strategy is the only thing that kept us going this summer, you feel wealthy if you have a zero bank account*'.

The centre is also fortunate in that even its military money, in a time of serious defence shrinkage, is coming from diverse sources - even within agencies.

*'At the present time it looks like one of our major funders will not have research funding, but because of some very conservative planning we'll be able to survive if that's the case. Secondly a lot of our 'military' money is not actually 'research' money'*. Military funds can be earmarked as research, development or training and *' it turns out a lot of our money is from 'development' and some is even from the 'training' category which is not really the way it should be.... however if the government decided to cut back on basic research spending it would partia*lly impact but not devastate us.... *The groups that might have the worst time are those that are dedicated to one particular project with one agency, and if that agency's budget is cut then they're doomed. We do science as well as we can under the present circumstances.'*

Has the fashionability of graphics and VR helped?

*'Well, it doesn't hurt to be in an area people hear about in the popular press, but I'm very careful not to mislead people and say either "virtual reality will solve your problems" or to come across as a virtual reality guru.... it goes back to an old adage "know thy user" and I simply want to learn about what the sponsor's ideas and expectations are.'* Realism and an honest dialogue are crucial*, 'the trouble with a buzz-word is you get characterised as doing that and then it's very hard to do what you want.... it drives sponsors crazy that they don't have a buzz-word for what we do.'*

### 9.1.7.2 Jeff Solash - Technology Transfer Center

**Interviewee: Jeffry Solash, PhD**
**Job: Director, Center for Technology Transfer**
**Organisation: University of Pennsylvania**
**Interviewer: Thomas Haigh**
**Date: Thursday 8th September 1994**
**Location: University of Pennsylvania**
**Revision: 0 (No feedback obtained from interviewees)**

**General Background:**

Traditionally, universities have had very well developed corporate gift departments experienced in '*making the ask*' with a high rate of success. However, limits do exist on the amount which can be given by corporates. A number of factors have caused universities to examine other approaches over the last 15 years.

In the late 1970s a debate began on the ownership of intellectual property. Since the Second World War the US government had been by far the greatest funder of university research, but universities felt they had a right to profit from innovations resulting from their research. In late 1980 the Bayh-Dohl or 'Technology Transfer' Act gave rights from government sponsored research to universities. At the same time there had been a few spectacular successes such as the Cohen-Boyer patent held by Stanford and UC San Francisco which has been licensed hundreds of times and is now worth about $20 million per annum, a patent for a successful breed of strawberry and the patent for fluoride in toothpaste. There is no inherent limit to the amount of money which universities could theoretically derive from this source - for example Columbia University earns over $32 million per year solely from royalties, a sum which is rising rapidly and is being used to build new buildings.

Many businesses resent this, as they are now having to pay realistic sums for technologies which were formerly '*had for a song*'. *'There are still many who feel that way, that the role of universities is to educate people, and please don't try to invent as we, the corporate people, know all about inventing things - just send us the right people*'. Some have been lobbying for repeal of the Bayh-Dole act, but in his view they should view the availability of technology from universities as a cost-effective way of maintaining their competitive edge and bringing products to market.

Another incentive to the licensing of technology was in the way patent infringement cases were handled by the courts. At one time the most severe punishment likely was 'reasonable royalties.' Companies could therefore routinely infringe patents, and treat any damages eventually awarded as a part of normal costs. A ruling by CAFCE - the Court of Appeals for Federal Court - changed this, allowing the specialisation of appeals judges in the arcane and case based field of patent law. They have enforced the law far more rigorously, and some high profile cases have resulted such as one involving triple damages running to hundreds of millions of dollars awarded against Kodak. Judges are also willing to enforce injunctions on the sale of disputed products, making the production of goods which are known to infringe on patents a huge liability - *'all that money would essentially be flushed down the toilet bowl.*'

Despite all these advantages, there are potential pitfalls for universities engaged in technology transfer. A university would not involve itself directly in manufacturing itself, but any involvement in commercial agreements carries risks - 'y*ou have potential infringement suit problems, and let's face it: if you are a licensee who is selling goods and making money, chances are there is someone else out there who will try and take their business away*'. Patent infringement suits are expensive both in terms of dollars expended and the time required from technology licensing professionals and the inventors themselves in dealing with them. In North Carolina a university has incurred more than $5 million from their royalty stream in direct legal costs, in addition to tying up the head of their office for two years doing almost nothing apart from managing the case and requiring the inventors to seek release from their faculty duties for the duration to handle the workload imposed. The latter represent a loss of skilled time an opportunities which is very hard to quantify. These kinds of potential costs can easily be overlooked when considering potential income from patents.

Cultural changes are also very important - '*the face of university research in the US is going to change forever*'. The post-war research apparatus has been very successful in terms of training, Nobel prize collection and so on, and represents a massive set of vested interests.

> *'An example, a lot of lip service is paid these days out of Washington to so called "interdisciplinary research". It's a total fabrication. Interdisciplinary research does not exist, it is not funded from federal sources. Why? If, for instance, you were a chemist interested in exploring the behaviour of peptide mimics, and you want to explore various clever chemical things like computer aided synthesis and assisting the compounds, and you wanted to collaborate with your medical school friends just to see how useful this stuff is in an interactive way, where would you send that proposal? If you sent it to the NSF, to which you had sent all your previous chemistry proposals, the National Science Foundation would come back and say "Gee, this looks like a medically related proposal. Dear Researcher, you should send this to the National Institutes of Health." You send it to the NIH, they say, "There's an awful lot of chemistry involved here, we think you should send it to the NSF because they handle chemistry." Because the reviewers at the principal basic research funding agencies are all pigeonholed in disciplines, there is no formal mechanism to evaluate an interdisciplinary research proposal.'*

*'Increased corporate involvement, by necessity, will change the way people think about doing research and how it is conducted*.' In corporations, interdisciplinary research is done all the time because it is necessary to bring a product to market.

> *'There is a prejudice against doing research that has practical implications in the US, at the major research universities. It's an interesting prejudice because on every grant application that goes in, you would not get funded if you told the truth and said "There is no way in hell that things are coming out of this research over the next five years that you're going to give me five million dollars to do, Mr Government (thank you very much) will have any practical aspects what so ever. I'm just doing it for the greater edification of learning, to enhance my reputation and to publish eighteen zillion papers per year. So instead they write all these happy words and wave their arms and make all these arguments as to the possible utility of the research when in fact they, if they were honest about it, there'd be a slim prayer of having anything useful come out. In fact when they review them, they themselves, because it's a closed community - the same people who write these grants review them - if it smacks of industry or is too utilitarian then it's downgraded, it's not as good as something which has less utility.'*

Industrially sponsored research requires a shift away from this attitude. At one extreme, it has always been legal for a researcher to submit a grant proposal of which every page is marked '*confidential and proprietary'* to avoid its public scrutiny under the Freedom of Information act. Legally, this may be crucial since such disclosure has been claimed as 'prior art' in patent law and might make patenting of resultant technology problematic. However, such a grant proposal would stand no chance of acceptance by traditional funding bodies such as the NIH and even by the DOD and Energy funding groups.

Today competition is 'cut-throat', with few new sources of government or foundation money, and for some industry is the only hope of funding. *'Here the rules are a little different and so, slowly but inexorably, things are changing. That's not so say that you can't still do high quality research, but now it's got to have a point to it*'. The graduate school system in America is the great strength of its educational system, and the culture of publication and discussion is deeply ingrained in academics. 'Publish or perish' may be replaced by the 'ears open and mouth shut' approach of industry. '*I predict that within the next ten years there will be major changes in the way that US graduate school culture is perpetuated*.'

> *'Until recently most academics had the concept that you watered the tree of basic research with dollars and the fruits of that tree would be inventions, and in much the same way that an apple falls from a tree, an invention would sort of fall (somehow), in rich fallow ground (somewhere) and spring forth into a new product'.*

This kind of process works much better if a more active approach is adopted, going out into the world to seek licensees and developers. However, there are also factors in corporate culture which have mitigated against technology transfer. If a company are offered a piece of technology, they will often send it through internal channels to an expert in R&D, together with a vague covering memo asking him to evaluate it. The natural reaction this causes is often one of suspicion and resentment, worry for his own job security and an instinctive rejection of the technology - '*Why don't you increase my funding instead*?'. A switch is required away from thinking in terms of a 'Research and Development' department to a 'technology acquisition' department - *'the president of Technology Acquisition should be in the business of acquiring technology whether it comes from internal or external sources*'. This department also needs to be better integrated with sales and marketing efforts.

**Work at Penn:**

Penn has traditionally handled sponsored programmes through a different office. However, '*corporate sponsored research and patents and licences have become so intertwined that right now my office is handling most of the negotiation of corporate sponsored researched agreements*.' This is because sponsors want to know at an early stage the details of how technologies developed might be licensed - before they are actually discovered.

> *'Sponsored research has a real sharp point to it, and what I mean by that is that a company will come in, speak to a particular professor - because that professor has particular expertise in an area of interest - and enter into discussions with the professor to undertake certain set of experiments or body of work, they'll pay for that and if any inventions come from that they'll want rights.'*

The precise rights gained are not automatic - a company might seek the right to negotiate first, or a 'right of first refusal'. Penn is reluctant to grant the latter, and the exact field over which rights will be gained must be carefully defined.

Many universities have charters which specifically forbid 'purely applied' research. However, engineering research would generally be regarded as 'applied', and so what is looked for more is evidence of 'originality' or 'creativity' in research. The clinical studies of drugs undertaken by all medical school are unquestionably applied.

> *'It depends who is doing the defining, usually - and I know this may sound a little cynical - if a professor is employed by a company to do some research, he is apt to find that research basic or useful, and not apt to find it applied in that definition.'*

The responsibility of ensuring propriety rests with the department chair. In computer science rules tend to be very fuzzy in this area - one pragmatic measure might be 'can a graduate student get a thesis from it?'. The most important question today is 'is someone willing to pay for it?'

Most companies prefer to undertake actual product development themselves, rather than entrusting it to a university, so this provides an example of self regulation. For example, a biology professor received a large sum to develop an invention - the early stages of this were undertaken at the university but as the work progressed its nature changed and '*both he and his colleagues began to feel uncomfortable to allow the work to stay at Penn and he moved off campus*' on a leave of absence.

What is the procedure for technology licensing? Every piece of technology presented to them is evaluated to decide how best to protect and commercialise it. Some might best be licensed to existing companies, others used as the basis for start-ups. A problem here is that the faculty members presenting an invention usually do not have the temperament or mind-set to become chief executives of new companies, so the office can attempt to help them find business experts, accountants and venture capitalists to provide the services and expertise needed. They do not get involved in fund-raising for start-ups.

As new companies are '*almost universally cash poor, the only thing they've got to trade is stock*' when they license a technology. However, '*the university does not want to sit on the board of directors of these companies, and does not want to own anywhere close to a majority in them*'. The latter is chiefly inspired by the avoidance of product liability, insurance against which is almost impossible to get. For example, one company were paying $551,000 p/a for insurance against $3 million of liability - which given that the first case to settle against the manufacture of a similar product gave damages $7 million is insufficient. Tension is produced by the balancing of likely returns from stock, which will only be realised if the company goes public, against the risks involved.

In practice successful agreements usually come about as a result of informal networking by faculty and their students and the exploitation of corporate contacts. '*Your inventors are often the best sources of information as to who is really interested - though their field of view is limited'*. Generally an inventor will suggest a potential licensee, though they would usually welcome interest from other companies and an auction of the rights. To find other companies which might be interested several tools are available, targeted approaches such as library work and consultations with business school students and 'seeds to the wind' approaches such as the listing of technologies in electronic databases such as 'Best North America' and 'Knowledge Express'. Technology licensing people themselves must network, via professional meetings and the development of personal contacts.

This kind of general promotion of sponsored research opportunities is less common. As with a piece of technology for licensing, it is likely that researches inside a company who were given a proposal to evaluate by their management would react in a hostile manner. Generally contacts are made directly between 'bench experts' within the company, and members of faculty and mutual interests are developed. For this reason there is little direct overlap between traditional donations and sponsored research - although charity donations are made with an idea of strategic interest they come from a fixed overall budget rather than that of a particular interested group. Whilst gratitude is expressed for sponsored research support, results of the research are *'discreet bits of technology*' and the company must pay the market rate for them - '*they'll try to connect it, when you get into licensing negotiation, but it fails*'.

When companies have been interested, strategy and negotiating positions must be established. *'Even there it pays to do your homework, and that is where I often depart from the company of a lot of my peers'*. A case must be made to the company in terms of business opportunity, in a business like way. Companies will have carefully analysed the business worth of the technology, done Net Present Value calculations, formulated marketing ideas and so on. Despite the great pressures of work on technology transfer officers, they need more than a 'vague idea' as to the possible worth of the technology or they will face *'a rather severe disadvantage.*' They have a responsibility, as guardians of the intellectual property, to have a good idea as to its worth - which is difficult and time consuming.

There are strict US government requirements, relating to conflict of interest. It is his view that if technology transfer is to be successful, with the attendant involvement of faculty with particular firms, potential conflicts of interest are inevitable - *'the question is how to manage a conflict of interest, not whether it exists*'. Some conflicts are so severe as to be unmanageable.

Industrially derived revenue currently is around 5 to 10% of the university's total revenue. Does this alter the direction of research undertaken? *'Yes, it may not be apparent at the moment, but it is unavoidable and as funding increases the effect will be compounded*.' This is not a cause for worry though - academic freedom has always been a chimera, with fashions in research dependent on the current direction of government funding. Faculty will remain free to do whatever they can find financial support for, '*nevertheless the tension will increase between traditional academic views of things and the corporate need to focus on end products*.'

Is industrial sponsorship of students and involvement in degree programmes common in the US? Gifts may be given to students, and types of work suggested by companies. The sponsorship of degree programmes varies from institution to institution, with places like MIT being far more sensitive than Penn to industrial needs. At the Penn business school, providing the only undergraduate programmes in the Ivy League, teaching is aligned closely with industrial need - as in the 'Management in Technology' programme which gives students degrees in both business and engineering. Most universities stick largely with traditional methods.

Different approaches do exist toward technology transfer. Some institutions might favour the use of ILP rights as a means of attracting sponsored research, others might view the establishment of a spin-off company as the generally preferred way of exploiting technology. Other institutions say '*To heck with small companies, 90% of them fail, they make all kinds of ridiculous demands, they give me stock, I don't care for stock, it's worthless - the best I can do is stick it on my wall and hope it goes with my colour scheme. I want cash up front, I'm going to license to big companies*'. Almost an infinite variety of approaches exist, and of course flexibility is required - no single approach is best for all types of technology.

> *'We try and evaluate the best place and spot for the technology.... Who's got the best philosophy? There are some early indications of the best mode if you're interested in maximising in licensing revenue, but in my view it's too early to draw any firm conclusions.'*

## 9.1.8 YALE

### 9.1.8.1 Nick Carriero - Computer Science Departmert

**Interviewee: Nicholas Carriero, PhD**
**Job: Research Scientist**
**Organisation: Computer Science, Yale University**
**Interviewer: Thomas Haigh**
**Date: Wednesday 14th September 1994**
**Location: Yale University**
**Revision: 1**

Nicholas Carriero's work is in the design, implementation and use of parallel systems. He has been most closely associated with the 'Linda' project, a *'software system that creates the illusion of a shared memory resource*' for process communication. The group works on a range of 'follow-on' projects, one of which is 'adaptive parallelism'. This involves the harnessing of the largely idle processors in networked workstations by providing 'software resources' so that a large computation can be spread over the network to idle processors, which will be 'relinquished' when their primary users need them. This project is of great interest to '*virtually all large research centres*' with an investment in workstations.

