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The Foundation For Science And Technology

Buckingham Court,
78 Buckingham Gate
London SWIE 6PE

Tel. 0207-222 1222
Fax. 0207-222 1225
Internet site: www.foundation.org.uk

Director:
D.N. HALL, OBE, FCIS

Editor:
D. EDDOWES, BSc

Editorial Advisory Committee:
Dr Richard J. HAAS, CBE LLD Hon ScD
Professor Chris ELLIOTT MA,PhD, CEng, MISE, FRAeS

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ROUTES OF EXCELLENCE IN HE

The Foundation held a lecture and dinner discussion on 14 December 1999 on "Routes of Excellence in HE – RAE and the Future" at the Royal Society. The Rt Hon The Lord Jenkin of Roding was in the chair and the evening was sponsored by Glaxo Wellcome plc. The speakers were Professor John Sizer CBE, Chief Executive, Scottish Higher Education Funding Council, Dr Alan Rudge CBE FREng FRS, Chairman, EPSRC 1994-1999, and The Lord Oxburgh KBE FRS, Rector, Imperial College of Science, Technology and Medicine.

Professor John Sizer CBE*

Summary: Professor Sizer outlined current funding schemes in Scotland and examined the development in that country of a knowledge-based economy which was fundamental to achieving economic growth. SHEFC had recognised the adverse possibilities that could arise from RAE-based grants and had introduced a second main funding scheme – the Research Development Grant. Dr Rudge discussed the dual support system and the weaknesses of the RAE. He urged we worked towards evaluation processes that could provide a genuine measure of the contributions made by research in the universities. Further, that we thought through the funding processes logically and did not become entrapped in even more elaborate correctives to sustain a rather tired system.

Introduction

When the Scottish Higher Education Funding Council (SHEFC) was established in 1992 with a remit to fund the provision of education and the undertaking of research in higher education institutions (HEIs) in Scotland, it brought together funding for institutions in Scotland which were previously funded by the Universities Funding Council (UFC) and the Scottish Office Education Department (SOED). The Council's main method of funding research, introduced in 1993-94, responded to an expanded higher education system and, for the first time, addressed particular Scottish needs. The research funding methods were designed to support an infrastructure for a balanced portfolio of high quality research right across the spectrum, in support of a wide range of purposes.

The Council has used four main funding streams to support research in Scotland: RAE-Based Grant, Research Development Grant (RDG), Initiative Funding and UK-Activity funding. Although there have been some changes to the four funding streams, the broad funding methods have remained relatively stable. The most significant development was the introduction of the Research Development Grant in 1997-98, in response to the Foresight Programme. The main funding stream for research, the RAE-Based Grant, has been subject to one minor change in its method since the Council's inception. SHEFC Initiative Funding encompasses a variety of schemes such as the Contract Research Staff Initiative, and the Promotion of Commercialisation of Research Grant. The fourth stream supports participation in initiatives such as the Joint Research Equipment Initiative and the Arts and Humanities Research Board.

SHEFC now funds 18 HEIs in Scotland and in this academic year will allocate 21% of funds (£110M) in support of:

- the people and infrastructure in existing areas of research;
- the development of new or emerging areas of research activity;
- the dissemination of the outcomes of research and the promotion of their commercialisation;
- the promotion of improvements in the management of research and the spread of good practice across the sector in Scotland; and
- participation in UK-wide initiatives that are judged to be of importance to the research base in Scotland.

Our methods have proved flexible enough to allow SHEFC to respond to changing priorities over time, and evidence suggests that they have contributed to improvements in the volume and quality of research. SHEFC policies have also brought about improvements in the management and organisation of research across the sector in Scotland. Arguably, the Council's policies have also worked at a much broader level by contributing to collaborative ventures between HEIs, and to strategic change in the sector.

* *Chief Executive, Scottish Higher Education Funding Council*

Overall, the Council's funding methods for research have served their original purposes well. However, the research landscape has changed. A number of new issues, indeed, a new ethos, has emerged.

The current research environment

The White Paper *Realising our Potential*[1] endorsed the role of government in funding UK research and, more recently, the White Paper *Our Competitive Future: Building the Knowledge-Driven Economy*[2] reaffirmed this commitment. In Scotland, the report of the Knowledge Economy Task Force[3] argued that Scotland could not compete in the modern, increasingly global, marketplace on the basis of a low-cost, low-skills workforce, and stressed that:

"*Scottish higher education institutions and research institutes are at the core of the government's strategy to modernise the Scottish economy by creating a knowledge-driven economy*." (p. 5.)

There is now a high profile impetus and interest in the application and outcomes of research for the benefit of society. The establishment of the Scottish Parliament and continuing increases in the volume and quality of research undertaken by HEIs in Scotland, make this the right time to look ahead to at least the next ten years of research funding, to discuss the implications of different funding models and ask some fundamental questions – "what is excellent research – how should we measure excellence – and how can it best be used to benefit society?"

The research environment – a Scottish perspective

The development of a knowledge-based economy is now viewed as fundamental to achieving economic growth. Global trends have tremendous impacts for economies, cultures and individuals. In the context of widespread, rapid technological change and the speedy availability of information, success depends on new knowledge, sophisticated and dynamic innovations; and intelligence about markets, ideas and products. The exchange of services and information is the basis for both global alliances and the intensely competitive environment in which Scotland has to be able to com-

pete. It is therefore crucial that our research, funding policies and practices are effective and relevant.

The Council's funding has always supported the structures and the people who carry out research without seeking to constrain their creativity, while implicitly requiring that excellence and efficiency be maintained. Scotland has many concrete examples of research expertise, talent and excellence. However, we are not always successful in exploiting these attributes, or in sharing best practice or expertise and developing new, fruitful alliances. Yet I would suggest this is the key to prosperity, to enhanced creativity and fulfilment of individual and community potential.

SCOTTISH CONTEXT, SCOTTISH PRIORITIES

The government has identified lifelong learning as crucial to modernising the economy and providing individuals with opportunities to enhance their lives. In its favour, Scotland already has one of the highest proportions of graduates per head of population in Europe, we have a higher than UK average educational qualification level, and 3.4% of jobs are in high-tech industries compared to 2.9% in the UK overall. However, industrial R&D expenditure is lower and Scottish GDP is slightly below average so there is room for improvement. For Scotland, the high incidence of poverty and disadvantage is a prime concern, and the Scottish Executive is rightly committed to tackling social exclusion. Education and research have a central role to play in building the knowledge, skills and creativity that will create and sustain a vibrant, inclusive economy. The Scottish Knowledge Economy Taskforce, chaired by Lord Macdonald, signalled too the central importance of improving the research infrastructure, particularly in an environment where most countries are attempting to exploit their knowledge and research bases.

The Council is therefore increasingly taking a holistic approach to ensuring that our policies and funding methods complement the broader framework in Scotland and across the UK. SHEFC's mission statement is to support the maintenance and further development of Scotland's world-class higher education system and to help institutions to increase and communicate knowledge and skills that will enrich society, allow individuals to realise their potential, and make a major contribution to the country's prosperity. SHEFC's role therefore is not just to fund the research infrastructure but to encourage research activity to be relevant to Scottish needs, while maintaining strong UK networks, sharing knowledge across research disciplines, and avoiding unhealthy parochialism at all costs.

In support of these goals, the small scale of Scotland is advantageous in that it facilitates collaboration and strategic development. Devolution offers opportunities to develop tailored strategies to support distinctive Scottish priorities, whilst maintaining Scottish commitment within the overall UK research environment. The Council will, for example, be seeking closer co-ordination with the Scottish Executive, also a major funder of research. At UK level we will continue to co-ordinate with the Research Councils through the operation of the Dual Support System, and we collectively discuss, and take action on, research issues with the Funding Councils to ensure relevance across the UK.

The establishment of the Enterprise and Lifelong Learning Department of the Scottish Executive has reinforced the public perception of the role of higher education in economic and social prosperity; and, I am pleased to say, demonstrates a timely recognition of the importance of high quality research across a whole range of interests.

The knowledge economy

Further and higher education institutions are at the heart of the knowledge economy and of learning countries. By "learning country", I mean one which has a lifelong learning culture, and recognises the added value that research and innovation contribute to society's development. A learning country is not static, but constantly recognises that its existing strengths can always be further developed, and that new potentials and areas of inquiry are always arising. The learning country is resourceful, uses its intelligence strategically and determines where it is going through inquiry and innovation. I believe there are prime opportunities for Scotland to further develop in this way.

Scotland is small, but has the potential to become much more than the sum of its parts. The developing knowledge economy is particularly important for Scotland, given our distinctive research strengths in science, technology and engineering, and our rich social capital. In the past, we have tended to rely on single industries and inward investment. We are now looking towards new industries and skills that will enable Scotland to compete successfully in the global knowledge economy. The Knowledge Economy Taskforce identified skills integration and commercialisation of key research strengths as overwhelming priorities for Scotland's development as an innovative knowledge economy. Our vision is of a Scotland that as a matter of course continually develops its potential, refines new products and processes and, crucially, exploits research strengths. If we can develop a "learning culture" that is embedded in all of our activities, Scotland will move further towards becoming a high added value, skilled labour, high disposable income, entrepreneurial, innovative economy.

Strategic joint working and collaboration

It is important to recognise that research meets a variety of needs, including social and cultural, and that research undertaken in one area may have unexpected, and potentially significant, consequences in another area, even when they involve subjects that appear to have little relationship to each other. For example,

▲ *Professor John Sizer makes a powerful point to Sir Walter Bodmer.*

research in linguistics is central to the development of intelligent automated information services using speech technology and natural language processing[4], technologies central to new developments in the telecommunications, education and entertainment sectors that support the knowledge-based society.

The Council's view therefore is that its policies and methods of funding should recognise the complex, multi-dimensional nature of the research process and the unpredictable benefits that can be derived from maintaining a broad-based, flexible research capacity. The HE sector and SHEFC have a pivotal role in ensuring that new knowledge and new techniques are exploited for the benefit of Scotland. Minimising barriers to a strong research base through collaboration and strategic thinking will directly contribute to Scotland's prosperity and quality of life.

Collaboration with potential partners is of prime importance at all stages in the research process, not just at the end product phase. For example, the Scottish Universities Research Policy Consortium enables HEIs to collaborate and formulate generic policy for research management. Initiatives such as this help us share good practice, and therefore to promote excellence, develop a higher international profile and a cohesive research strategy. SHEFC also works with bodies like Scottish Enterprise to promote collaborative efforts in commercialisation and to increase competitive capacity in established and emerging fields such as electronics, energy and biotechnology.

Good links with partners are especially critical to developing an integrated infrastructure at UK level. SHEFC has excellent working relationships with the Research Councils, SEBCC, the OST and economic development agencies; and ensures Scottish participation in UK-wide schemes such as JREI, JIF and AHRB, as well as government initiatives such as the University Challenge Fund and Science Enterprise Challenge. Other joint and local strategic initiatives and multi-disciplinary input enhances our capacity to innovate, to keep thinking strategically and laterally. The SHEFC/RSE Science and Technology joint seminars are invaluable, as are the Scottish Foresight Forum and the Scottish Universities Policy Research and Advice network, funded by SHEFC. I am glad to say it is now widely accepted that we have to move from Competition with Scotland to Collaboration for Scotland.

Foresight and innovation

SHEFC has recognised that some criticisms of RAE-based grant have some merit – that it may overly promote competition between institutions and preserve established disciplines. It is sometimes claimed that the use of RAE in the main funding stream places too much emphasis on the publication of research and acts as a disincentive to innovation or collaborative projects. SHEFC has therefore sought to mitigate these possibilities through its second main funding stream, the Research Development Grant (RDG). Nearly 8% of the Council's total funding for research (£44M this year) is allocated through the RDG scheme. The main objective of this scheme is to help develop identified research gaps, encourage new areas of investigation, new ways of organising research and inter-disciplinary crossover.

The scheme encourages proposals that develop emerging areas of research, particularly in areas that will meet Scotland's long-term needs. Grants are allocated competitively on the basis of submissions from institutions, which are assessed by an expert panel. Importantly, the Council places no artificial limits on type of expenditure, allowing ambitious, visionary, sometimes unconventional ideas to be explored that would not otherwise be funded through other routes.

Through Council funding, Scottish academies are therefore encouraged to think broadly about their future research agendas. RDG helps to take forward proposals with identified niche market opportunities within the Scottish, UK or global context. This indeed is Foresight in action, and we have funded such diverse projects as the use of chaos theory to analyse financial markets and cardiac health care; and the development of high-tech materials for medical uses, including the treatment of burns.Additional resources of £23M over 3 years will be administered through the scheme, which will continue to be the main financial means by which the Council addresses Foresight.