> *'Typically any organisation, whether its a university or a government research lab or a commercial research lab, enjoys certain economies of scale from buying large numbers of pretty much the same kind of workstation and they have to pick workstations that more or less meet the peak demands of the few high-end users and so otherwise just aren't being used to their capacity.'*

Another area of research has been the 'packaging' of distributed computation so as to be invisible to the end-user. For example, information extraction from a continual data flow is crucial for a Wall Street dealer or an intensive care monitoring system - to provide an *'informed snapshot'* of the status of the world. This is most easily intellectually structured as a sequence of independent tasks, such as the 'cleaning' of raw data followed by various stages of filtering, analysis and high level trend analysis and diagnosis. It is thus natural to represent these tasks in terms of a hierarchical arrangement of 'boxes' with input and output streams. What is needed is a system which takes definitions of these boxes, prepared by a domain expert and *'figures out how to actually execute them on a bunch of machines so that as data pumps into the system answers pump out'* in real time. This specialised parallel model is called 'Trellis' due to its lattice structure.

FGP - 'Fetch, Generalise, Project' is a system which *'takes a lot of data records and treats them almost as diagnostic cases'*. A medical system might represent patient information as an n-tuple which forms a single point in a space. By examining the clustering of these points a possible diagnosis for a new case can be produced without the need to derive explicit rules. The technique has been applied to areas as diverse as the analysis of mammograms and folk dances; one obvious commercial use is the analysis of credit card transactions to organise marketing efforts around common buying patterns. This application is even further from explicit parallelism than Trellis, the user *'would be absolutely oblivious to any issue of parallelism'*. However parallelism 'underneath' allows the very heavy computational demands of the technique to be met.

> *'The trajectory of these projects is to start out with exclusive concern for parallel systems, build explicit parallel applications, and then begin to build software frameworks which rise higher and higher in the level of presentation to the end-user and hide away more and more of these details, but as they rise higher focus more and more narrowly on a particular style of application.'*

Are basic research, applied research and technology inseparable in this kind of work?

> *'From our point of view they are... there are people who pursue strongly conceptual research with no real concern for bridging that gap between the conceptually interesting problems and how they might be applied in any kind of practical domain. I have to say, though, that the field we chose to work in doesn't allow us that luxury - if you're working in parallel computing.... by and large most people working in the field are very concerned with the practical issues - how do I get things done faster? Once you come into that kind of field you don't just want to do things in the abstract, you want to see practical gains achieved from this practical concern. Much of what has driven parallel computing has been the demands of a bunch of different people in industry and in the government....'*

The government's involvement was originally prompted, in the days of national labs with huge budgets, by the rate at which Crays were being consumed. '*They were just building the machines and shipping them down to the lab*' and would be saturated within a week. The demand for better ways of achieving very high performance led to a revival of interest in parallelism. As time has gone by, attention has shifted from these '*very exotic performance at any cost large scale machines*' aimed at ever larger problems towards industrial demand for machines to solve large problems in more cost-effective ways - making new applications of computing economically viable. Thus, instead of machines being designed with the aim of '*selling at least three to the national labs*' they are being aimed at corporates such as Boeing and sold on grounds of cost performance and economies of scale in their components.

Yale's research is an extreme example of this, which '*uncovered, as it were, parallel machines that people already owned, in the shape of their local area networks*'. '*For the cost of a software system they could realise performance improvements that were significant, and made a difference to their production cycle of computing*.' This is reflected in a shift in the group's interactions from basic work with massive government and industrial laboratories, such as AT&T Bell Labs, towards more applied work with corporate entities.

They now have a co-operative arrangement with a local software house for the distribution of their software with a local company who has '*opened the doors to a number of different environments*' - providing a point of contact with the financial, petroleum and microelectronics simulation communities and developing finished code for industrial use. '*This company for the most part is the one that takes on the responsibility of doing the serious, commercial grade research and development of the software*'. This arrangement is very beneficial, as the group aims to produce software '*which people will use*' but cannot practically aim to produce and support finished products itself. They have the flexibility to '*pursue interesting ideas, get the software to a point where we have a prototype that demonstrates feasibility'* and then transfer them for debugging, further implementation, porting, support and maintenance to the company. SBIR (Small Business Innovation Research Program) grants from the government are designed to support companies engaged in this kind of work. They are important because an idea which is too close to commercialisation to attract academic grants will require further work before saleable products are ready.

As far as he understood the terms of the agreement, Yale gained royalties on sales of the software and usage of the code produced. Ideas on the division of royalties are '*so much sifting sand over time'* but are currently paid to the university, which shares a portion with the department - some of which goes to the individual researcher. Royalties have not been a major motivating factor in the agreement - sales from the product meet the costs of commercialisation and continuing development, but Yale's own costs have already been funded by granting and do not need to be recouped.

Another advantage of the arrangement is that companies are '*less generally interested*' in funding general research and '*much more interested, both in their in-house research activities and in their dealings with others, in research projects for which there is not some mysterious leap of faith between that research project and something of practical interest to the company*'. If the company deals with another company, rather than directly with the university, they have the feeling that '*they are dealing with a serious organisation that knows and understands*' the way companies function, corporate culture and so forth. An external example is the transfer of the Mosaic software to a company for support and maintenance.

'*As a research institution you quickly begin to feel the pressures on your normal activities from dealing with software distribution and support in dealing with something that has become popular in the outside world*'. Most major departments have produced spin-offs of one kind or another. Another group at Yale set up a small company around the 'wavelets' compression technique, and historically a company called 'Cognitive Systems' was set up around AI researchers. Yale has an 'incubator site' in shape of their Science Park

> *'The ideas are there, the interest's there, the enthusiasm's there - the difficult part is the set of legal entanglements.... it's just a problem that the universities have got to come to terms with. In the recent past their model of the product of intellectual activity was the book... That model doesn't really apply any longer when you talk about pursuing interesting high-tech ideas.'*

Different interests might be claimed by funding agencies, graduate students, universities and faculty members in the rights to inventions, and academic freedom must be preserved, but companies look for exclusive licences. So far the system has allowed a '*roll with the blows*' approach which has been workable in practice, but '*one would much prefer.... to know what the bottom looks like before you jump*'.

The group has a good working relationship with IBM, which supports the approach of cost effective, scalable systems with their SB/1 and SB/2 lines and switching technology. They provide Yale with hardware, equipment and joint study arrangements. This contrasts with their far less product oriented work a decade ago in conjunction with AT&T's basic researchers. From IBM's point of view, a major gain is '*creating the ability to demonstrate the technology to their customers*'.

> *'The focus has shifted dramatically from exploratory research to practical development, which from IBM's point of view allows them to say "Oh, you want to speed up your application? Well, let's try to work with Yale and we can talk with them...", and there's a much tighter relationship with business activities than we would have had with Bell Labs in the past.'*

This development of example case studies allows a '*portfolio of technology demonstrations*' and data to be built up for IBM's use. This relationship is symbiotic, as Yale welcome the provision of equipment and real situations for their work. '*We don't just want to build parallel systems and let them sit and say "Well, we've done it so let's more on to something else". We want to use them, make sure they work, achieve a certain level of efficiency, understand where the weakness are and improve them - and in the course of doing that work we will naturally develop the kinds of case studies that IBM are interested in.*' This willingness to be involved with real '*industrial codes*' is a great strength of the group in its relations with industry. Yale provides '*reasonable access*' to IBM, its sales people and its potential customers - most demonstrations are internal within IBM. IBM's contribution is a '*loan of equipment*' valued at over $1 million - machines, switches and resources to support them. As far as he knew, no cash was involved. IBM gets the results of the group's efforts for a substantially lower price than they would cost to duplicate internally, and the group are doing '*work that they wanted to do*' anyway. An agreement which provided resources for work which was not of direct interest to the group would be counter-productive.

In the past it has sometimes been possible to obtain grants which match donations of equipment from industry with donations of cash, but in '*corporations themselves, at least recently to my mind, there is some willingness to give cash, but they prefer to give as equipment, or possibly even researcher time on their end*.' They have '*talked endless with company representatives.... we see a lot of them in the hope that one of them pays off*'. Alumni relations provide another means of making contact - again low probability and requiring careful nurturing.

How are industrial links likely to develop in the future? '*The particular combination of sponsored research mixed with focused industrial collaboration will become more prominent.... Everyone seems to have brought into the "let's get a little more practical" style of funding*.' The development of royalties are much harder to predict and are not the motivating factor. '*We'd love to spawn two or three companies with significant revenue streams, but I think realistically that can't be relied upon.*' About 10 years ago a company, Multiflow, was set up to build computers in a Silicon Valley style operation, but this was not successful in the long term.

Will this trend favour certain sorts of institutions? Well, Yale suffers to some extent from its '*non-technical image*' as opposed to MIT, Stanford or Berkeley. Smaller institutions will tend to have smaller expectations - although sometimes deliberate efforts have been made to change the balance through the backing of 'centres of excellence' by government and the wealthier states. One example of this is the funding of Syracuse university by New York state - and with its proximity to important manufacturing companies it enjoys an environment productive to this kind of research. With projects such as 'North Eastern Parallel Architecture' and their 'Infomall' initiative they are very focused on technology transfer and compare interestingly with nearby Cornell.

> *'There was a time when high tech companies, to some extent, helped fund research, but I don't believe that it was ever as generous as the perception was, and we got to rather a difficult time a few years back (it hasn't really changed now but people are more honest about it) when the government was saying "Well, we're not financing that" and industry was saying "That's what government grants are all for" and they were just pointing at each other'.*

The poor fortunes and reorganisations of organisations such as IBM, DEC, AT&T and Xerox and the *'lean, mean economic machine'* approaches they have adopted limit their willingness and ability to invest in basic research to create ideas for products in five or ten years time without any provision for competitive advantage.

Would restrictions on publication and increased exclusivity for research sponsors make such corporations more willing to fund universities? Possibly, but the large issue is '*do universities need to undergo the same kind of restructuring that industrial concerns are going through? Can the universities continue to be pure bastions of abstract reflection, or do they need to get their hands dirty and begin to worry more seriously about what's really important to current economic environments'*. When a Yale education costs a student around $100,000, questions of 'value for money' cannot be ignored. '*What did I get from that? What am I able to do that I couldn't have done some other way*'. Such questions require a reappraisal of mission given the standing commitment of Yale and other distinguished universities to diversity in their intakes and '*bring to the university the best young minds, regardless of their background and training*.'

Such considerations make the search for practicality and relevance in research part of a '*wider Zeitgeist'*. The quest for intellectual freedom may have led to '*excesses in the academic environment*' in some areas, but there is merit '*in maintaining at least some notion of an ideal cannon - stuff that should be pursued because it is intellectually important, not because it will help your bottom line in the next three months.... Finding the balance there is going to be the trick*.'

### 9.1.8.2 Henry Lowendorf - Technology Licensing Office

**Interviewee: Henry Lowendorf, PhD**
**Job: Technology Transfer Associate**
**Organisation:Office of Cooperative Research, Yale University**
**Interviewer: Thomas Haigh**
**Date: Tuesday 13th September 1994**
**Location: Yale University**
**Revision: 1**

The main responsibility of the Office of Cooperative Research is the commercialisation of inventions made by members of the university. This includes the evaluation and examination of their patentability, the contacting of companies which might be interested in the technologies and the administration of their licensing and patenting. The office also advises on the setting up of 'spin-off' companies, and helps to obtain research funding for relevant research. It provides expertise on negotiating contracts and ensures that agreements meet university policy with regard to Intellectual Property and conflict of interest issues, and the director of the office - Robert Bickerton - works with the '*highest levels of administration*' to develop policy on these matters. Industrial Liaison Programmes, of which one currently exists in computer science, are another responsibility. It also has responsibility for the university's reporting requirements to governmental and other (funding) bodies. These functions have been integrated within the office since its formation in 1982.

Yale also has a separate Development Office which performs traditional 'fund-raising'. '*More and more the people in that office go to industry and say "we would like money for certain kinds of research - so in the past it used to be more gifts, but now it's aimed at something that companies will benefit from.*"' There are also two grants offices, which, in addition to administering government and foundation grants and contracts, include some industrial work and are involved in drafting research agreements.

The office works with a whole spectrum of different type of companies. '*I went over the licence agreements database recently, and determined that a large fraction of the licence agreements we have are with very small companies - start up companies. I was surprised*'. Industrial, chemical, pharmacology, computing and engineering companies are all represented - '*basically the companies we work with are determined by the kinds of inventions we have and the kind of research that's being done*'.

What kinds of research are acceptable to Yale? '*The kind of research that's done is determined by the faculty, based on their interests and sources of funds*.' 'Secret' research is forbidden at Yale, but the most powerful driving factor for non-tenured faculty is recognition of the kind which will gain them tenure. *'Largely the university sees itself as advancing knowledge through fundamental research*'. There is no explicit ban on applied research, and much clinical research is based around drug trials which are unquestionably applied - medicine offers a very wide range of research from basic to applied.

The computer science department has '*some interesting relationships with small companies, where small companies take, say, a new language and generate applications with that language. That allows the people in the department to focus on basic research, but at the same time know that the stuff that they create, if it's useful, will find outlets*.' Some universities, such as Johns Hopkins, have set up development centres intended to take technologies and commercialise them - but at Yale this is done indirectly, through private companies.

What does a company which sponsors research get for its money? “First of all it gets the results from the sponsored research.” Often it wants ownership in any resultant inventions, but Yale refuses this - '*if the invention is made in the course of research by a member of staff at the university then it is owned by the university*'. In our experience most companies accept that.' What is offered is a 'right of first refusal' for licensing of inventions. '*We are careful to limit what a company gets to the results of research that a company paid for*' and avoid clauses which attempt to grant rights to the whole of a laboratory's output.

> *'An agreement is "sold" by a researcher and her work. A company comes to Yale not because of a general interest in research (although we do get that) but because there is someone at Yale doing research that is of interest to the company. The company may not be doing specifically that research at the moment, but wants a window on what happens to that research, or a company may have its own research projects going on but wants to keep close tabs on that particular investigator's work.'*

Thus a research agreement provides access to information, and '*the research agreement and research funding is connected often to consulting by the person doing the research*.' Discussions on consulting agreements are ongoing at Yale - '*we're in the discussion phase and we've been in that for a long time*'. Conflict of interest questions are still unresolved - for example the

> *'range of material that an investigator is consulting around. It used to be that someone in chemistry would be hired as a consultant because he knew something about catalytic chemistry, and not specifically to consult on his own research. That's changed - more and more consultancy requires faculty to talk about, and give advice about and respond to questions about research very close to or even in the investigator's own area of specific research.'*

If an invention results from this discussion, based on the faculty member's ideas, who owns it? Different universities have taken different positions on the issue.

Voluntary guidelines are in place, these are principally designed to protect the interests of faculty members from dangerous clauses in consultancy agreements - '*sometimes agreements companies come up with are extreme, giving the company basically any rights to intellectual property that the investigator comes up with at any time in the future*'. Yale explicitly forbids some clauses, including restrictions on publishing - although a short delay is allowed and of course the university cannot directly force faculty members to publish. Restrictions on the dissemination of confidential information provided by the company itself are allowed. Faculty are also advised on appropriate rates: *'sometimes a company would like to say we're going to pay you five hundred dollars a year and you're going to consult with us once a week*'. Faculty are not allowed to spend more than one day a week on external business or consulting.