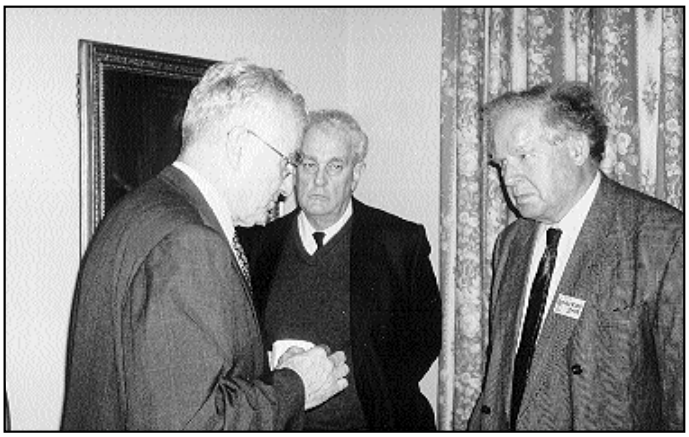
Commercialisation

The importance of commercialisation cannot be underestimated. If we are to embrace the knowledge economy, we cannot allow breakthrough developments to be lost or overtaken elsewhere. Strengthening institutions' capacity for technology transfer and commercialisation is crucial, and SHEFC and the Scottish Executive are therefore providing £6M over 3 years to support Professionalisation of Commercialisation. This initiative will improve management and support for activities such as the development of applications, patents and spinout companies, and will promote sharing good practice to overcome institutional barriers to commercialisation and technology transfer. Scottish Enterprise also recently announced a Proof of Concept scheme, which will provide £11M for developmental funding for the Scottish Science and technology base over the next three years. Scottish Enterprise's and the Royal Society's Technology Ventures programme, which supports commercialisation of research for the benefit of Scotland, have refocused activities on practical knowledge transfer and bridging initial funding gaps.

In addition, we are establishing initiatives such as the Scottish Research Information System that will showcase Scottish research talent and expertise throughout the world, effectively marketing the Scottish research base through ICT. SHEFC also works in partnership on a day-to-day level with a variety of organisations, and is a core sponsor of the CONNECT programme, through which universities have been encouraged to develop commercialisation strategies. Connect also facilitates business development opportunities. Such networking also supports inward investment and contributes to the integrated structure and practical support for commercialisation.

Next generation of researchers

SHEFC is also driving forward the progressive research agenda by focusing on the people who carry it out. Through the innovative Contract Research Staff Initiative, and the pioneering Women in Science and Technology Programme, we have recognised and highlighted the value of investing in and developing excellent researchers. For Scotland to develop and attract the next generation of researchers, it has to offer a dynamic research environment, as well as training and attractive career routes. The research infrastructure will be further improved by establishing centres of excellence, such as that supported by the successful Science Enterprise Challenge Award of £4m to five Scottish universities. This will be a world class self-sustaining base, promoting commercialisation of scientific and engineering technologies, entrepreneurialism and teaching of enterprise in the science and engineering curricula. SHEFC also intends to engage with government in developing a co-ordinated national strategy on research and science policy.



▲ *A solemn moment's discussion between Lord Oxburgh, Tom Dalyell MP and Sir Peter Swinnerton Dyer during the evening.*

Centres of Excellence

Scotland already has a dynamic research base with many centres that are regarded as world-class in terms of quality and volume of activity, including Biological Sciences, Computer Sciences, Physics and Electrical and Electronic Engineering. Nine departments achieve 5* in the last RAE, including areas where Scotland has significant industrial strengths such as Electrical and Electronic Engineering, Computer Science and Mineral and Mining Engineering. The Council's objectives are for Scotland to develop these strengths, for example through increasing numbers of internationally competitive centres of excellence. Such centres would further enhance institution capacity to collaborate and disseminate research outcomes for social, cultural and commercial benefit.

SHEFC vision of long-term outcomes

So, SHEFC's current funding methods are designed to ensure that the Scottish research infrastructure facilitates a balanced portfolio of high quality research which also supports government strategy on cross-sectoral investment and exploitation of the research base more effectively. As the research emphasis changes to more fully consider the applications and impacts of research, the changing balance of priorities is reflected in the key themes underpinning SHEFC's policies:

- Excellence
- Relevance
- Commercialisation
- Good management of research processes

To progress our policy priorities, SHEFC is undertaking a review of its research funding methods this year. We want to refine our research funding mechanisms to reward more effectively the successful use of research and to facilitate delivery of government policy objectives. SHEFC's review will stimulate an informed dialogue with the sector and the wider research-user community on the purposes, methods and effectiveness of research funding. The review will explore alternative ways of assessing excellence and relevance, and how the balance might shift to reflect changing needs. Our goal is to assist investment in research areas of key importance and emerging priority for Scotland.

As the research scenario is changing, we therefore need to consider widening the definition of research excellence to encompass a more rounded consideration of research capabilities – one that rewards ideas, inter-sector collaboration, and the successful use of research outcomes. In ten years time in Scotland, we hope that research quality will keep improving by national and international comparators; and that institutions will be able to optimise the benefits of their research. Research excellence should also benefit the curriculum, contribute to new teaching and learning methods and generally improve the student's whole educational experience, knowledge and skills. This also has implications for a new phase of entrepreneurial education and researcher/student entrepreneurship, at undergraduate, postgraduate and CPD level. Close links with SMEs will also be important.

We simply can't compete in the modern, global market place as a low cost, low skill economy. The Scottish Knowledge Economy Task Force began its work recognising Scottish under-performance and the pressing need to transfer knowledge from the science and engineering base to the market place. Scotland's research capacity and excellence must be a successful catalyst for investment in business development and Scotland's social capital through links with public, voluntary and charitable sectors too. The cross-cutting themes – lifelong learning, social inclusion the knowledge economy – offer opportunities to bring together the objectives of different sectors. While there are barriers, such as traditional practices, attitudes and teaching demands, there is room to learn from others too. Can research consultancies and technology transfer be given the same status as publication in refereed journals, which may dilute intellectual property and potentially reduce the commercial value of some research? Do attitudes and incentives have to be reassessed?

Fundamentals of a system of research assessment

The RAE has also done its job well, but it has limitations. It was developed by the UGC as a process measure, to implement a strategy. It was not intended as an end in itself. We must now consider whether, given the SHEFC research strategy, excellence should be measured not only by success through publication, but by contribution to invention, the development of critical expertise and innovation. We may need to develop more than one research assessment system; more than one process measure. The RAE is publicly recognised as a tool of selective allocation of resources and across the UK, research quality has improved dramatically over the last decade. Should we not also be concerned with how far the successful societal application of research is rewarded? The RAE methodology – or conception of research quality – is not necessarily responsive or dynamic. It will also benefit from the fundamental review of assessment that is to be carried out by the Funding Councils.

There is much to be said too for gaining clearer evidence of the real research needs of Scotland, the UK and the international markets. Quality and relevance are as important as maintaining the capacity for cross-fertilisation of ideas and speculative research, particularly for a small country such as Scotland. It will make the difference between a low cost, low income, low skill economy and a competitive, high added value, innovative, knowledge-based economy.

[1] *Realising our Potential: A Strategy for Science, Engineering and Technology*. CM 2250. May 1993.

[2] *Our Competitive Future: Building the Knowledge-Driven Economy*. CM4176. December 1998.

[3] *Scotland: Towards the Knowledge Economy. The Report of the Knowledge Economy Task Force*. The Scottish Office 1999.

[4] *A Future for Scottish Higher Education*. Committee of Scottish Higher Education Principals. 1997.

Dr Alan Rudge CBE FREng FRS*

Introduction

The requirement to quantify the quality and scale of the research contributions made by institutions in the higher education sector has led to the introduction of the Research Assessment Exercise. One important objective of the RAE is to enable Government to direct its research funding to academic institutions more effectively. However, before becoming immersed in the complexities of this topic it may be helpful to take a step back and put things in context. For example, what are the objectives of university research and why does government fund it at all? A concise definition might be as follows:

'*Government invests in scientific research primarily to build the knowledge and expertise which will enable the nation to deal with the next generation of change.*'

The basic process could be defined simply as one of Knowledge Generation and Knowledge Flow – the generation or accretion of relevant knowledge and its outflow into the community at large. Government funding of research is not motivated by charity and if the definition above is correct there should be a virtuous circle here – a cycle which, over time, repays the nation for its investment.

Government investment

In this cycle, the government invests in research by using Agencies such as, for example, the Engineering and Physical Sciences Research Council (EPSRC). The Agencies then seek to fund research and training in universities, which is both relevant and of

* *Chairman, EPSRC 1994-1999*

high quality. It is then important that the consequences of the research, in terms of new knowledge and trained people, can flow out to the wider community. The cycle is completed when this community, and notably Industry, provides a return to government by way of taxes and other contributions to the economy.

If this model for the contribution of universities with respect to their research activity is accepted, then it is possible to evaluate the benefits arising from research more specifically by examining the outflow of knowledge, without which there can be no benefit.

The first of the major outflows is the key role of research in refreshing the content of undergraduate courses, which, surprisingly, is often overlooked. In this case the outflow is knowledge on the hoof, post graduation. New course content is essential and teachers are often at their most effective and persuasive when presenting work where they themselves have made a research contribution. In general, a more formal evaluation of the contents of courses for their freshness and new knowledge would not be too difficult.

A second and more recognised contribution involves the flow of postgraduates and researchers from the academic environment to industry following a period of research or training activity. Again, this is knowledge transfer on the hoof.

A third path for effective knowledge transfer is that which arises from the interaction between academic researchers and industrial colleagues as a consequence of collaborative and industry-funded projects and from consultancy.

A fourth channel for the flow of knowledge from universities to the wider community, is that of publications. It must be acknowledged, however, that the results are then widely available with little weighted advantage to the UK.

Finally, there is the outflow benefit that arises from technology or inventions directly transferred to industry and often associated with hopes for royalty income on the part of the university.

Measuring importance of contributing flows

If we accept the importance of these contributory flows then we can give attention to the methods by which they can each be measured. Let me take three examples.

One clear product is the flow of trained people from the university to the wider community. Considering how significant this flow can be and considering that it can in principle be directly measured, it is perhaps surprising how little attention it has received in the past. When studies are made, the results can be indeed informative. For example, analysis has been made of the first destinations of post-doctoral research workers in chemistry who have been supported by the EPSRC. Most of the researchers have rapidly found employment and an encouraging number have entered the industrial sector. This is only a sample, but the potential value of this outflow information, in confirming and optimising the contribution of universities, is evident.

The knowledge flow deriving from publications can be, and is, measured, sometimes to a misleadingly precise degree. The technique of bibliometrics, which has become fashionable in recent years, makes a record of each reference to a given publication by research colleagues who have made use of it. There are many arguments about the validity of such bibliometric methods and I do not propose to expand on them here. However, in passing it is noteworthy that electrical engineering publications from the UK reach a similar level of popularity to those of chemistry – a result that may be unexpected to some.

A third measurable quantity is that of the royalty income derived by universities through the protection of intellectual property rights. Here, the key point is that such royalty income is small, forming some 0.3% of university income; it therefore constitutes only a very small part of the beneficial interactions between universities and the wider community. Indeed, if the objective is to ensure a healthy flow of research-driven knowledge between universities and the wider community, then care must be taken that royalties do not become a barrier. Even more importantly, they must not detract from, or otherwise hinder, the other much larger contributory flows.

To summarise the discussion to this point, my argument is that government funding of university research seeks to achieve relevant knowledge generation and that the benefits of this can only be realised ultimately by the outflow of knowledge and expertise to the wider community. If this were accepted then it would make sense to measure all of the principal outflows when seeking to evaluate the university contribution.

The dual support system

We then might ask how universities are evaluated currently, in terms of their research performance. To explore this issue we have to consider the dual support system which has been long established in Britain and whose merits are often taken as the first assumption in any discussion of research support in universities. The scheme for dual support is shown in Fig. 1. One element of this system, shown to the right, is the flow of money through the Research Councils to individual researchers or research teams in response to proposals for specific projects.

The flow of money down the right-hand side channel represents the accumulated effect of a large number of individual peer review decisions on proposals for **future** research work. However, each successful project is funded at less than its full cost and it is assumed that the balance of the overhead will be retrieved through funding obtained through the left-hand side channel.

The flow of money down the left-hand side is co-ordinated by the Funding Councils and is awarded to institutions on the basis of a formula. The dominant elements in the formula are first an assessment of the quality of research at the institution formed by looking over its **past** research activity at the departmental level. A second element in the formula is simply the number of active researchers whose work is put forward for consideration.

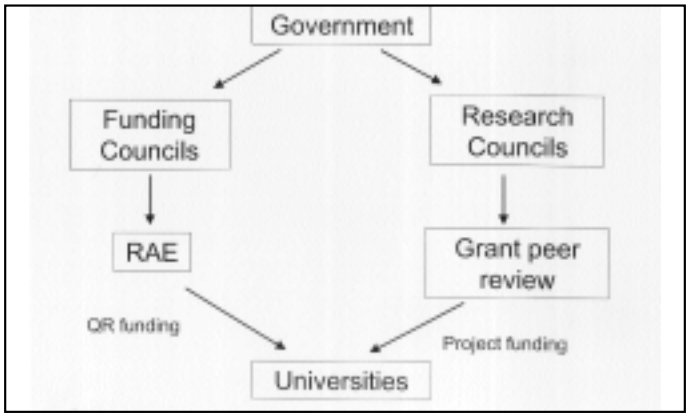
Let us briefly consider some of the characteristics of the two funding streams. If we turn first to the Research Council stream, then two aspects are worthy of emphasis. The first is that the peer review decisions made within the Research Councils result in a high degree of selectivity between the different institutions. Taking the EPSRC funding of general engineering shown in Fig. 2, for example, some 80% of the research support funds are placed in some 15% of the active institutions. Other subject areas vary in the degree of selectivity but in all instances there is clear evidence of selectivity and, by implication, quality, based fundamentally upon peer review.