Another problematic area is the funding of research by companies where faculty hold equity. Faculty may be connected to companies in ways including research agreements, consulting, directing and ownership - the more of these exist the more potential problems. Chairs of departments must be informed of all such relationships - possible conflicts are examined by a committee.

Have joint projects proved attractive in providing 'leverage' for each participant? In practice, this has been limited - '*we have tried to create situations like that*' - for example the Center for Applied Neuroscience which seeks funding from a consortium of companies - but '*that's difficult to do*'. At the moment the only common form of joint funding comes from a government source and a single company.

How is technology licensing addressed?

> *'We first have to identify companies that are interested in the technology. We have to look at the technology and determine if it is patentable, or is it something that would be licensed without being patented, such as a cell line or antibodies or something like that. We look at whether it would be the kind of technology that would be licensed non-exclusively or exclusively, whether it is a technology that might make sense to encourage a company to start up around, whether the technology can be divided up into fields of use so that we could license exclusively in one field of use to one company, and exclusively in another field of use to another company - or if we might want to divide it up geographically.'*

Another issue is the kind of royalty demanded - a specialised research instrument might have a limited market. Probable profit margins must be considered, as must the costs and risks involved in commercialisation - for example the chance of a drug passing trials may be low and the costs involved enormous. A proposal is made to a company as the basis of negotiations, standard 'boilerplate' involves product liability, payments for patenting, definitions of the company and sublicensing. The times at which payments must be made are specified, and 'due diligence' clauses obligate the company to devote a certain amount of effort to the technology.

Valuation is very difficult as there is no empirical measure of 'worth' other than the eventual sum negotiated. '*The inventor usually has a very high valuation of his own invention*' - which can produce problems. Other experts in the field might be asked for their opinions to counterbalance this. '*Sometimes you can't come to an agreement*' with a company on terms agreeable to all.

Product liability is a particularly important issue 'which Yale tries to stay as far away from as possible'. '*The concomitant care is taken that we don't try to be involved in the company's plans - marketing and so forth*' although they do ask for a business plan as evidence of the company's seriousness. '*We try to keep out of the company's business, partly because we're not experts in that and that's not our job, but partly to keep the liability question in the company's pocket*'. This would be particularly dangerous in the case of a small company, where its limited resources might make Yale a tempting target.

How does this affect their involvement in start-up companies? Equity has been accepted sometimes rather than cash upfront payments for technology - but this is usually limited to a small minority. Equity is not accepted 'in-lieu' of royalties payable as the invention is commercialised.

Usually the decision on whether to license a technology or form a start-up around it is easy. When inventors want to start a company, '*in my experience we take that seriously as an important opportunity*'. Likewise, if no existing company can be persuaded to license but the technology seems viable then this is a strong option. The hard decision is faced when neither the inventors themselves, nor any existing company, are interested. Venture capitalists might then be approached '*but they're not going to do it unless they can get some kind of help, in terms of consulting or something like that, from the inventors*' and so complex technologies cannot easily be treated this way. Yale has not so far started-up companies without the involvement of inventors, though the possibility has been examined on occasion.

> *Yale does not so far have formal industrial advisory boards to provide input of the content of the curriculum, skills demanded from graduates and the like. 'The faculty feel they know best what the curriculum should be'. Faculty maintain their own personal contacts. One recent development was the appointment of a Dean to the School of Engineering, one of whose roles is 'to create better links with private companies. I expect him to be successful, and I expect there to be much more interaction.'*
>
> *'Yale already feels that the undergraduate engineering curriculum is a very high level curriculum, very intense, and the students who come out are well prepared to do whatever they want to do. But generally I think Yale sees itself as providing the academic leaders of the next generation, and not so much the industrial engineers.'*

How is industrial funding likely to develop in the long term?

> *'My own feeling is.... it is not going to become significantly greater than it already is, and Yale gets about fourteen million plus dollars from industrial research annually now. I think that industry is not prepared to take over the role of government funding and lately as US companies downsize they seem to be less and less willing to pay for general research and more interested in paying for specific research - that is research that's going to lead to applications and products right away.*
>
> *Everybody is concerned about the decrease in real funding by the US government, and I think that faculty here have often looked to companies to supplant money that didn't come in from government and was less than they expected. I don't think that's going to happen. I don't think we've reached the limit, but we're not going to get enormous quantities of money from industry - though it might become more important as it becomes a bigger proportion of the university's total research budget.'*

Currently Yale's total grants and contracts are around $250 million, so the $14 million derived from industry is significant but by no means the most important source. At the same time, as implied previously, this money is being more directly targeted by companies. *'People in big companies that in the past could give large gifts are tending to give less money and say more "what are we getting for it"'*. Development people are tending increasingly to involve faculty and their research in their work with companies.

How great a part does Yale's name play in their efforts? '*I think it helps a lot. Initial selection of students, excellent faculty and facilities and the Yale name'* ensure that alumni do well, creating contacts at the highest levels. '*More CEOs of American corporations have graduated from Yale than any other university*.' This ensures respect for Yale is maintained, something which the Alumni association bank on '*both literally and figuratively.... For all those people who graduated from Yale, to enhance the name enhances their own image*'.

> *'On the negative side I think it is important to realise that Yale still has in the state of Connecticut a reputation for being "ivory towerish", and this office has done a lot I think to break down this image, because we do work with industry and we do work with companies, gladly.... But this image does still exist, and it exists among people who ought to know better because they've worked with us.... It's not that that image grew out of nothing... but at least in terms of industrial relations it persists despite the fact that we have a million and a half dollars coming in from licence agreements we signed with companies all over the world for inventions and fourteen million dollars in research agreements with companies.'*

One of the benefits gained for Yale is therefore the improvement in its 'image'. Not all faculty view this in the same way. '*Some are anxious to connect up with industry, and others couldn't care less. I remember a case of an invention which was disclosed to the office and the inventor refused to patent it. He said "Look - I'm not interested in patenting this. I want to publish this, I want the people to use it, freely*"'. Sometimes this approach is correct, but at other times it can actually prevent it being used effectively, as for any technology with a high commercialisation cost (for example a drug) it is likely that only an exclusive licence will attract a company to invest in it. This has other unfortunate consequences - for example if a technology has already been patented but university work has discovered new uses for it Yale is unlikely to be able to license those uses independently from the original technology with sufficient protection to encourage investment. '*To summarise the point, if it's in the public domain it may not actually get used*'.

Is a significant change in university culture likely to occur as a result of the relative increase in importance of industrial funding? The office has had more than 600 inventions disclosed in the 12 years of its existence by perhaps 500 inventors - each one of whom has '*learn't about the value of technology transfer*' as a result. This represents a more general surge in interest '*and the culture of the university is changing - I don't think there's any doubt about that*'.

> *'Important questions need to be asked whether that's good - or where it will lead, maybe that's better, less of a value judgement - and what that increased commitment on the part of the faculty toward applied research will mean for the future of the university; and on a more general scale the future of the research establishment. I think probably, however, that funding is going to have a much more profound effect on whether faculty lean toward more basic leading edge research or more applied, practical research.... People go into research because they really are interested in discovering new things and while there's funding to discover new things I think people will do that - but there will be people who say "I want to discover new things, but I also want to have inventions and make money"....'*
>
> *I don't see that changing, but if the direction we've seen in the last period of time continues.... if there's a government emphasis on applied research, on products or "maintaining US competitiveness", whatever the hell that means, then I think that's the direction will go, and I think the culture will change in a very distinct way, a very radical way.... Conceivably the universities will become an adjunct to the companies, a research institute which carries out work for them. I can't see that happening tomorrow, but a lot of people here are very worried about that.'*

Some faculty are more excited by the idea of making money than others. '*We're going to have some millionaires come out of the pharmacology department in the next few years.... and I don't think the people who discovered those inventions had ever conceived of making lots of money when they went to university*.' This will play its part in altering the kind of research undertaken, though '*I'd put weight on the direction of funding rather than the technology transfer side*' as the more important factor here though '*they obviously inter-relate'*.

## 9.2 UNITED KINGDOM INTERVIEWS

### 9.2.1 CAMBRIDGE UNIVERSITY

#### 9.2.1.1 Richard Jennings - Industrial Liaison and Technology Transfer Office

**Interviewee: Dr Richard C. Jennings**
**Job: Director, Industrial Liaison and Technology Transfer Office**
**Organisation: University of Cambridge**
**Interviewer: Thomas Haigh**
**Date: Friday, 5th May 1995**
**Location: Cambridge University**
**Revision: 1**

The Industrial Liaison and Technology Transfer Office is responsible for the general promotion of contacts between the University and Industry - specific responsibilities include technology licensing and IPR issues in sponsored research contracts. More generally, it provides advice and guidance on all forms of collaboration and deals with external enquiries. Its precursor, the Wolfson Cambridge Industrial Unit, was established in 1970 and was originally part of the Engineering department.

Dr Jennings' background is as an organic chemist, with experience in industry and in a government lab. *'You need a scientific background, I think, to be credible - but you don't need to be an expert... no one person could possibly understand all the technologies of the university.'* The office is currently expanding, and as well as Dr Jennings comprises a PA, a secretary and a consultant - with additional recruitment planned for later this year. Its small size allows it to function efficiently in a catalytic rather than bureaucratic role.

With regard to sponsored research, the Office is involved '*at the front end of things*' in initial contact with companies and negotiations. They have responsibility for the intellectual property aspects of all collaborative programmes (including Research Council funded projects), and work closely with the separate administrative offices which administer research grants, from both industrial and non-industrial sources. Recent university reorganisations, including for the first time a full time Vice Chancellor with executive responsibility, are leading to a large number of internal changes which are likely to include a consolidation of responsibility for research administration similar to that seen at other universities.

The university's technology exploitation company is called, for historical reasons, Lynxvale Ltd. It has no employees, is wholly owned by the University and provides a legal and financial mechanism for commercial interaction - its main formal link with the Office comes from the position of Dr Jennings as one of its directors. Initially it was used by the university to sell works of art - during the late 1970s its role expanded to include the sale of software and the provision of consultancy. Following the removal of the BTG's monopoly on technology exploitation, the remit of the company was in 1986 expanded further to include the patenting and licensing of technology produced with Research Council grants.

In this case a patent would usually be applied for on behalf of Lynxvale and rights transferred from the university and inventors to the company for exploitation and licensing. Sometimes a company might be set up to commercialise the technology in which equity was held jointly by the inventor and by Lynxvale. Lynxvale's revenues from technology transfer are just over £1 million - of which £200,000 or £300,000 comes from consultancy arrangements made through the company and about half the remainder comes from sales and licences of software. The rest comes from sales and licensing of other forms of intellectual property, including tangible items such as cell lines and antibodies.

Revenues are divided between the inventors, their departments and the university. A standard formula exists for inventions funded by the Research Councils, in other cases a variety of arrangements have been made. Cambridge's revenue levels are fairly typical for a large British university - they have a broad, well balanced portfolio without any hugely successful single items. There is a major element of chance in the achievement of spectacular revenues -

several therapeutic antibodies licensed to pharmaceutical companies were recently abandoned during clinical testing.

> *'That's the nature of technology transfer - it's a high risk activity but the rewards are there. You have to be very patient, it takes a long time to build up and you can't predict where they're going to come from.'*

Often the technologies which bring in the biggest revenues when licensed are not those which result from dazzling scientific breakthroughs - the commercial value of a technology may depend far more on business related factors. In many cases the technology may not even be the expected end-product of the research.

> *'I feel very strongly that what we deal with is often a by-product. A very clear responsibility for offices like this is the educational function - both to educate the researchers to keep an eye out for potential commercially useful results of their research... I think we collectively have a responsibility to do that because we receive so much of our money from the public sector and charities, and to make sure that we have mechanisms which allow that process to happen and, very importantly, which motivate the academics to use them. Without the academics collaboration and enthusiasm, in my experience, very little happens.'*

This educative role includes the giving of seminars and other activities within departments. An important tool for the stimulation of interest is the promulgation of previous success stories - if someone within a department has had a good experience then their colleagues will be greatly encouraged.

Cambridge has an unusual IPR policy, in that it does not take out patents in its own name and allows employees the right to patent and exploit their own work, as long as it has not been produced with external funds involving a commitment to other exploitation frameworks. Cambridge imposes relatively light contractual obligations on its employees -

> *'Employees are supposed to carry out research, teaching, scholarship and the pursuit of religion.... during term time - which in Cambridge is three eight week terms per year. Essentially what they do the rest of the time is up to them.'*

This 'flat and democratic' structure gives considerable individual freedom in the discharge of obligations to the university - providing that these are met then faculty are free to spend an entire vacation on consultancy work. There is no extensive or formal conflict of interest policy, expectations are largely implicit. To some extent academics are protected from conflicts of interest by the webs of potentially conflicting obligations to university, department and college which must be carefully balanced and negotiated. The emphasis on consensual decision making has the advantage that the eventual decisions will have been made for clear reasons and that enthusiasm and motivation will often follow. An excessively rigid and formal system is likely to demotivate and irritate faculty.

> *'In my view that's one of the things which has contributed to Cambridge's success.... whether it would work anywhere else, or whether - if you were starting again from first principles - you would do it like this, is a moot point....'*

One important aspect of the Office's industrial liaison role is the handling of speculative enquiries from companies. Cambridge has attracted a proportionally similar amount of industrial funding to the other major research universities,and are are in absolute terms one of the most sucessful - though because they do very well in obtaining Research Councils and Charity funding this is a smaller proportion of the whole than for some other institutions, especially the former polytechnics. Cambridge has a great number of departments officially ranked as excellent in research by the government - this makes the idea of collaboration with the university per se unusually attractive to companies.

> *'One of the side effects of the quality assessment exercise has been that companies approach me and say "We're interested in collaborating with a university, but our resources are finite so we are just going to talk to the top six universities in the country."'*

Large companies, who are by far the most active in research collaborations, have their own substantial research teams. These have close contact with their university colleagues -

*'they're similar people, they read the same journals, they go to the same conferences, they go to the same seminars - therefore they'll meet each other. As a result I feel that the academics themselves are very much at the leading edge of the marketing activity.'*

In such cases the Office is more likely to become involved when approached by an academic who wants advice on the appropriate mechanisms for collaboration available at Cambridge and how to ensure its success. The Office is most likely to be the first point of contact for smaller companies.

*'Always, the perennial difficult question is - how do universities link with small companies? My answer to that question is rather facile, and is "With great difficulty". There isn't at first sight a natural basis for collaboration, because the small companies don't have the resources, they don't do research - they are product and market oriented and the timescales on which they act are in general very much shorter and more immediate than those on which most university research activity occurs. Having said that, it's the exceptions that prove the rule and there are increasingly high-tech companies which are more research focused and the start-ups do increasingly undertake research activities with the University.*

*In general the links are to do with specific problem solving, in many cases consultancy type activity on a single person basis. Participation in more applied student projects and things of that nature can be very effective... you can get a bright undergraduate to work on a project for a month, and somebody good... can make a very valuable contribution to a company provided the management issues are addressed. Sources of material, exchange of materials, use of equipment, use of libraries - transfer of knowledge in a very broad sense is clearly a very real thing. Small local technology companies are increasingly employing graduates, and that's a very real, and in some ways the most important, source of technology transfer: the movement of intelligent people.'*

These kinds of contacts with small companies have been encouraged and subsidised by a number of schemes, including the DTI's LINK programme, Teaching Company schemes and CASE awards for postgraduates. Cambridge was very well known in the 1980s as the centre of an exceptional growth of smaller, high technology companies. This has continued, although the emphasis has moved away from electronics, communications and computing based firms and towards biotechnology as a major source of current growth. Around 1,200 technology based companies are located near Cambridge, employing a total of 27,000 people - however very few of them are large and there are no local giant companies.