A second aspect is that there is a close correlation between the departments, which are successful in winning research grants and the departments which win high ratings in the Research Assessment Exercise used by the left-hand side of the dual support system. In practice, the bulk of the EPSRC funding goes to departments with RAE scores of 4 or greater which corresponds to the third point or higher on a seven-point scale.

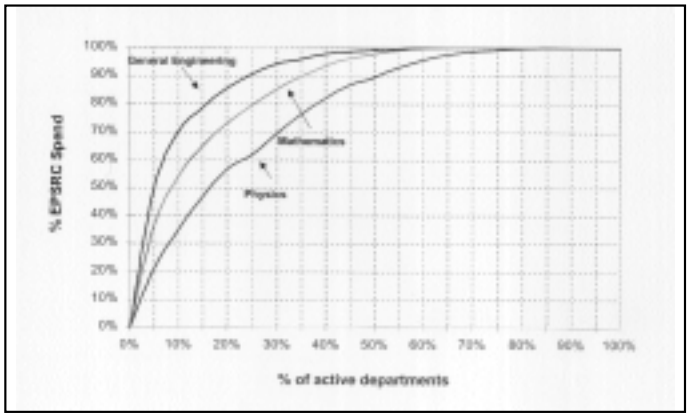
In one sense this correlation is reassuring. The two sides of the dual support system are behaving in a consistent manner. In another sense it could be seen as an unnecessary duplication. The overall system can be characterised by noting that sums for the partial support of research are passed down the right-hand side and that a large component of the associated overhead for this research is passed down the left-hand side. The right-hand channel is based upon the integration of elemental project by project peer-review decisions, the left-hand side upon the outcome of an extensive RAE exercise which seeks to ensure that, broadly speaking, the overhead will be distributed to the right departments – that is those doing the research. Indeed, if this is not the case then those universities taking on significant amounts of partially funded research could find themselves with severe financial problems.

Weaknesses of RAE

The Research Assessment Exercise is a large-scale review, which inevitably consumes a considerable amount of academic time and effort. It also has a number of weaknesses. For example, it is a retrospective assessment of a department's past contribution to research over the previous four years, which will only coincide with the current research effort providing the research community



▲ *Fig. 1. Flow of funding in the dual support system.*



▲ *Fig. 2. Concentration of EPSRC funding in disciplines. (RAE units of assessment)*

is not too mobile. Although some differences have arisen in the different cycles of the exercise, most weight is placed on identified publications by individual researchers and no attention is given to the other major knowledge outflows. But perhaps most critically, after four cycles of the exercise the RAE has become a rich field for gamesmanship.

In addition to such points, there have been concerns about the health of multi-disciplinary activity and about the emphasis on maximising numbers of researchers, which results from the application of the formula. The recognition of these flaws has led to a review of the Exercise. However, the participants in the Review are predominantly associated with universities themselves or with Funding Councils. Remarkably little weight has been given to the opinion of those in the wider community who are the ultimate beneficiaries of the outflow of knowledge and expertise.

The fear is that further refinement of the exercise will take place, that its complications and correctives will become ever more numerous, and that future generations of university research workers will become ever-more preoccupied with optimising around a specific set of rules. There is a great danger in all this that the real world could become a special case. Certainly there is a real concern that the focus of attention will increasingly move away from the main objectives of government funding, which must be the generation of relevant knowledge and its beneficial outflow to the wider community.

The future

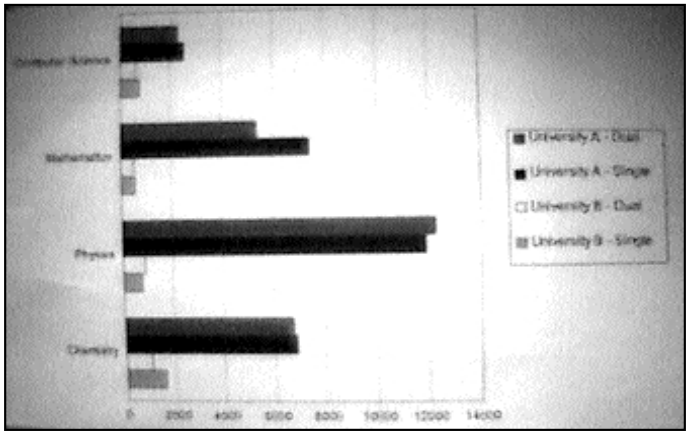
We are therefore faced with a future in which we must make continuing corrections to compensate for faults in the dual support system; or we can consider alternatives. Despite the long record of achievement which the dual support system has established it should not be seen as so persuasive that consideration of alternatives becomes taboo. As one possibility, therefore, I offer the following sketch for a single support line system which, while imperfect, has the benefit of logic and which saves the huge opportunity costs associated with academic effort required to operate the RAE.

Proposals from individuals and teams for specific research projects would be peer-reviewed as in the current Research Council system. The award to successful applicants would then be made with a full overhead. This pre-agreed overhead would vary between different subject areas. As an illustrative exercise, if we take the current Funding Council contribution and convert it into an overhead, then a figure of around 120% would be typical. As indicated in the figure, the intent would be that a certain fraction of the overhead would flow to the research group directly and a fraction would be available to central university administrations for more general initiatives such as the establishment of new disciplines, departments, or facilities.

If we follow this argument then it is possible to compare the income which universities would derive by such a single stream support system. This is compared with the existing income for two universities across a range of subjects in Fig. 3. The results indicate that, while there are differences, the single stream support system in this very crude form shows good potential for providing a satisfactory replacement for the RAE structure.

Since, under a single-stream support scheme, the allocation of funds is more clearly tied to specific research endeavours, there would be less concern about the sometimes uncertain link between Funding Council support and the use to which this support is put. Accordingly, there would be less need for the Transparency Review which is currently under development and which is soon to be imposed upon universities.

Above all there is a need to understand that the current dual-support system does not provide a second independent source of research funding. This is an illusion, since the HEFC funding is, in large part, the overhead element of the research funding which flows through the Research Councils. If the overhead funding does not follow the research then the universities taking on the work must fund the balance of the costs from their teaching or other budgets, if they are not progressively to under-fund their infrastructure.



▲ *Fig. 3. Changes in research income with dual or single support systems.*

▲ *Sir Robert May, Mr Tony Quigley and Sir Alan Rudge pictured during the evening.*

My objective is not to act as champion for a single-stream support system, although I do believe that there are clear attractions in terms of logical clarity resulting from the closer link between the awarded overhead and the proposed research which has been used to justify it. There are clear benefits too in avoiding the costs and distraction which focus on success in the RAE is increasingly creating.

Conclusions

My principal messages are, first, to urge that we work towards evaluation processes that can provide a genuine measure of the contributions made by research in the universities and the benefits which government, on behalf of the nation, derives from its investment. Second, that we think through our funding processes logically and do not become entrapped in even more elaborate correctives to sustain a system whose principal merit is its tired familiarity.

It is only then that we shall be justified in believing that we have found routes of excellence for the future which are meaningful. We shall have set in place ambitions for university colleagues that can be recognised as fitting to the importance of their calling and to the benefits that they bring to society at large. With this improved clarity of purpose there is every hope that we shall be able to reward success in these ambitions by logical and defensible systems of funding.

Acknowledgements: With thanks to Professor Richard Brook and colleagues at the EPSRC for their assistance in the preparation of this talk.

Dr Elizabeth Mills writes:

I was delighted to be able to attend the lecture and dinner discussion on 14 December 1999. However, I felt that the speakers neglected the important role of medical research charities in support of the science base. Dr Alan Rudge went so far as to imply that support for medical research from charities is both burdensome and problematic.

I would like to place on record my concern that among the powers-that-be in the Research Councils still lurks the attitude that the contribution of the medical research charities to the universities' research endeavours is unimportant. Fund-raising medical research charities have a major role to play in the support not only of biomedical research but also in other disciplinary areas – engineering, economics, physical sciences, social sciences, etc. Excluding the Wellcome Trust, the 100 members of the Association of Medical Research Charities provide nearly £250m p.a. to support medical research in the UK.

Most of the money provided by medical research charities is spent in academic departments of universities. These contributions not only support equipment, salaries and consumables for 2 or 3-year projects but, in many cases, also education and training awards like Fellowships and Studentships. They are paid net of non-attributable overheads and the appropriate Higher Education Funding Council treats those contributions (as long as they are for peer reviewed work) in the same way as awards made by a Research Council. But it is not merely the funding that provides value.

Charities provide a link between the scientists at the laboratory bench and the people their work is trying to help. And this is achieved in the most tangible way possible. Those individuals who support the charities dig deep in their pockets because they really want to make a difference. In reality, charities provide valuable funds for "blue skies" research, thus providing academics with freedom, often not available from other funders.

Dr Rudge should remember that the constituencies we week to serve are our donors, whose interests are represented by trustees, not the academic community.

Irrespective of the specific objectives of a charity, each has an important role to play in enabling Britain's scientists to improve the quality of all our lives.

Mrs Elizabeth Mills
Director
Research into Ageing

IT AND THE HEALTH SERVICE

The Foundation held a lecture and dinner discussion on 19 October 1999 at the Royal Society on the subject "IT and the Health Service". The Lord Butterworth CBE DL was in the chair and the evening was sponsored by EDS. The speakers were Mr Alasdair Liddell CBE, Director of Planning, Department of Health, Mrs Jackie LM Axelby, Chief Executive, Northumberland Health Authority, and Dr Jeremy Wyatt, School of Public Policy, University College London.

Dr Jeremy Wyatt*

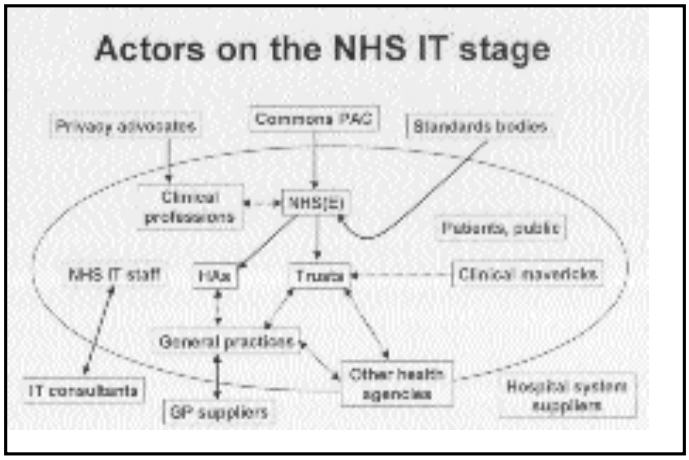
Summary: Dr Wyatt outlined the pressures and challenges facing IT and information management in the NHS, the pilot projects that had been undertaken, the impact of the Internet, including NHS Net, and the possibilities that existed for the future. There could be less clinical engagement, with more emphasis on community resources.

Introduction

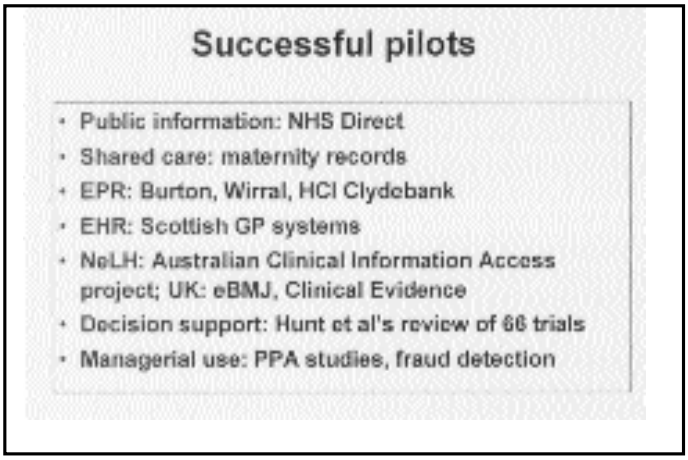
I'd like first of all to acknowledge most significant contributions to my talk from Justin Keen, who is a health economist with the King's Fund and whom I have been working with in one or two areas I'll mention later, and Sir Michael Packham, who is the Director of the School of Public Health where I work and I will allude to some of his insights shortly.

I am going to be talking about some of the pressures and challenges facing information technology and information management in the NHS and, particularly, how we can engage a very vociferous and sometimes powerful group, the clinicians, in moving things forward. I'll then talk about the wider health service and then I'll discuss some strategic options and what the implications of those might be. I don't think that any evening meeting like this, in which the focus is on IT and the health service, would be complete without some attempt at predicting where IT might be in five

* *School of Public Policy, University College London*



▲ *Fig. 1.*



▲ *Fig. 2.*

years' time and so I hope you will indulge me while I just throw one or two slides up to discuss what might be possible over the next five or ten years. Then I'll conclude with some warnings about the dangers of the technology pushing without an adequate pull from genuine problems.