*'These sponsored awards are very helpful in principle, the problem with all of them is that small companies see them as bureaucratic and difficult and see an enormous opportunity cost associated with them.... LINK is a very good programme in principle but it's a bureaucratic nightmare - everybody's been saying that from the very beginning but there's no will by the DTI or anyone to sort it out - the people involved are just saying "Oh you sort it out, we're government, we don't get involved in that sort of thing" and that's not helpful.'*

Something as simple as a model contractual agreement, to provide a framework for negotiation, would greatly aid the practical usefulness of the scheme.

Currently attitudes towards biotechnology in the UK are '*optimistic but realistic*' and there has been a lot of interest in the area recently. An advantage of the shortage of venture funding in the UK has been that those companies which have managed to raise funding are in general well conceived and attractive to investors - in contrast to the American situation where during a period of optimism and hype large number of companies were started without good prospects in the longer term. In his view *'we are getting increasingly more intelligent investors, it's fairly slow but it is onwards and upwards*' - and people now realise the need for companies to have a strong technological base.

*You need a platform of technology within a company which you can spin products off from - you can't base your companies around a single product approach. It's always been the problem in Cambridge - you set up a company with a nice bit of technology, well what do you do for an encore? That's one of the major weaknesses of many high-tech companies.*

The Office deals with a '*steady trickle*' of start-up companies, and is usually involved in two or three at any given time. There are two local seedcorn venture funds -the Cambridge Quantum fund and Cambridge Research and Innovation Ltd, which '*I'm afraid in Britain this is almost a unique resource - the shortage of funds needed to get over the so-called development gap is as bad as ever*.' A number of companies have been set up with the help of these funds, with stakes also held by Lynxvale on behalf university and by the individuals themselves. Equity stakes are now held in around ten companies, and the rate of activity is increasing.

He sees technology licensing mechanisms as being '*almost ideal'* for universities, bringing a revenue stream and further consultancy, and possible additional research contracts, as well as ensuing that the technology is utilised. Small companies account for a high proportion of licensees - they are less likely than larger companies to have developed their own, and '*see technology from universities as very much a potential source of new technologies and new business*.' The problem, as always, is that the number of technologies well enough developed to be used 'off the shelf' is limited, and so additional resources must be found.

Terms relating to eventual exploitation of the results of research are often build into sponsored research agreements. Cambridge is quite flexible in agreeing terms and has no model agreement of its own, though previous agreements and collective experience are obviously crucial. '*Model agreements can be very useful as a tool, so that you at least know where you start*.' They are 'comfortable' in assigning IPR to the company, providing that revenue sharing, obligations to exploit and so on can be agreed accordingly. '*Where we have missed tricks is where universities have assigned rights and the companies haven't done anything with that technology, or they use it as a blocking device*.' Problems arise because terms must often be agreed before the value of the results is known - ideally specifics would be negotiated only when more information was available, this is more common in Europe and is gradually coming to be accepted here.

> *'It's a cultural thing too - different countries are happy with different arrangements. In America companies in general are quite comfortable for the university to retain ownership, comfortable to have an option to license. British companies traditionally go for assignment and ownership.'*

A large number of companies make gifts to the university and to individual colleges. These are kept clearly separate from research agreements - not least because tax can be recovered from them by the University and so they have a different legal status. Legally, nothing can be demanded in return for a gift, and it is important to make sure that companies understand this. Currently an appeal to raise £250 million is underway by the development office. However, big companies are now less likely to make large donations with no strings attached - for example whilst a company might once have established a chair in perpetuity they might now fund it for a fixed period and in a more highly specified field. In the current business environment '*just giving money away isn't always favoured, people may not like showing it on their accounts*'; most donations come from trusts and from private individuals.

Have the recent changes in emphasis by the government produced any practical changes yet?

> *'There is a great anxiety on the part of many academics that "Oh, we'll be receiving all this industrial money, it will change what we do". I think the more interesting question is "Why are you doing what you are doing in the first place...?" Every academic, if you ask me, wants their work used in some form or another... they do see a value in it.*
>
> *Despite the role of this office I think that it's crucial that we don't eat our future seedcorn - there is some extraordinary naiveté around in government, it suits current party dogma. That's what I find so distressing - they are intelligent people, they know the situation and yet they pretend that it's different from what everybody tells them it is. I don't know how they live with themselves, frankly - all logic tells you that you can't predict where future breakthroughs are going to come from.... The trust has been lost, I think - the government does not trust its researchers. It is clear that the current government does not like universities and does not like academics - Margaret Thatcher particularly believed that the universities had failed the country.*
>
> *Because of both external and internal factors, the level of interest in this area is growing considerably. People recognise that collaborations are a good thing.... not a rather offensive peripheral activity.'*

Has he seen any signs of increased commitment to collaboration on the side of companies? The move towards the outsourcing of research has '*certainly been seen*' - one short term benefit from this has come with the donation of millions of pounds worth of equipment from corporate labs which have been closed. In the longer term, of course, this reduces the number of potential partners.

> *'People looking very much at what their core business is, considering whether to spend money internally or outsource, ultimately this must benefit the universities. The good news is that it's reached the top of the industrial agenda - when I started in this office seven years ago, one felt that, both in companies and universities, industrial liaison officers were somewhat marginal. Now, both are much more a part of the core business, and the quality and the exchange has increased dramatically, as has the support in both sectors.'*

In the long term, companies need to retain some core research activity - '*you can't transfer technology if there is no one in a company to receive it*.' Some companies may have moved too far towards outsourcing, but fashions change in business and often trends are cyclical.

Awareness of, and support for, technology transfer is now greater than ever before. Resources do need to be increased if it is to happen as efficiently as possible, though in general it is not a hugely expensive process to support and pump-priming money is likely to be a good investment. Many benefits appear in the longer term, and it is essential to take a careful view.

> *'It's very important that people don't just look at flows of patents, because there is a crucial quality issue there. It's very easy to file hundreds of patents and to say that you've got a great technology transfer office, revenue is another measure but it's long term - the Americans say ten to fifteen years to build up a substantial activity.'*

### 9.2.1.2 Roger Needham - Cambridge Computer Laboratory

**Interviewee: Prof. Roger Needham**
**Job: Director, Computer Laboratory**
**Organisation: University of Cambridge**
**Interviewer: Thomas Haigh**
**Date: Friday, 5th May 1995**
**Location: Cambridge University**
**Revision: 1**

Patterns of industrial involvement within the Computer Lab vary over time. Some industrially sponsored development is undertaken, but it is the exception rather than the rule - *'we are not in the business of doing boring work for money.'* However, a large amount of funding comes through ESPRIT and EPSRC via schemes involving collaboration with industrial partners.

Informal relationships are very important, many of which involve no contractual element whatsoever. Companies have provided equipment donations '*because they thought it would be a good thing and they enjoy talking to us.*' The best example of this is Olivetti - the head of Olivetti research is a member of faculty, and resources have been supplied to the Lab over a long period, most of them on an informal basis. Such donations bypass the central University mechanisms, which are based around contracts, and so do not appear on official statistics. Many faculty members have good relations with, and sometimes receive support from, various companies.

An Interdisciplinary Research Centre is currently being set up to research communications systems - a total of £100,000 has been raised from companies and trusts to employ a senior person to oversee its establishment. Pledges were raised on the strength of long term relationships, rather than particular contracts. A '*supporters club*' is run for companies, many but by no means all of which are local. In return for an annual contribution, which varies according to size and wealth, members receive invitations to seminars, copies of technical reports and easy access to faculty. A mutual benefit is the opportunity given to companies to recruit students from the department - smaller companies do not have the resources to participate in the Milkround and so value the annual event where they make presentations to the students. A dinner afterwards allows the companies to form links and to do business with each other - and some formal collaborations have emerged from these relationships.

> *'If you look at formal relations, they underplay the reality. If you insist on formal relations to make the statistics look good then you're not doing anybody a kindness; and the best things are corporate friendships, where you may formally collaborate from time to time, but probably not all the time. When a collaboration is obvious then it happens. At the moment I would say that we are on those kinds of friendly terms with Hewlett Packard, Digital and Sun. This takes all kinds of forms: I consult for Digital in a purely private capacity, but it's because I consult that so many of our students are taken on as summer interns in their research lab, and it's because Digital know me so well that they're lending us some equipment to use in a research project, but none of this is written down anywhere....*
>
> *I think this is all good.... If there wasn't an industry concerned with making and using computers the subject wouldn't exist. It's not like physics - physics was made by God, but computer science was made by man. It's there because the industry's there.'*

The Lab offers short courses to industry. Currently a very successful course is being offered on ATM networking, which is taught publicly and on an in-house basis. Some of the proceeds go to the Lab and some to the University, most goes to the individuals - '*which is important because they are paid so little.*' This helps to keep staff motivated and happy within academia. He feels that rigid restrictions on the activities of academics are counterproductive -

> *'Cambridge has a very relaxed attitude to this sort of thing. Provided you are visibly doing your job right we don't fuss ourselves over what else you are doing.'*

Some departments, such as materials science, have opportunities for very short term industrial work based around services such as the provision of time on their machinery and instrumentation. This is far less common in computing, re-enforcing the dependence on longer term relationships. Contract research is not usually undertaken -

> *'Companies tend, perfectly reasonably, to have short term goals - and a good computer science department does not want to do short term work. Maybe it sometimes will, to keep the wolf from the door, but it's not what grade 5 departments should be doing.'*
>
> *'It would be bad it we were diverted by the need to get money in this way from doing what we are good at and what we are for. It's good if you pick up good ideas from talking about industrially relevant projects, and it happens sometimes. We did some consulting the other year to do with burglar alarms which gave us some very interesting ideas and we got several papers out of it.'*

When long term projects do take place, it is because a company is interested in the same kind of project as the Lab, allowing research to take place in valid areas which might not otherwise be funded. Currently work is being undertaken for BT and for the Korean telephone company. Prof. Needham sees one of the most important functions of the Industrial Liaison and Technology Transfer Office as the provision of advice '*to make sure that we don't get taken to the cleaners.*'

Companies are now seeking to outsource more of their research, and they can gain tangible benefits and know-how by funding university research, they also gain the advantage of awareness of and access to university research in general. In his view this is more common in the US.

> *'At the MIT Media Lab, at lot of companies - including many British companies - subscribe to fund their research without controlling what it is. You can whistle for money from the same companies if you are British, and the companies will spend money at MIT when they won't spend it here, even if they got the same thing for it. It's for the same reason that grocers sell imported delicacies - you tend to think that the thing from overseas is better.*
>
> *Also there are difference of national habit - big American companies like Digital, Hewlett Packard and Xerox quite often telephone me, send email or visit saying "Do you have any really high flying doctoral students finishing this year?" These companies have people on their payrolls, part of whose job description is to stay in touch with the work of my lab and to know when there is someone really hot coming out so they can try to hire them. No British owned company has ever asked me if we have anyone really good coming out this year - I think this is extremely sad, but it is true. Go to Palo Alto train station in California - there are about two dozen of our PhDs within 10 miles.'*

Many British companies seem to have failed to realise the importance of high quality research staff, but '*if you don't have your research done by the best people it's so inferior.*' In his view '*the best method of technology transfer is by people.*' Another problem is physical remoteness from the main research centres of the big computer companies - local companies are mostly smaller and less able to sponsor major research projects, though the Lab's other links with them are valuable to both parties.

The Lab has been involved in a number of EU projects. Their experience of collaboration with other academic institutions, via '*Basic Research Actions*' has been

> *'entirely favourable, we are involved in a number of them and I am sure that this has increased greatly our contact with Continental European universities. It's an interesting observation that people of my generation tend to look west for collaboration, because when we were young there wasn't much going on in Europe to collaborate with, whereas my colleagues twenty years younger tend to look to Europe.'*

The Lab has also been involved as minor participants in a number of the large scale ESPRIT projects with international industrial partners. '*My observation, which I hope is untypical, but I fear isn't, is that if you're going to waste that much money there must be easier ways*.' Companies often try to base projects on work which they have already undertaken, are subcontracting or planned to do anyway, whilst often most of the work in a project comes largely from one of the partners. However, some projects have achieved '*respectable'* results, and of course, the process does encourage greater contact between European companies - '*but it's hard to think that you couldn't achieve this amount of conversation slightly more cheaply.*'

ESPRIT funding has the advantage of being assured for a number of years once allocated. However, a general feature of industrial funding from this kind of consortium based system is that it cannot be relied upon until contracts have been signed. Whilst a university will almost certainly respect a commitment to a project once a broad agreement has been reached, a company might pull out at any stage before signing for reasons such as bad results, change of personnel and so on.

> *'Everyone says that technology transfer is truly wonderful, but everybody also says that universities ought to "exploit" the technology which they have generated for money, as effectively as they possibly can. These two things are actually slightly opposed to each other. I think that there is a very widespread view among university people, unfortunately, that what they had developed is worth more than it actually is. In the computer field patents that are worth anything are quite uncommon - I have my name on two or three patents, but they are not worth the paper that they're written on in my opinion. Much of it is know-how, and know-how resides with people. You get the people by hiring them and paying them what they're worth.'*

Of course, some fields - such as medically relevant areas of biology and chemistry, generate intellectual property which can be patented and licensed to generate significant income. Similarly, chemical engineers may develop processes with direct industrial applicability. Although academics produced some potentially very valuable and patentable developments in the early days of computing, today such developments are rare. Furthermore, attempts to patent algorithms have not proved productive - '*all they have done is to cause people to go off and do the necessary research to find algorithms for doing the same thing which don't infringe the patent.*' Successful software companies tend to have done well as a result of understanding customer requirements and producing marketable packages rather than great technical innovations, and copyright is more important than patents.

The most important licensable technology developed in the Lab was the Cambridge Ring networking system - this was given away to a number of companies for nothing more than tuition fees. '*Our policy was that we wanted to see it used, not exploited.*' Some money has been raised by the sale of natural language software tools, and a few academics have gained personal income from the sale of compilers. A start-up company is producing under licence a piece of equipment developed by the Lab - the company is owned by current and former members of the Lab.

> *'Very little has been done in taking ideas and licensing them to people in the serious outside world, and I don't think this is because we are slack in this regard, I think we have as good an eye for a fast buck as anyone. It is because very little of our work lends itself well to that sort of treatment - particularly without our taking our eye off the ball.'*

In his view, there is less of a need for formal policies relating to matters such as conflict of interest in Cambridge than in the US. Americans are often more legalistically minded, and are more likely to push the limits of what is permitted.

> *'I know some British universities own companies which actually do things, and I've always considered it to be a great mistake. There have been instances where Cambridge University has held shares in local companies, but this has always been regarded as an investment - just like we own 33% of shares in the local water company.... For the University to be the majority or only shareholder in a company that conducts a business in the ordinary sense is not terribly sensible - because as a class we are not terribly good businessmen...'*

He does not feel that, in the computing field, commercial applications are likely to arise as an unexpected result, or by-product of basic research.

> *'Our research is pretty well goal directed - but the goals are set by us. In a lot of computing there is no such thing as basic research, excepting some theoretical areas of the subject. We do a lot in networks and communications and so forth - I would assert that there isn't any basic research in networks and communications... the statement "They discovered an important truth about packet switched networks and it's no use for anything" is just inconsistent - it wouldn't be an important truth unless it was useful for something.... One of the heresies of recent times is the view put about by government and such people that people in universities are not able to set their goals properly - and in computer science this view is no doubt found as offensive in Manchester as it is in Cambridge, for obvious reasons - I mean we invented the bloody things. For it to be suggested that there is some sort of magic touch that industry has, and we don't, which allows industry to select goals for worthwhile research is quite rubbish, but ministers are not deterred by that fact that something is rubbish from asserting it.'*

So far, no practical changes have been experienced as a result of recent developments in government science policy. He finds it probable that the Technology Foresight programme will eventually have effects - these are as yet unknown but *'bound to be good*' for computer science and related fields because their crucial importance is recognised by the panels responsible for very many of the different areas represented in the programme. For example, research into security, privacy and authentication in computer communications - one of his own interests - is seen as crucial for several fields including retailing and financial services as well as IT.

He feels that industrial interest in funding of university work does have potential to increase, largely as a result of the trend towards outsourcing. However, like much else in business this has an element of fashion and so can swing from one direction to another. No clear increase in overall support from industry has been apparent to him during the last five years.

### 9.2.2 International Computers Ltd.

**Interviewee: Peter Wharton**
**Job: Chief Engineer**
**Organisation: International Computers Ltd.**
**Interviewer: Thomas Haigh**
**Date: Thursday, 23rd March 1995**
**Location: University of Manchester Dept. of Computer Science**
**Revision: 1**

Though Peter Wharton's post of Chief Engineer is essentially a corporate function, because ICL no longer has an extensive corporate infrastructure - having moved to a structure based on autonomous business divisions vertically integrated by market - he is a part of the Corporate Systems Division, which deals with larger systems. His own background is in ICL's mainframe business and its VME operating system, which involved him in work with a number of universities.

The job entails a general responsibility for '*improvements in engineering*' within ICL, a major part of this consists of the encouragement of networking within the engineering population of the company - both informally and through schemes such as the ICL Fellow and Distinguished Engineer programmes. It also includes responsibility for coordination of work in areas such as development and redevelopment techniques in the Software Engineering field and the adoption of standards within the company.

ICL's overall strategy for higher education is coordinated by a high level steering group, including the Head of Research, the Technical Director, the chief sales person for universities and education and a Human Resources representative. The group meet approximately quarterly - until recently it was known as the Universities Committee, but the sales force prefer to consider the whole of the education sector in an integrated manner and so it is now known as the Education Committee.

Traditionally ICL has had strong links with several universities, most especially Manchester, whose computer science department produced a lot of research which has found its way into ICL machines since the early 50s. Today, attention is focused on a small group of universities with particularly relevant strengths. A significant recent project involved research teams at Manchester and Imperial collaborating on the EDS massively parallel computer system, which formed a basis for an important commercial product.

At one time, central funding and grants of equipment were available to internal groups that wished to provide support to universities via joint projects. Many of these collaborations went on to become part of Alvey and ESPRIT projects and received further support from the government. Another main area of activity was in the employment of academics as consultants - professors are valuable to the company both for their knowledge and for their standing in the community, and so their participation in meetings and other activities can provide a useful perspective. They usually enjoy the chance to try out their ideas with a company.

Technology transfer is an important outcome of collaboration, and includes formal elements such as IPR agreements. He sees the *'missing link'* in this activity as the capability to pilot a technology which has been developed and is now 'l*oosely around*'. Whilst universities produce a large number of interesting technologies they are usually not mature enough for immediate use; before work can begin on incorporating any such technology into a product an internal technological demonstration must be produced. In Germany the Fraunhofer helps to provide this missing link, whilst in Japan companies tend to conduct much more research internally and so can work on technologies which are less well advanced. In his view the DTI do not provide sufficient support for this activity, and its schemes are too complex and bureaucratic.

The move towards autonomous divisions and an internal market caused something of a 'hiccup' in collaborations with university. '*A whole lot of things stopped happening.*' Of course, more efficient use of resources is one of the main motivations in moving to this kind of corporate structure, and there is therefore an argument that this is a good thing and that activities which no one is willing to pay for are not needed. A problem remains when the benefits of a collaboration might be spread over a number of different business divisions, providing good value overall but failing to justify the total cost for any single division. To facilitate this kind of activity a small R&D unit is being established to put in place mechanisms for joint support. This kind of support is particularly important for technologies *'in the gap'* between research and product development.

Whilst consultancy agreements have remained popular, joint research ventures outside of programmes such as ESPRIT have become significantly less common. Research funding, like most other spending, has been devolved to the various business divisions - so central support is no longer available. Businesses have found that in general better value for money is available from other methods, though individuals may collaborate when suitable opportunities arise.

Another mechanism for collaboration is via 'visiting professors'. Under this scheme, ICL staff spend spells from a few weeks every year upward working at ICL, during which they are unpaid by their university. Placements have been made with universities including Manchester, Edinburgh and Imperial - three of the country's top centres for computer science research. At the other end of the academic spectrum, students are involved in development projects with the company, often supported by EPSRC initiatives including the CASE awards and the 'Teaching Company Scheme'.

How is spending on universities evaluated? Some spending, like the work on EDS, is product based and is designed primarily to bring in expertise. Other spending, such as that to support sponsored chairs with universities, whilst valuable as a general promotion of the company is not expected to bring a short term payback. The institution involved is often in geographical proximity to the business division involved.

Most spending is reviewed regularly - for example when a group of four standing consultancy agreements were reviewed recently two were dropped and another transferred to a different budget because the focus of the work had shifted. Expenditure on university research support brings both technical knowledge and marketing advantage for the company - too often one of these advantages is ignored. He sees it as important to evaluate both when judging the returns on such investment, and synergy may be produced between them.

At one time ICL was a major supplier of computing equipment to universities. The rise of DEC and a general shift to minicomputers, and later still to desktop computers eroded this position. With the establishment of ICL as a leading corporate vendor of PCs in recent years, attention has again been focused on education as a significant market. Relationships are being built, and more effort expended on client management - though ICL does not operate any formal 'favoured buyer' scheme for selected institutions.

He sees a general problem for collaborations as being the differences in personal driving forces usually found between academics and industrial developers. Because academics are oriented towards writing papers, having these published and seeing them cited by others they tend to seek widespread individual credit as the primary outcome. On the other hand, industrial teams are oriented towards the integration of work from a number of different sources into a saleable product, are concerned with competitive advantage and do not wish to give their work away.

Because of the potential for mutual misunderstandings and culture clashes which this produces, it is very important for personal relationships to be developed. These lead to much better understanding of the priorities on each side, and provide a sound basis for subsequent collaboration.

Does the shift towards the internal market lead to an increased willingness to look outside the company for technology acquisition? Overall it does, but collaborative ventures remain the primary source of technology transfer from universities. Complex chains of relationships develop, because universities collaborate with each other and so collaborative work with one leads to contacts with others. However, support for university research remains *'an act of faith'* and ultimately the company must give money to good researchers and hope that good work is produced.

## 9.2.3 University of Manchester

### 9.2.3.1 Peter Schaefer - Vuman

**Interviewee: Peter Schaefer**
**Job: CEO, Vuman**
**Organisation: University of Manchester**
**Interviewer: Thomas Haigh**
**Date: Wednesday 26th April 1995**
**Location: Vuman Offices**
**Revision: 1**

Vuman's aim is the exploitation of research carried out by the University. There are two main channels through which this can be accomplished - the protection and licensing of intellectual property and the setting up of companies by the university. So far around ten companies have been set up, and joint ventures are favoured wherever possible.

In practice Vuman learns of research with potential for exploitation when members of faculty come forward with ideas. Ideally a regular technology audit would be conducted, and an obligation exists to exploit work funded by the research councils wherever this is possible. Unfortunately the resources required to conduct a full audit are not available, although strong links now exist between Vuman and the university's Research Support Unit.

> *'In practice few of the companies have been founded on an invention, most of it is the university's "know-how", which is another form of intellectual property.'*

Of the companies themselves, the oldest is Medeval, which provides services and conducts clinical trials on behalf of pharmaceutical companies. Their strength is in pharmacokinetics - the rate at which drugs are metabolised within the body. The company has been established for twelve years and is soundly profitable with a turnover of around £2.25 million.

Predictive Control, the second largest of the companies, is now an associate company rather than a wholly owned subsidiary. They have developed programs which manage process control within complex industrial plants. Their customers include Unilever, ICI, BNFL, Nestle and other major corporates. Turnover is between £750,000 and £1 million.

APEM specialises in aquatic pollution, and has been involved in projects such as the Salford Docks reclamation - it has expertise in environmental monitoring and has also worked with the National Rivers Authority and English Nature. Vuman Interactive provides multimedia training, and Flow Science capitalises on the expertise and laboratory equipment of the Aeronautical Engineering department to pull in around £300,000 of turnover. Another company offers educational assessment services.

The company established in conjunction with the department of Computer Science is Manchester Informatics - this was founded '*initially as a way of legitimising the outside work which they were already conducting*'. It is now '*starting to look at what skills might be saleable'* within the department.

Sensor Solutions is the only one of the companies to be founded on a particular novel technology, it has '*an extremely strong patent base*' based on work by a Professor of biochemistry in the School of Medicine. Their sensors were originally developed for diabetic screening, but they are now pursuing developments such as alcohol sensors and potential applications in agriculture and the food industry. Medical applications will take longer to reach maturity due to the more involved development and approval process.

Several potential opportunities for companies based around pieces of university technology are currently under consideration. No general rules exist to establish whether a piece of technology is most suitable for licensing to an external company or setting up a new company to exploit. Decisions are made case by case according to the position of the technology in the marketplace.

> *'The only rule that we've come across talking to our counterparts in the other forty university companies is that there are no rules that apply... each case is different.'*

Whilst they listen with interest to the advice of American universities over the setting up of start-up companies,

> *'it's very hard to draw analogies... there's such a different culture, especially in the investment community, that's it's very difficult to apply that over here. People there are very much less concerned about risk, they realise that risk is necessary and that if you're going to risk then failure is inevitable in a number of cases - you play the percentages. Universities don't like risk, venture capitalists don't tend to like risk, there is not much of a market in start-up funds. Making the investment and managing the investment is out of all proportion to the return which you are likely to make in the early stages.*

With the exception of Predictive Control, the university is the majority owner of all the companies, though in some cases there are other major stakeholders. These may include faculty members - although '*we use very few members of faculty in our companies - I can only think of one member of faculty who's got a stake*.' The only significant restriction which is imposed on the companies as a result of their university ownership is that '*they are precluded from investing major amounts of money in new development - if we need development then we have to find outside sources for that.'* One source of investment has been three SMART awards totalling around £150,000, revenue was also raised via an option fee on a piece of technology and in several cases industrial sponsorship has been forthcoming. In all other respects they act as a commercial company and are subject to normal restraints and responsibilities.

Government support for the companies has been limited to the SMART awards. The only other prospective source of government money is the Regional Development Fund of the EU.

> *'There are very few [incentive schemes] for which university companies are eligible, which I think is an inconsistency in approach. On the one hand the government is saying that it wishes to encourage universities to exploit IP, but on the other hand it removes all the incentive schemes such as SMART - that's been withdrawn now, they are saying that universities are not small companies.'*

The university does not run any kind of risk of liability from its ownership of the companies. '*Legal entities are legal entities... and unless there is fraud, dishonesty or anything else like that then the liability remains with the company*.'

Returns to the university department from the longer established companies are made by covenant. The current model for new companies, following the establishment of Manchester Informatics, is to deduct university costs from the profits of the company and return the remainder not required for re-investment directly to the department, avoiding the 'central university tax'. So far no significant returns have been generated by these newer companies. Other benefits include 'a strengthening of industrial awareness, both for research and teaching'.

Peter Schafer also has a senior role within the University's Research Support Unit as head of the Research Development division. The Unit was only established in August of 1994 and is still distributed over a number of locations. His role is '*to make sure that research contracts are wholly compatible with later exploitation and to bring a greater degree of commercial reality to the negotiations and again to strengthen the links between university and industry*.' Currently priority is being given not to general industrial liaison but to the development of information systems - this includes the development of a database of research, but

> *'goes wider than that - there was no single point to which a researcher could go to find out which programmes might support his work. He might be aware of the Research Councils, he is unlikely to be aware of the charities, he probably wouldn't have an awareness of all the European programmes, he probably wouldn't know what kinds of industrial sponsors might be around. We want to bring together that information and make it accessible over computer or hardcopy... if we want to see more targeted information that requires us to know what research is going on.'*

The challenge is to make sure that researchers are aware of likely sources of funding without swamping them with masses of information about funding sources which are unlikely to be applicable to their work. In the first round of ROPA awards, general awareness was poor among researchers - for the current round publicity has been targeted at those groups which meet the requirement threshold of £25,000 of industrial funding and the response rate has been very high.

How are exploitation issues dealt with in the research agreements which the university negotiates with industrial sponsors?

> *'There's a complete spectrum here - from the sponsor claiming rights to not just what comes out of the research but everything the investigators find in the next fifty years to no rights being conceded to the sponsor. We are trying to put some policy in place - there is quite a long education job there because often the researcher has more or less agreed all the terms before he comes into the Research Support Unit... the researcher can't commit the University, but in practice the University is seen in a bad light if after something has been purportedly agreed by a researcher somebody in the centre says "No, you can't do that." We want to get all of that clear, the fact is that we are keen to see intellectual property exploited, but we are not keen to see the University exploited by industry. We want fair reward for the inventive efforts of out staff.'*

Terms in sponsored research must be agreed with a strong framework, so that, for example, a sponsor which makes no attempt to exploit their options on a technology will lose them and so will not be able to prevent competitors utilising a technology unless they are prepared to invest in it themselves. It is possible to agree this framework as part of the sponsored research agreement itself, and to delay negotiations over the exact rates of royalties and precise conditions until the value of the research has become apparent. University policy is to split net receipts from licensing approximately equally between the inventor themselves, the department or resource centre responsible and the central University.

Finally, how does he react to suggestions that it is inappropriate for a university owned company, subsidised indirectly by public money, to compete in the marketplace against private concerns?

> *'We are not competing with industry using public money. The university made an investment in us, but we have to stand on our own feet. The university has earned a lot of money, for example it put £50,000 into Medeval twelve years ago and this year it will make in excess of £200,000 pre-tax profit.... The university is allowed to buy shares in the stock market, it is allowed to buy buildings. We are not taking subsidies, none of out staff on the commercial side are paid by the university.'*

But surely the 'know-how' of the departments, which is the main asset of the companies, is a public asset?

> *'Well let's have a look at where that comes from. You received a state education, at least to a degree. Therefore, do you feel that that belongs to the state, or has it been subsidised by industry? If you go into business on your own, are you competing unfairly with industry. I don't think there's much of an argument there. If we generate business it's rarely in direct competition with private companies. Iit's new technology which would not otherwise be funded. I think it's bringing benefit to the country - perhaps the worst thing to do would be to sell it abroad, although we do license abroad.'*

#### 9.2.3.2 Mike Taylor - Research Support Unit

**Interviewee: Mike Taylor**
**Job: Industrial Liaison Manager**
**Organisation: University of Manchester Research Support Unit**
**Interviewer: Thomas Haigh**
**Date: Thursday March 9th 1995**
**Location: University of Manchester**
**Revision: 1**

The Research Support Unit (RSU) is a relatively new body, having been set up in August of 1994 as part of the restructuring of the central administration of the University. It is responsible for the administration, development and exploitation of research carried out by the university. All research funding falls under its remit except for postgraduate research which at the time of the interview was still managed by a separate office. Development and Alumni matters are also the responsibility of other offices.