NHS Structure

First of all, talking about the challenges and, in particular, the many actors on the NHS IT stage. Fig. 1 depicts the NHS with the Executive sitting at the top, directing, with a light touch, of course, the Trusts, the Health Authorities, about their business, but the NHS Executive itself has had pressure – for example, from the Commons Public Accounts Committee. There have been three previous inquiries and there is a fourth hearing happening on 1 November and, if you like, we can regard that Committee as the rather savage theatre critic who is commenting on the play which is evolving on this stage.

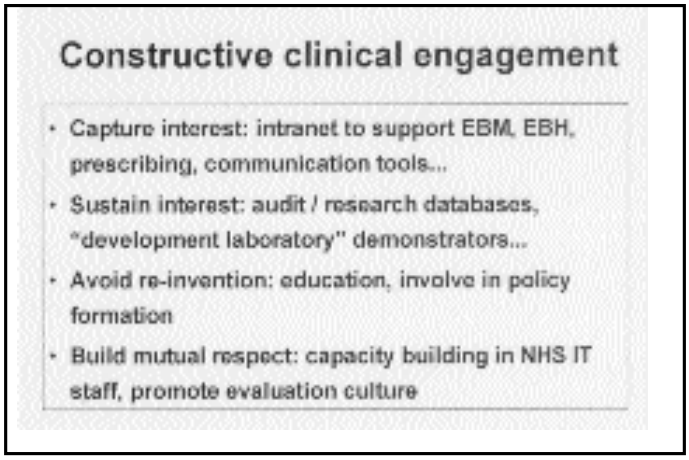
Meanwhile, there are the standards bodies, and some of the national and international standards bodies which have been trying to get in at the soft under-belly of the Executive. The Executive has perhaps tried to seek assistance from the clinical professions but they have been a bit dilatory and, at times, it has been difficult to see what their real position was, perhaps because the privacy advocates and other pressure groups have been trying to act through them. Of course, there have been clinicians who are very active in NHS IT. Unfortunately, these are the clinical mavericks set down on the right hand side; they tend to have been loners, people who aren't interested in the emerging national picture, who merely want to push forward their own individual departmental system, irrespective of some of the accepted standards and ways of practice. Nevertheless, some very important advances have been made by some of those.

Pilot projects

Of course, there are other health agencies under the commercial sector. The GP suppliers have been very active and very successful in getting information systems into general practice; over 90% of general practices in the UK now are computerised and most of those systems are used for prescribing and other clinical data. But the poor hospital system suppliers have been left out in the cold. So, despite all of this, I think that it is necessary to emphasise that there have been some very successful pilot projects (Fig. 2). We have heard already about the NHS Direct Public Information System, which really has been a spectacular success – Alasdair Liddell did not mention this statistic, perhaps modesty forbade it, but I can say that the NHS Direct Public Information System has been *the* most popular public service that has been researched and evaluated. Something like 97 or 98% of people who telephoned the Helpline have reported that they are either satisfied or very satisfied with the service that they get and that really is a spectacular result.

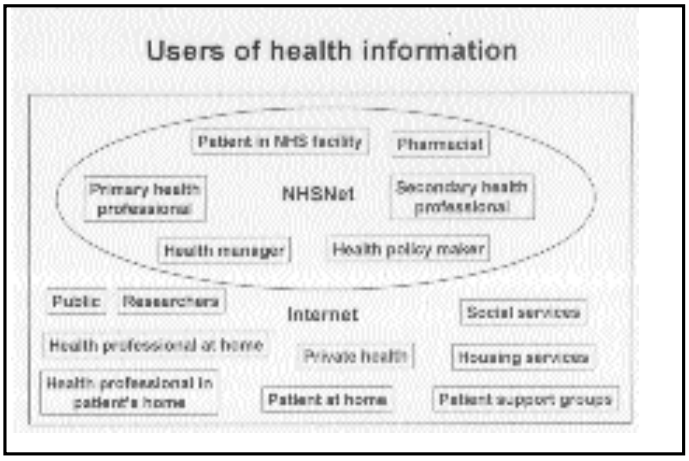
There have been a number of other very successful pilots – electronic patient records. There have been some electronic health record pilots in Scotland: they have very successful GP systems. Also the National Electronic Library for Health. We've heard that there is a pilot up and running in the mental health area on the World Wide Web. There have also been a number of other interesting pilots overseas. For example, I went out to Australia to look at the clinical information access project there which has been going for about eighteen months and again it has been very successful. It is made available to 70,000 healthcare workers in New South Wales.

In the UK, perhaps the best example of an electronic library of health, although not a national one, is the British Medical Journal's web site and electronic BMJ site which is very comprehensive with quite a lot of extra functions, not just access to the text in general, although that, of course, is itself very valuable. Actually, BMJ Publishing have now launched a new venture called Clinical Evidence which is a move towards an explicit way of bringing together lots of different insights to answer clinicians' questions. This could also answer policy makers' questions and the public's questions as well.

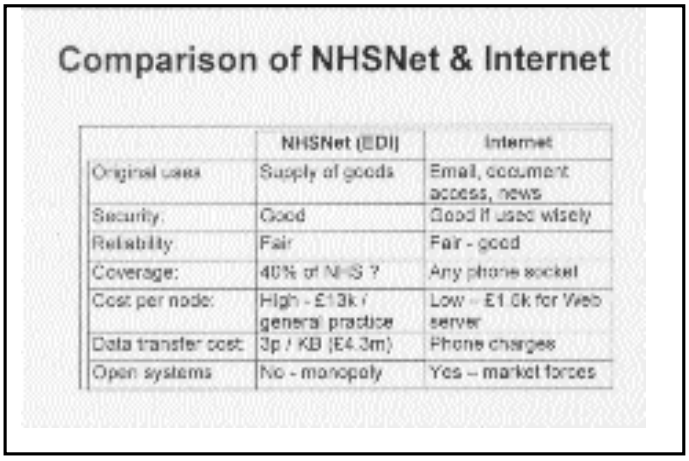


▲ *Fig. 3.*

▲ *Fig. 4.*



▲ *Fig. 5.*



▲ *Fig. 6.*

There has been great success with decision support systems – some projects in this country, many others in the States and, actually, there has been a systematic review which identifies over 60 randomised trial decision support systems and three quarters of those were effective at improving clinical practice.

And, of course, managerial use of information has been another success. To name just one example, the Prescription Pricing Authority, Newcastle, which processes the many millions of prescriptions which are written every year. They've launched a number of useful studies, including studies of fraud. They have now got nearly fifty people working on prescription fraud and they aim to make some very substantial savings as a result of that.