Previously the various tasks had been carried out by a number of separate offices, for example the Industrial Office, Grants and Contracts Office, the European Office and so on. The integration is aimed to give a coherence and a common set of strategies and aims to the university's activities in this area. The new unit comprises around 30 staff, headed by Mike Littlewood.

The RSU is split into two divisions. Academic Research Services supports tasks relating to the university's core research funding from HEFCE and similar bodies, which totalled around £28 million an 1993/94. It is also responsible for co-ordinating the university's preparations for the Research Assessment Exercise. The other division, Research Development, is headed by Peter Schafer who is also CEO of Vuman, the university's exploitation company. It includes responsibility for grants and contracts work, European funding and industrial projects.

In 1993/94 industry provided around £4 million of the £39 million annual total of grants and contracts from different sources. Manchester's particular success has so far been with other sources, especially charities. The bulk of industrial funding has been directed towards the medicine and the life sciences, for example an award from Glaxo of £750,000 over three years and a £1.5M contract from Zeneca. A number of industrial contracts of somewhat smaller size are in place for departments such as Physics, Computer Science and Engineering. Some of the contracts involve collaboration with other universities.

In general the impetus towards industrial funding comes from academics themselves. The process is market driven - academics network professionally with corporate researchers and can use the opportunities presented to seek funding for their research. In general, funding does not spring from interaction between the university and central corporate offices. Smaller companies which do not have their own substantial research teams tend to treat the matter differently - they will usually be seeking immediately relevant work to provide short term benefits in a specialised area. They are less likely to have existing contact with researchers, and so may make initial contact with the central administration or a particular department.

All research contracts require the approval of the RSU - academics are not allowed to sign off agreements on their own behalf. Often the Unit is presented with a contract which has already been negotiated, so only minor changes can be made to maximise the university's interests and integrate it into an overall framework. If a contract would work to the detriment of the university - for example unacceptable exploitation clauses or an unreasonably low price, then it must be re-negotiated or vetoed. For a major, long-term contract exploitation rights must be negotiated carefully, and the company will be presented with a standard contract as a basis for negotiation. If the academic involved has experience of contract negotiation then the role of the Unit is likely to be much less important than in cases where researchers without previous experience in the field need to '*have their hands held.*'

When a contract with a smaller company is being negotiated it is necessary to identify whether the work can be undertaken, and to refer the company to relevant contacts within the appropriate department. An understanding of the capabilities possessed by the university in different areas is needed to accomplish this - a database holding the expertise and interests of researchers exists within the RSU.

The rights which will be granted to companies over research which they have funded depends entirely on the type of work undertaken and the terms negotiated. A consultancy agreement will routinely give all results and exclusive rights to the work undertaken to the sponsor - it represents commissioned work and will more than cover costs. At the other end of the spectrum, a major piece of sponsored research may be negotiated with academic rights as a priority. The university prefers to retain ownership of resultant intellectual property, but often builds exploitation rights - exclusive or non-exclusive, into the initial contract. Agreeing exploitation rights at the outset has the advantage of transferring risk onto the company involved.

Some aspect of philanthropy may be seen at work in the actions of larger companies - their eventual returns may come ten or fifteen years after the conclusion of the research which they are funding. Smaller companies are more concerned with immediate returns on their investments. Geographical proximity is much more likely to be a factor in attracting interest from smaller companies - larger companies are more likely to be based in Europe, the USA or the Far East but to act globally in their research funding.

Consultancy is not regulated exclusively by the Unit. Dividing lines are '*rather blurred*' - whilst consultancy is clearly distinct from large scale collaborative work, strategic research it is not always clearly possible to distinguish it from applied, contract research. Some consultancy work is agreed directly between the individual's department and the academic concerned - it is possible that the RSU will '*never get to hear about*' such work.

Even centrally processed consultancy agreements do not generate direct revenue for the university. They are permitted and encouraged because they motivate academics and stimulate more general relationships with companies. Whilst it is not practical to centrally support very small pieces of work, some 'fairly significant' projects are undertaken on a consultative basis. Consultancy agreements can also be made directly between the individual and the company - these cannot include significant use of university time or resources. Private arrangements are carried out at the individual's own risk and do not benefit from the university's liability insurance. At the time of interview, the university did not have a formal conflict of interest policy - the situation was being looked into at a senior level.

The importance of industrial funding of research is expected to increase. This is driven in part by government policy and the common theme of 'wealth creation' adopted by the Research Councils. According to HEFCE guidelines, the next Research Assessment Exercise will include a higher weighting for industrial research. This presents a problem for Manchester, because it is hard to identify direct industrial returns from many traditional areas of prestigious pure research such as astronomy and particle physics. HEFCE also encourages universities to recover their full costs when negotiating terms for contract research - though this will not be judged in the exercise itself.

In general there has been a steady increase in direct funding from companies, although this is dependent on their economic health. A similar increase in indirect funding as a result of industrial cooperation has resulted from government (national and EU) sponsored programmes such as Framework 4 and the DTI LINK programme. The recent recession prompted a general trimming of companies' own research capabilities, which has led to a more widespread reliance on contracted work - universities sometimes being seen as a cheaper alternative to commercial research teams.

## 9.2.4 NEWCASTLE UNIVERSITY

### 9.2.4.1 Tom Anderson - Centre for Software Reliability

**Interviewee: Tom Anderson**
**Job: Director, Centre for Software Reliability**
**Organisation: Newcastle University Dept. of Comp. Sci.**
**Interviewer: Thomas Haigh**
**Date: Friday 17th March 1995**
**Location: Newcastle University**
**Revision: 1**

The Centre for Software Reliability is an official research centre of the University, located logically if not physically within the department of Computer Science. The work of the centre is fairly broadly defined in terms of increasing 'dependability' of systems - including safety, availability, reliability and so on. Not only must these characteristics be built into systems, but their existence must be demonstrated. Almost any area of systems development research could contribute towards these goals, but work tends to focus on core areas such as formal methods and new software engineering techniques. The centre's mission includes an explicit commitment to transfer of results beyond the academic community - '*the aims are to progress our objectives in research and to succeed in communicating our own and relevant research... to the industrial community*.'

What are the benefits of formal organisation as a 'centre' rather than informal existence as a group within the department? The centre was established around ten years ago to provide a '*label to hang things on... at that time it consisted of a secretary and a telephone - rather more support than the standard university infrastructure gives an ordinary member of a department.*' Increased independence as a centre allows the raising of additional resources - '*secretarial support and then research staff and projects and other activities get attached to your organisation, and before you know it you have something much more substantive*.' After five years the centre expanded with the recruitment of additional researchers and moved physically out of the computer science department. Currently the unit employs twelve staff.

The centre has two main 'strands' of industrial sponsorship - from British Aerospace (BAe) and Scottish Nuclear. Funding from BAe is long term and is renewed on a rolling basis. Scottish Nuclear are supporting work on behalf of a larger group within the industry, and their funding is for a two year project. Both projects are directly funded exclusively by the industrial sponsors, though indirect leverage of their investment occurs through the expertise which researchers develop on other projects and the infrastructure provided by the centre.

Each member of the centre has their own contacts so relationships exist with a range of other firms - which are strengthened through the approximately monthly events organised by the centre. These are based round 'community clubs', most of the members of which come from industry. These are mostly one day affairs, though some are longer and a three day symposium on safety systems with around 200 delegates is held annually. Club members which contribute a small 'participation fee' receive a newsletter and a discount on the cost of participating in the events - income from which is the other source of funding for the clubs. At present the clubs' income does not cover costs, in the longer term it will have to do so. Approximately 2,500 contacts exist on the centre's database. Some individual consultancy occurs, but on a fairly small scale due to time pressures.

Around 25% of the centre's income comes directly from industry. The governmental ROPA (Realising Our Potential Awards) are only available to groups with a minimum of £25,000 of industrial support and so represent potential additional revenue. The changes of emphasis by the research councils are '*in a sense a game, a system within which you have to work... and there's some value and validity to all this but there are also also weaknesses and deficiencies....*' An increased stress on wealth creation by the Research Councils may lead to more support for work of the kind undertaken by the centre.

The Alvey programme was influential in the early development of the centre and was overall very helpful despite problems with the contracting mechanisms. The experience of working with consortia involving industry, gained as part of the Alvey mechanism, has been continued by the department as a whole through involvement in Esprit programmes. Tom Anderson feels that collaboration is most successful when it involves '*basic research with* *collaboration between researchers... in collaborations with industry the partners often have very different drivers which can lead to different directions with the collaborative project.*'

What does the centre tell its sponsors they gain from funding research?

> *'The reality is that you do two things, you seek to latch into the things that they are seeking - you select among and align yourself with what they see as the objectives of buying external research... they've usually got a fairly clear idea... the alignment may not be perfect but by and large you've got to talk to them and therby maximise the alignment that already exists in terms of the research that you can undertake. The other thing that we would stress is our track record and the established body of "successful research" that we would lay claim to and the benefits that they get from being associated with a cohesive set of ancillary activities.'*

Sponsored work should be publishable, but '*if you work with an industrial sponsor then I think it's legitimate to accept that they have a commercial position to protect; so our deal with British Aerospace is that it is normal to anticipate publication but that they have a right of veto*'. The clearance process works efficiently, as immediate approval can be given for non sensitive information. Product related commercial information can usually be removed without compromising the core of the paper. Secret work is not currently undertaken, although *'in these hard times... there may be ways of persuading us that that is acceptable to work in a different mode... or take the contract on a consultative basis.*'

Would contract development work ever be considered? This work is not suited to a university department, essentially for pragmatic reasons. Any spin-off software business would be handled by the University's exploitation company NuVentures. Thus whilst it not impossible that the group might become involved in development this would be done on a consultative basis and through a separate company. So far a situation has not arisen where the needs of a potential sponsor were close enough to development to make this necessary, perhaps because industrial partners have been attracted by the Centre's research rather then being approached speculatively.

> *'We have not got the time to set up a research marketing team... it's more a case of responding to opportunities that either come in at the door explicitly, or are around and we are aware of them.'*

What kinds of deliverables do the industrial sponsors expect? Scottish Nuclear work in 'hands off' mode. '*They impose demands that follow patterns that they insist on us working to; so they require project plans, time-scales, deadlines - very fixed deliverables, on schedule. They would criticise if these were not adhered to.*

> *I think this is an aspect of what you do see from industry - that's the way industry operates in its own field and they are reluctant to accept that real research, which is what we're genuinely supposed to be doing for them, does not fit that model. What they may do is to say "Yes, we fully accept that it doesn't fit that model" and then ask you to follow the model anyway, because they have nothing else to operate with, and attempt to convince you that it's a good thing in terms that you can't argue with...'*

Adherence to this pattern is '*a little bit artificial for us... but it's easier to adhere to it because they don't pester us, they let us get on with the work. They don't give us as much feedback as we'd like...*'. In order to gain feedback from their engineers it was necessary to build into the contract additional money to be returned to Scottish Nuclear to pay them to take part - although this arrangement initially struck the academics as odd, '*when you think about it, it makes sense... looked at from their perspective.*' This kind of cost accounting is an example of the kind of cultural differences which exist between the two sides.

Problems had previously existed in the relationship with one sponsor due to differing expectations of what constitue appropriate management structures. '*You can fall into the trap of over specifying, over-stipulating, over-egging the pudding with things that are beneficial. Separate activities, ideas and ways of working when treated on an individual basis can be hard to criticise, but that does not mean that the entirety of those things, taken together, is a good thing - indeed it can be enormously detrimental... Early on we fell into the trap of trying to do too many good things and over-managing the process... We realised that this was the case and now have a much better mechanism in place. Now when good ideas come along for us to do we say "That's a really good idea, which of the last set of good ideas are we going to drop?"... put too much management overhead in and you won't have any research..*'

Aside from the revenue, what other benefits does the centre gain from its industrial collaboration?

> *'I think you get potentially enormous benefits. [With British Aerospace] there was an opportunity to get the best of both worlds: well funded academic computer science systems research that was grounded in extremely practical applications - real engineers very committed to the work, seeing the need for it, wanting to support it, both very much pulling in the same direction... They get the benefit of independent, academic, longer term perspectives embracing a much broader community of work; we gain from their experience of building real applications. Potentially, that is very good at steering what we do and enlightening what we do - and what you want is to get the best of both worlds rather than falling between two stools, and early on we maybe didn't get that balance right... The lesson for us was that you couldn't make it up as you go along... those benefits don't come for free - you have to work for them.*

BAe, one of their principle sponsors, is not a monolithic corporate entity, and so the collaboration involves several distinct firms within their overall structure - a process with its own potential problems.'

Is industrial funding of university research likely to increase? The department as a whole has been strengthening its long term links with companies such as ICL and BT. However,

> *'they've all got budgets for how much they're going to support, and although the government wants to encourage research, it costs money - the Treasury knows that it has to control this burgeoning expenditure and wants quite sensibly to have its cake and eat it - it wants to persuade industry to pay for this by exhortation and not by tax incentives. Industry would like the tax incentives.... and I think it's for this reason that we won't see any sea-change in the situation.'*

However, in the current climate this is something which '*the universities have to do in order to survive, so we may be able to persuade and cajole more out of industry. If we were not so strapped for resources we would do far more*' but the department must seek to balance its budget and attempt to preserve core activities such as teaching and mainstream research. The financial situation in the Computer Science department as a whole is much less satisfactory than that within the research centre, and so older research equipment can be transferred into the department - which is now on an eight year equipment replacement cycle.

#### 9.2.4.2 Nick Cook - Computer Science Department

**Interviewee: Nick Cook**
**Job: Research Administrator**
**Organisation: Newcastle University Dept. of Comp. Sci.**
**Interviewer: Thomas Haigh**
**Date: Friday 17th March 1995**
**Location: Newcastle University**
**Revision: 1**

Nick Cook is involved in the negotiation of research contracts for the Computer Science department and in liaison with the university Research Services office. The Distributed Systems group is one of the Department's two main recipiants of industrial funding (the other being the Centre for Software Reliability which is dealt with in a separate interview) . Roughly 25% of overall departmental external research funding is currently coming from industry, and, interestingly, another 40% or comes from Europe - the proportion from the Research Councils has declined to around 25%. He attributes this partly to a general increase in availablity of funding from other sources and to the increasing difficulties of attracting Research Councils funding as well as to their particular success with Europe and industry.

The three current sponsored research agreements have arisen from long term relationships involving the researchers themselves - particularly via the ESPRIT linked ANSA consortium for companies interested in Distributed Systems research. Long term relationships have been crucial to these contracts, and therefore a importance is attached to activities such as the annual ESPRIT workshops which may allow further links to be established with corporate R&D departments. These involve invited speakers, often from industry, as well as presentations of results.

As the Distributed Systems group's research has progressed it has shown its strength and moved closer to application and so has recently been in a strong position to attract industrial funding. Because of this there has been a good degree of agreement on the technical work involved, though obviously the negotiation of financial and intellectual property aspects tends to be more involved.

When negotiating contracts, ILP and money are '*obviously linked - if the university retains ownership of all the intellectual property then one would expect the amount of funding to vary because they are not buying the results - they're buying the right to exploit the results rather than the actual ownership.*' One contract leaves ownership with the university but exclusive exploitation rights with the company, another involves essentially the reverse. In some senses this is a mutual learning process. A clause will exist to ensure that companies will loose rights which they fail to attempt to exploit. A certain overhead exists in terms of the increased reporting and management.

Consultancy to individuals is often agreed as a part of a contract, though the overall levels involved are not high. Individuals can enter into agreements directly - these are not regulated at the departmental level.

The end results of each project were far from clear when the contracts were agreed and no guarantee exists that exploitable results will be obtained - this is a product not just of the technical progress of the project but also of the changing organisational priorities of the companies involved. The university's direct involvement is with research groups within the company, but obviously eventual exploitation would involved product development groups. '*The nature of research is that you don't know what your results are and you don't know if they're exploitable - but you do know what you're delivering to a company*.' What the university agrees to provide is essentially a certain set of reports and '*a certain level of effor*t.'

This is not necessarily always the case - a contract currently under negotiation would involve the further development and integration of an existing piece of software to form part of a larger commercial system. Further maintenance would be provided as consultancy.

*'The key thing in all these contracts is that you define the results by what you deliver in the report to the company. That's where we have to be careful that we don't deliver results that haven't been genuinely funded by the company, because that becomes the basis for any exclusive licensing or ownership by the company.'*

Have any results been seen yet from the Research Councils' new emphasis on 'wealth creation'? The Distributed Systems group has been successful in winning a ROPA award worth around £50,000 p/a which it was only eligible for as a result of its industrial funding. More generally, given that successful collaborations are so dependent on personal relationships, he sees difficulties in trying to centrally enforce this kind of cooperation. Another problem would be the inappropriateness of any attempt to use public money to conduct applied research specialised to the requirements of a handful of companies. Potential problems obviously exist if industrial funding becomes a more general prerequisite for government money and the focus moves away from basis research all together.

Some areas of research, such as Distributed Systems, tend to be inherently 'labour intensive' and can only be undertaken with the additional manpower provided by research contracts. However even the governmental awards, such as those from the ESPRIT programmes, are now oriented towards industrially fundable projects and therefore the direction of future research is likely to move further from basic areas. Another trend is for such contracts to be awarded only to consortia with previous experience in such projects.

*'Increasingly, as the research selectivity exercises bites and, due to funding pressures, the University's room for manouver is limited, research groups are forced to rely on research contracts - they cannot expect additional money from within the institution.'*

Because of the increased management overheads involved and the distraction away from basis research, industrial funding '*cannot be increased forever - a balance has to be struck*'. The Distributed Systems group is approaching the limit of industrial collaboration it can cope with, and there is a limit to how much the group can grow.

So far a situation has not arisen in which a company has tried to contract the department to undertake development work which has not included sufficient academic content. '*We'd have to look at the resources required... at the moment given financial constraints you'd probably do it anyway but certainly it's a concern.... you'd have to make sure that it wasn't detracting from your other activities'*. The university itself would also be concerned about such work if it were seen to be by public money - so the potential for profit might be a crucial consideration. However, they would still rather engage in a worthwhile research collaboration giving lower financial return than undertake contract development work on more generous terms.

#### 9.2.4.3 Richard Tomlin - Research Services Unit

**Interviewee: Richard Tomlin**
**Job: Head of Research Services Unit**
**Organisation: Newcastle University**
**Interviewer: Thomas Haigh**
**Date: Friday 17th March 1995**
**Location: Newcastle University**
**Revision: 1**

Research Services is an integrated unit which is responsible for *'just about everything that the administration does that touches on research in the university*.' On the highest level this involves a '*very intimate relationship*' with the Research Committee - which sets policy and allocates resources, performs the internal performance review and is responsible for a budget of £750,000 to support 'pump-priming' projects and a £2.5M budget to prepare for the research assessment exercise.

Another area of involvement is the production of the research directory 'REFUND' which lists up to date funding information and to which other institutions can subscribe. The same team provide an in-house consultancy service to those looking for research funding. A further group are responsible for grants and contracts - around 1,100 applications for external research funding are made every year resulting in 700 awards totalling in the region of £40M.

These responsibilities have been gathered together in a single unit since December 1990. Newcastle was one of the first of the large civic universities to adopt this model, which has since become commonplace. Previous administrative organisation was around faculty groupings - this system gradually collapsed as the world of grants and contracts became increasingly more specialised and complicated and policy became more important.

Around £4M of the research total, representing roughly 10%, is from industrial sources. A further 10% is from the EU and so targeted towards projects involving industrial cooperation. Another £3M comes from the UK Government, much of it is from the DTI and is also targeted towards industrially relevant areas. Industrial funding is '*remarkably diverse*' - there are few single huge projects. Much industrial interaction does not involve direct research funding and is handled at the departmental level - for example the Engineering Design Centre offers training to local companies and the Design Unit in Mechanical Engineering handles about £2M of consultancy projects each year.

The Unit's involvement in a particular agreement typically begins when a contract is in the process of being negotiated.

> *'There's almost a triage in these things - there are those academics who know how to do it, because they've done it before. They do it well and basically they come across to us with three quarters formed projects and deals, which are essentially fine. At the other end of the spectrum there are people who turn up with something so comprehensively awful and done at the last minute that there's not really anything we can do with it... and then there's the group in the middle... of people who come fairly early on in the conception of a relationship with a company and come to talk about customer pricing and what kind of an agreement would the university look for.... That's grown substantially in the last few years, largely on the back of work which we've done with people's EC projects.'*

Because the EU funding process is so complicated and unknown to most academics, they realised the need to seek help from experts and did not feel that they were 'losing face'. As a result they have become more aware of the services offered by the administration and are now far more likely to talk about other kinds of applications. The Unit's approach is to focus on the project and look for all possible sources of support.

A certain amount of centralised promotion is attempted by the university, in terms of presentations at exhibitions and so on and a comprehensive research directory is produced. Some industrial enquiries are fielded by the Unit, but the vast majority of contacts are made directly by the academics concerned. They have also been able to provide support to academics seeking consortia partners for the various EU grant programmes, particularly in other European countries - for example by providing contributions towards the cost of travel.

Many of the agreements processed by the Unit include grants of equipment instead of or as well as cash. There are also DTI Club and Link projects where contributions can take the form of man-years of skilled effort. Financial payments have risen as a proportion of the total, aided by the trend towards ‘outsourcing’ of activities by larger companies in recent years. ‘*It’s generating more cash for us, that’s for sure. Not for everybody*.’

A technology transfer company, NuVentures, exists, with which the Unit works closely. Rights over possible resultant technologies must be considered when research agreements are being negotiated, and so this company has a ‘*legitimate and necessary involvement, on occasion, in negotiating the intellectual property conditions in particular*.’ Likewise, a new research project is likely to be building on background intellectual property of previous projects, the licensing of which is undertaken jointly with NuVentures. Whilst any published patent may legally be used as the basis of research, it will be impossible to gain sponsorship for a project if there is no prospect of exploiting the results - which will require some kinds of rights to the original work. These must be safeguarded when licences are being agreed - this might be achieved by the university retaining ownership but could also be achieved in a number of other ways.

What rights over the results would a sponsored research contract typically grant a company? The minimum provision would usually be a right to negotiate and an assurance of ‘fair and reasonable’ terms. They would be reluctant to assign a value to the results before the conclusion of the research, although companies sometimes attempt to insist on capping the maximum level of royalties payable. Compromise is necessary on a case by case basis during the negotiation process. As mentioned above, the rights to publish and to use as the basis of future research will not be surrendered - ‘*providing we can arrive at that we are happy to enter into almost any arrangement that makes both parties feel comfortable.’* It is important to make sure that the contracts reflect the fact that the results are unknown and may not be in the form expected - no guarantees can be made as to the nature or usefulness of the results themselves.

The proportion of the overall cost of the project which must be met by the sponsor depends on the closeness of the work to the kind of basis research which the faculty would be carrying out without sponsorship. Work which represents a diversion from academic priorities would carry a premium. The advantage of a university over specialised research contractors comes principally from its ability to share costs, and so to leverage industrial money.

The new ROPA awards from the Research Councils represent an attempt to apply ‘*quite small sums of money, at the right time and the right place’* to act as a catalyst in altering internal priorities. Most of the departments at Newcastle already have some tradition of industrial partnerships and are therefore quite well placed to benefit, with only a minor change of emphasis required.

Does he feel that the amount of money which companies are prepared to spend is likely to rise in the future? His impression is that

> *‘companies are becoming much more discriminating, and a little more demanding, and that’s no bad thing. Many companies have scaled down their in-house R&D, and that’s a bit of a worry because I don’t really want the university to be doing research which is of such central commercial importance to a company that if it goes wrong or it gets leaked at a critical moment then some major calamity is going to befall the company. Companies need to think carefully about why they are commissioning research within a university.*
>
> *The emphasis here always comes back to the collaborative project and to try and get a clear dialogue between our academics and the sponsors in which both sides recognise that the other side is contributing and has it’s own goals in the project, and that the art of a good project is so to align those goals that there is a viable project - not to substitute one for the other.’*

During the recession the overall amount of money available from companies was fairly ‘*flat’*, but did not fall significantly. However its spread is becoming much more concentrated. The philanthropic element is minimal outside occasional gestures such as sponsored chairs. Research contracts are entirely separate.

Is an increasing reliance on industrial funding changing the nature of research undertaken or the culture of researchers?

> *'I personally don't think that there's been any huge change  Perhaps there's been a slight shift of emphasis, but good researchers still want to do what they see as good research - though perhaps they are showing a little more flexibility in how they adapt and how they present things.'*

For example, many senior academics are willing to take advice on the new styles of grant proposals now required by funding bodies. He does not feel that there is an optimal proportion of industrial funding, beyond which academic priorities and basic research must inevitably be disrupted. '*It depends entirely on the requirements that industry is attaching to that funding*.' Arrangements such as the CASE awards have no adverse consequences, proving that the source of the money need not in itself disrupt academic culture.

## 9.2.5 RANK XEROX

### 9.2.5.1 Bob Anderon - Director, Rank Xerox Research Centre

**Interviewee: Bob Anderson**
**Job: Director, RXRC Cambridge Laboratory**
**Organisation: Ranx Xerox Research Centre**
**Interviewer: Thomas Haigh**
**Date: Friday, 24th March 1995**
**Location: Manchester Business School**
**Revision: 0 (No feedback obtained from interviewees)**

The RXRC Cambridge lab, established in 1987, is now a part of Xerox's European Research Centre, one of four world-wide of which the most famous is PARC in California. The European Centre also includes a lab in Grenobles. The different centres world-wide concentrate in different areas - the European Centre is concerned with document services and '*next generation but two*' techniques. As well as research groups, the lab also houses part of the Business Development Group '*whose job it is to take technologies from the start to the market.... or to help commercialise them within the company*'.

The mission of the lab is unusual in that it is structured around a set of problems, centring on exploration the work of individuals and organisations with documents and looking at ways in which technology can support this work. Thus the lab employs teams with diverse backgrounds - such as psychologists, cognitive scientists and sociologists. They came to realise that the issue in human-computer interaction was '*systems integration, not in terms of hardware and software but business systems, work practice systems and technical systems*'.

An incentive for Xerox to place a major research facility in Europe came from the expectations held in previous decades that moves towards a monolithic European trading block, particularly the establishment of the single market and the foundation of the EU, would lead to increased trade barriers to foreign firms. To be regarded as European a company must manufacture in Europe, export goods from Europe and perform sufficient R&D within the EU - an the establishment of the European Research Centre allows Xerox to fulfil the latter requirement.

What does Xerox expect the lab to produce?

> *'Envisionments, prototype technologies, design specifications and intelligence. What corporate research does for Xerox is to manage risk, it reduces uncertainty. All these things are outputs by which we reduce uncertainty for Xerox.... We do lots of other things for Xerox that it doesn't really often recognise it gets - we give it high visibility, we penetrate communities... we provide a certain credibility for some of its longer term envisionments and provide a "feel good factor"....'*

These less obvious contributions can be very important. For example, to retain and motivate able and ambitious staff it is essential for a corporation to present a credible future strategy for continued growth and the potential for "exciting" careers. '*Corporate research provides a part of that internal credibility, and I think that's something which is often forgotten*.' Equally important is the appeal to customers of knowing that their investment in the relationship is protected by corporate commitment to technological improvement.

Roughly 40% of current research is intended for publication. Does this open distribution of results compromise the advantage Xerox accrues from having conducted the research?

> *'Look at publication as a management tool... you need external validation, and all research organisations need that, to make sure that the work which is going on is world class. The fact of publication is a good way assessing your credibility, also it's a good way of "moving the barrier", and as a manager you can insist on certain kinds of publication.... It's also important motivationally that the people feel that they are in a community, and that community is of course providing feedback and the flow of information and knowledge in is often much greater than the flow of information out.'*

Designs can be patented before publication to ensure their protection. If a researcher's project as a whole is not publishable then components can be identified which are suitable to be placed in the public domain - this is done between the scientist concerned and their managers.

Does the lab sponsor research within universities? Yes, but not '*contracted research - I don't do that because I don't believe in management at a distance... it's hard enough to get software delivered on time and to specification when you've got control*.' Sponsored research primarily takes the form of CASE agreements, student sponsorships and internships.

It is important to make sure that a genuine coincidence exists between the academic interests of the researcher and the commercial interests of the company. '*...the important thing is not to force it. The great mistake that I've made, other people have made, is to say "This is a great person, we must get him to do research for us.*"' Without identification of a genuine area of mutual interest the result is either an unhappy and unmotivated researcher or work which the sponsor views as a waste of money.

> *'I have found that some academics are much better than others at doing it, and you learn which ones will be able to serve you the best, and those are the ones which you build a relationship with.'*

Does the interdisciplinary nature of the lab affect the people it attracts and the work which is carried out there? '*The kind of people that we tend to attract are people who have a wide ranging curiosity.*' As far a results go, this is reflected in the pushing of boundaries in the research itself.

How would Xerox go about evaluating the cost effectiveness of the lab's work? One of the main answers is simply '*the gut feel of me and my managers*' - this is based on a number of signs such as '*engagement with business divisions, engagement with Xerox's vision of itself, closeness to something approximating compartment transition.*' (?) This intuitive sense of confidence is increasingly 'buttressed' by factors such as '*return on intellectual property, return on investment in research*' and so on - these calculations are '*very interesting*' but will not replace the judgement of managers.

Whilst it is important for the results of research to be shown to be useful, it is just as important for decisions to be made openly and to be seen as well grounded.

> *'If nothing I did in the lab ever ended up in the marketplace then people would start to ask questions, but if 90% of what I do never ended up in the market place that wouldn't necessarily be a disaster - as long as it was clear that we made the decisions and what the basis of those decisions was.'*

Xerox has a complex research and development structure, and other parts of the company are responsible for the commercialisation of research. For example, a specialised 'scale up' facility in Toronto looks at the transfer of processes to commercial scales. The Business Development Group within RXRC, which performs some technology transfer functions, primarily looks for external partners to share in technologies, for example to allow their application to new areas or to provide the expertise needed to bring a new technology to the marketplace.

> *'If any organisation tells you that they've got a smooth flow from research into development then they're lying to you. It's a political process... it's about negotiation, it's about getting win-win situations, making investments.... Taking a technology, no matter how revolutionary it is, and getting a development group that's made a amount huge investment in personnel and skill to accept it, if that technology actually undermines what they've invested in, is extremely difficult.... '.*

Has the nature of research at Xerox been altered by the transformation of corporations into increasingly autonomous divisions? There are now nine divisions, with complex management and contracting mechanisms connecting them. However, research and development is still a corporate entity in itself. This arrangement is not as radical as that adopted by some companies, for example divisions do not currently have to undercut external bids in order to win contracts from each other. As far as research goes, these changes have '*forced a closer alignment... in both* *dimensions. Researchers have become more concerned with knowing how business is going, but the business themselves now realise that they are dependent on research, and since they are paying for it... they ask questions like "How can I make sure that the investments I am making are the right investments for me to make."*" Overall R&D spending has not diminished as a result of the changes, and although research itself now probably represents a lower proportion of overall spending than it once did he does not see this as a direct result of the contracting process.

He sees changes in the nature of metaphors used to discuss the nature of the research process as significant.

> *'We used to talk about pipelines... we don't talk about pipelines anymore, transactions are one thing that we think about - the ways in which we are exchanging between groups.... It's no longer viewed in this linear way where we "see what's coming down the line" or try to "speed up the flow"'.*

Could any aspect of Xerox's relationship with universities be characterised as philanthropic? '*Even a philanthropist does things for a reason*' but there are some activities which have little relation to immediate business needs - these tend to be oriented directly towards the Cambridge community, such as their donations to the university labs which are expected to produce little more than minimal goodwill.

> *'I have two concerns, one has to do with research funding for universities. Research funding goes to the research centre - it's too unfocused, and as a consequence very little useful knowledge is generated - knowledge which I can use.... In the longer term I get less and less interested in getting involved with the SERC and doing validations and that kind of stuff, because I really don't think that system is working very well.... A very good example of it for me is the Cognitive Science Initiative.... it looked to me that they tried to cut the cake so many ways that nothing came out of it.*
>
> *The second worry I have is that universities are looking at themselves increasingly as businesses. Trouble is that they don't know how to play the business game, and I have some very difficult relationships with universities simply because they haven't learned the difference between collaboration and competition.... If a university will insist on owning patents totally for collaborative projects then it will not get collaborative projects, and I'm worried about the way that commercialness has been forced into the university setting.... I can see their fear, they've been told that they have to generate funding and revenue and they may think that we're going to shaft them, but that aggressive defensive response does not help anyone.'*

### 9.2.6 THE TURING INSTITUTE

**Interviewee: Peter Moforth**
**Job:?**
**Organisation: The Turing Institute**
**Interviewer: Thomas Haigh**
**Date: Wednesday 19th April**
**Location: The Turing Institute**
**Revision: 0 (No feedback obtained from interviewees)**

The Turing Institute is named after the great English mathematician and pioneer of computing theory Alan Turing. Turing is well known for his war time work in Bletchley Park, and for his time at the universities of Cambridge, Princeton and Manchester. The link with Scotland comes via Donald Mickey, a colleague of Turing's who became interested in Finite State Automata and was instrumental in the establishment of the pioneering department of Artificial Intelligence at the University of Edinburgh in 1963. Following the Lighthill report in 1973 and the effective removal of government support for AI in Britain, work in the area subsided until the early 1980s and the revival of interest in the subject brought about by the Japanese 5th Generation project. The resultant infusion of money to the field, governmental and industrial, led Mickey to move from his small Machine Intelligence Unit at the University of Edinburgh to a new body called the Turing Institute which was intended to '*sit part way between industry and academe*', formed in 1983 as a limited company. Glasgow's status as a development zone made it an attractive location for the new Institute, and close links were formed with the nearby University of Strathclyde. The Institute grew to employ around fifty people by the late 80s.

Scottish Enterprise, who were responsible for the influx of electronics manufacturing to Scotland and were keen to encourage the software industry, stepped in to rescue the company after it ran into acute financial difficulties. The influx of cash was accompanied by '*professional managers, who knew a lot about business and marketing, but they didn't know anything at all about computer software and our business.*' Two years, and a great deal of money later, the company floundered in this commercial incarnation.

It was saved by the intervention of Glasgow University, and returned to its core business and original non-profit status - funded by the Glasgow Development Agency and the University. It is intended to cover its costs without further subsidy, and derives roughly half of its income from contract industrial R&D, the remainder coming from 'soft' sources such as ESPRIT and LINK. Since its reformation in July 1993 targets have so far been met and an upturn in business has taken place. The University has made it clear that more money will not be forthcoming and that their loan will eventually have to be repaid.

> *'At the moment about 60% of our turnover is commercial, where we deal with companies, and the reason why we are in a position to win business quite successfully is that one of the things that the University does is to very significantly lower our costs as a commercial company.'*

These advantages include cheap accommodation, low cost network access and IT infrastructure and access to graduate students. '*We're a small company - at the moment we only have seven members of staff, although there's quite a number of PhD students.*' Their links with the university give them advantages comparable to those enjoyed by members of a huge corporate research lab, such as access to experts in a vast number of fields, but with none of the huge cost overheads which such organisations entail for their parent companies.

> *'Depending on where you're coming from you can see the organisation in different ways. One way of reading the articles and memoranda is that we are a part of the University, and that is very important because it means that success that we have in winning R&D moneys, in publishing papers and running PhD students are counted within the University's success, and as such they get a better score in comparative studies with other universities... and they get a larger block grant. That's the main benefit that they see out of it.*
>
> *As far as we're concerned we have this access to cheap labour and cheap infrastructure, it's symbiotic - quite mutual. However, when we talk to commercial companies it is very important to stress that we are an independent, commercial company and we tend not to stress the university involvement. I'm not talking confidentially here, because a lot of other organisations do this, but when we talk to suppliers about getting equipment and they say "Are you part of the University?" we say "Oh yes, we're part of the University", because you get your academic discount. There are other sums of public money which you can only get access to if you're a commercial company - universities don't have access to that, we do. Basically you're dealing with an organisation which has a big hat rack: some commercial and some academic. Every new situation that comes along you adjust your presentation to optimise the amount of resources that you get. It's very simple.'*

The work of the Institute has machine learning and knowledge based systems as one of its main foci. Their approach is firmly symbolic, involving the automatic generation of humanly transparent production rules from data. For business use this technology has the distinct advantage over sub-symbolic approaches like neural nets that the operation of the system can easily be understood, debugged and validated - important for mission critical applications and for compliance with various international standards. Their other main area of activity is 3D image processing - in the last year they have serviced four separate contracts involving the synthesis of a 3D surface image from photographs. This technology has a wide range of applications - from the production of 3D models of the earth to the representation of human heads for medical work, and such has been the interest in this area that they are currently working to 'productise' the system.

This is a shift away from their mission as a contractor of R&D.

> *'It's an interesting question - how often do you do repeat business before contract R&D become a product. If you do the same bit of contract R&D twenty times then it begins to look very much like a product. One way to migrate a technology from contract R&D to being a commercial product, which is a completely different business with almost nothing in common, is to do the same thing over and over again. I say that because the contract R&D business has a culture and a community of people in it whose interests are in "pushing the envelope", they have academic and scientific interests to "boldly go" - whereas in a products company everything's about the bottom line, and it's basically 99% marketing and sales and 1% yesterday's technology. It's likely that our organisation may split in the coming years, because of the cultural problems of keeping the products side in parallel with contract R&D.'*

In his view it is inevitable that universities will eventually '*have to bite the bullet*' and consider the setting up of spin off organisations to provide support and maintenance on any products which they wish to commercialise.

He sees the move by larger companies towards 'rightsizing' and increased reliance on external contractors as working to the advantage of service organisations, including research service organisations such as the Turing Institute. '*It's definitely flowing with the direction of what's happening in the marketplace - people outsource and you go in there and get business which otherwise would have been handled within the company.... People have come to recognise that the most successful companies are small, but make up for having a small size by having a big network.... The social side is as important as actually writing code*'.

Does he see technology exploitation in the software field as similar to established methods in other fields, such as biotechnology or pharmaceuticals? He holds the film industry up as an perhaps the closest relative - like software it is project based and has technical and non-technical components. Studios are loosely organised, large numbers of small and highly specialised companies handle work on a contract basis and many participants are self employed. Distribution is a separate process and can be handled via a variety of channels. '*We're probably where Hollywood was in the 1920s - still at the silent movie stage. Perhaps in the 30s*.'

Have traditional ideas of basic research, applied research and product development no place in the software field? The film industry model suggests that the strict framework of conventional science, funding bodies, laboratories, hypothesis and so on with research papers as the primary output is restrictive. '*You don't do software for its own* *sake, software is always targeted to somebody else's problem. That always takes you into other disciplines*'. Within the Turing Institute itself some have artistic backgrounds, others were trained in mathematics, physics or computer programming.

> *'The traditional departments which make up universities, the Department of Physics, the Department of Chemistry, these things are starting to break down anyway - and what you're replacing it with is just a big soup of people.... You work in one subject and you end up contributing to another subject - and all the time, when dealing with people in the university doing mechanical engineering and genetics and geology, all the projects that people are getting involved with are all interdisciplinary, multi-disciplinary.... I think that because computers and computer software are so esoteric that they tend to permeate almost everything so that to an extent people in the area of computer software tend to be leading this cultural change.... replacing the conventional barriers within universities with a heterogeneous series of barriers, all of which are project based.'*

For example, a robotics initiative within the university also involves the departments of zoology, aerospace engineering and mechanical engineering. These kinds of temporary groups of interested participants, raising money and working together for a particular purpose, again remind him of the film industry. This kind of organisation is far more suitable for the addressing of complex, real-world problems - '*I can't think of any problem we've come across in the last five years where you can go to a single department and have all the expertise you need.*'

How important does he feel local contacts are? Despite the potential of modern communication technologies, '*none of these are a substitute for people getting together, scribbling on the back of beer mats and that kind of thing.*' Similarly, although bands can now record together without entering the studio at the same time, the creative quality of the music suffers. '*I think geography is very important - location and image*'. The Turing Institute is just a five minute walk from the campus - distinct enough preserve a separate identity, but close enough for regular social interaction and university members to drop by for coffee. In future the role of a computer lab may become primarily social, with development work best undertaken in more private conditions on a laptop or at home. However, so far no particular benefits have accrued from the relative concentration of computer companies in 'Silicon Glen' - '*my personal view is that we are yet to achieve the critical mass*' achieved in California where high staff mobility and strong personal contacts ensure rapid transfer of ideas and expertise.

> *'All the time... I keep going back to social things, cultural things and presentational things. I think that those are some of the most important issues to get right if you're going to treat software as a business successfully and make money from it.'*

The Institute has been involved in projects as part of ESPRIT I. II and III. How did he regard the experience?

> *'I regard it as a total a waste of time. We were in there right at the start, and we've been involved in a dozen different ESPRIT projects in one way or another, and I can't think of a single useful bit of technology we generated, or a case where we did something that led to any kind of genuine commercial business or a technology produced as an ESPRIT result actually went out and was commercially successful for Europe. The only beneficiaries I have actually witnessed are the international airlines and the hotels. I'm extremely cynical....'*

The projects involved work with organisations of all kinds, including large and small companies and universities. '*I suppose we have made some interesting links, but I honestly there's any business has come from them*.' However, a further ESPRIT proposal is currently under preparation. Preferred projects are those 'in the corners' of a diagram which are not reliant on the inputs of other groups.

> *'It really has to be a piece of code that you've already written, or failing that - which would be annoying - something that you had to do anyway.... You've also got to make sure that there's a member in Greece or Portugal to hold your summer management meetings and someone near Grenoble for your winter meetings - quality of life. Given the amount of money that's gone into ESPRIT it would have been far better used if people had made these projects much smaller, with a much much lower bureaucratic overhead.'*

What is the Turing Institute really in existence to accomplish?

*First and foremost, operating as a hard-nosed commercial company, to make money. If you've got money you can do anything - make a nice pleasant environment for yourself to work with, buy lots of machines, pick and choose on some things, it's definitely a way of solving a lot of problems.... The second element of the mission statement is "to boldly go" - everybody inside the Turing Institute has got a reasonable CV. I've got about 80 research papers to my name, and although I've talked about the commercial side you always like to carry little grains onto the beach of scientific knowledge... doing a bit of that is pleasant. The University can build that into their metrics of success, so there's no conflict there. The third element, which is implicit in almost every organisation, is doing things so that you can hopefully have a bit of fun... the Turing Institute organised the first Robot Olympics in 1990 - that was a real boost, put us on the map and it was a lot of fun.*

How does he react to the suggestion that universities are public institutions which should not be heavily involved in ownership or support of commercial companies competing in the marketplace?

*I think that is nonsense. If the suggestion here is that private companies are not receiving soft money from the government then that's baloney - just look at Nissan, how many millions did they get? You look at all the grants and so on which are available to commercial companies - we've set ourselves up sitting on this fence to try and kind of milk from both sides, and if you've set it up right and have a clear view of your goals and objectives and are prepared to do accounts and all that then you get your VAT back - that's 17.5% on the bottom line we're talking about, and there's all kinds of things you can do as a company which connect you to soft money which universities don't have access to.... Universities should be free to compete, the only thing is they need to be a little bit more professional about it, and a lot of that just comes down to people being honest with themselves, I think, about what they have to do.*

*I think universities do need to undergo some restructuring in thought, in as much as part of what a university is there for is to be a centre of broad based expertise in research and development... a conglomeration of people with in depth, specialist knowledge in certain areas. A university should also be a place where large numbers of people come to get taught, and I think that those are the two vision statements of universities, and that duality should be reflected far more in the physical structure of universities.... This obvious and natural dichotomy of what the goals of a university are will separate out into the R&D thing, in which people need to be sufficiently professional that they can compete on equal terms with commercial companies, and the teaching side - with whatever metrics and so on are appropriate there....*

Whilst the two tasks should remain in the same institution, there is a case for differentiating between teaching and research staff, especially since prestige and promotion tends to accrue only as a result of research and publications under the current system - which is unfair to staff whose interests tend towards teaching. '*I think that's something which universities need to come to terms with, and they have barely started that process.*'

*'If you look at many computing science department they run like businesses - take away the teaching side, what you've got left is at the level of a commercial business. They've got millions of pounds worth of turnover, they've got contracts, they've got deliverables, I think one of the major reasons why universities do find it hard to compete is that they are managed by people who have so little experience of those things. Typically you find the senior manager is an academic with a great CV who is suddenly promoted to be the departmental Prof. and are expected to play the role of a company CEO, and I don't think that they're cut out for that. There are some departments which are headed by people who do have the skills of a company Chief Executive, they are few and far between, but boy do they make their departments go super nova... they can get incredible leverage over the departments which aren't as good as they are.... Sometimes departments bring in people called Business Managers, but when you look at how this is done, particularly in British Universities, they do what the Prof tells them.... On the business side of things, and let's be blunt it typically is a business - look at all the contracts you get - they should be run by someone with formal business training. Most Profs don't even know how to read accounts... and I think universities lose out by not having a management structure that reflects what they're trying to do.'*

He doesn't see any conflict between a more 'commercial' approach oriented to fund raising and the continuence of a strong tradition of basic research. Rather increased activity will create a surplus which can be chanelled to knowledge creation.

*'Look at MIT, it's very comercially managed, yet you've got lots of people in there doing totally hare-brained things. The important thing is to get away from all these horrible old monastic traditions which I think have held academia back.'*

*'All of these ideas are only relevent at this time now - I'm sure that if we'd been having this conversation in the late 1980s I would have said different things, and all the people you've talked to would have said different things, and in five years time they'll be saying different things again. I've used the example of the football team - because these are the rules which apply now we're all developing these finely tuned strategies to optimise our play. At the moment it's football, maybe by the turn of the century it'll be hockey and we'll all be playing a different game.'*