Clinical engagement

I mentioned the issue of clinical engagement, and I should like to come back to that because I think it is a key element and it is identified in the Information for Health Strategy. Every time the community is mentioned, the clinicians are usually mentioned first. But I think, and I have seen this myself in our local health authority, that it is hard to get clinicians fully engaged and constructively engaged in this (Fig. 3). I think we need to consider carefully how to capture their interest, sustain their interest, try to avoid reinvention, and I mentioned the tendency of mavericks to weigh in with a programming system themselves, even, and do something which is often an off-the-shelf solution. We need to build mutual respect; clinicians, and I am one, tend to err on the side of assuming that they can do things and they should be the ones who are leading. I think that we do need to work carefully to build the capacity in the NHS information technology staff and promote an evaluation culture which is something which clinicians do respect.

Next week in *The Lancet*, Michael Packham is publishing an article which is based on his lecture this year in which he discusses the idea of NHS development. I remember that Michael was the person who set up the NHS research and development initiative. In that article, he defines development activity as "innovative use made of knowledge and information to turn ideas and technologies into better, more affordable health care". I think that, if we can engage clinicians in that very information intensive process, then that will be one way of bringing them in on what is happening in the Information for Health Strategy.

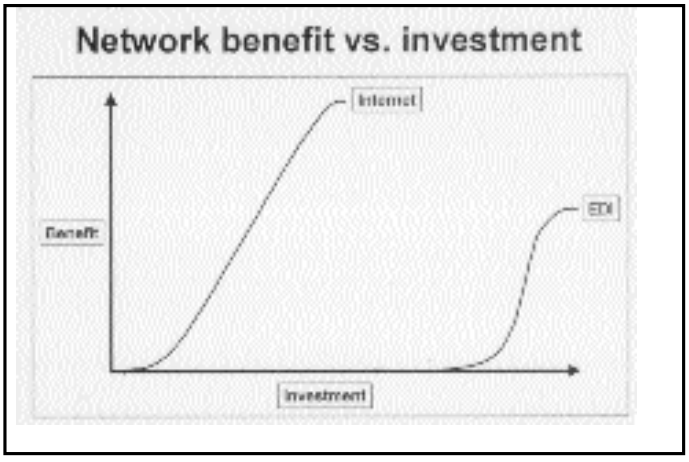
The wider health service

Moving on to the broader, what I call the wider, health service, we have heard already that there is a very strong policy push to engage a wider range of agencies – individuals from social services through to education and beyond – in the health of the nation. (See Fig. 4) And, of course, we have had the Health Act 1999 which has started to set up organisations which are even beginning to employ salaried general practitioners who are not within the NHS but are very active in health care. There is a whole range, from patients, patient support groups, suppliers of goods and services to the private health system even, which does account for quite a lot of elective surgery.

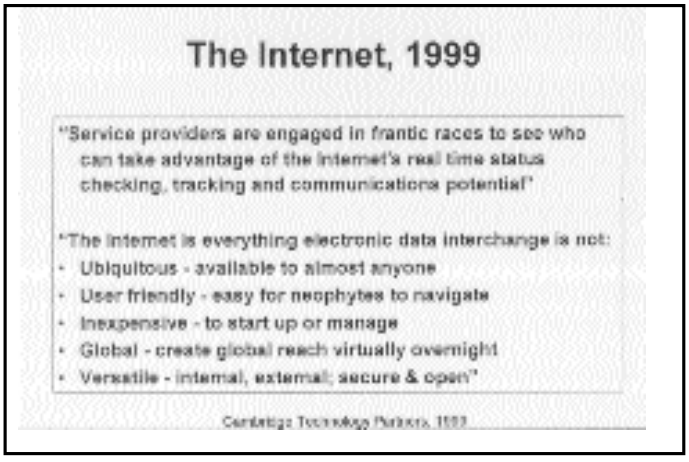
How can we ensure that those providers and users of health information can get fully involved in what is happening in the NHS? Fig. 5 shows that if you happen to sit inside the remit of the NHS Net, then it shouldn't be too difficult. But a lot of these people will never be within the scope of the NHS Net, which is a private network which the NHS has set up. Even the health professional at home, over in the bottom left hand corner, doing some work, maybe wanting to get access to some information from – shall I call it the national library for health? How is he going to get that? Because he won't necessarily have NHS Net access at home. We do need to extend the scope of health information beyond the scope of the NHS Net. Obviously there are a lot of issues that come up with that.

NHS Net v. Internet

There have been some comparisons looking at the kind of technology on which the NHS Net is based – it is called electronic data interchange – versus the Internet, and it is interesting to look at not only the economics (Fig. 6) but also to think about what the origi-

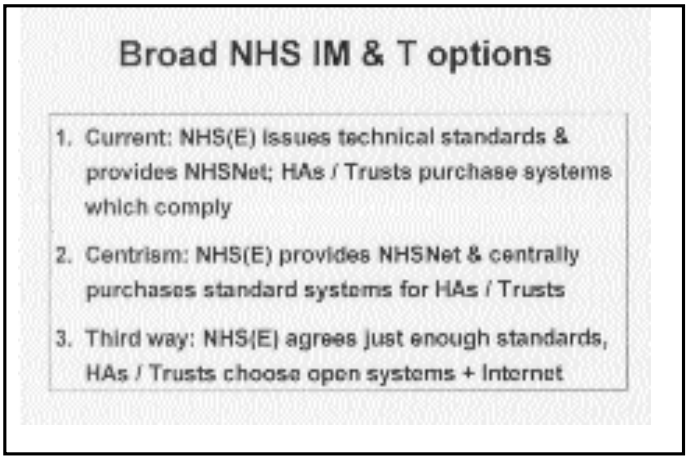


▲ *Fig. 7.*



▲ *Fig. 8.*

▲ *Fig. 9.*



▲ *Fig. 10.*

nal technology was designed for. In the case of the Internet and World Wide Web, it was actually designed for sharing information, communications, document access and even news, whereas electronic data interchange was designed for supporting transactions, particularly in the retail trade. For example, Sainsbury's is a major user of electronic data interchange in this country. There are some issues about the charges on the NHS Net and the fact that it is not an open system. It is very difficult for a small organisation, let's take a general practice, for example, wanting to join up. There is, or has been, a barrier to joining up. Now, it has been announced that there will be a programme for bringing general practices in because, of course, the value of networks only really accrues when you have got the majority of people signed up. This is one of the problems with networking without using the Internet – with any private solution, it is going to be difficult to get the isolated GP to sign up.

Fig. 7 shows that more clearly. On the bottom axis we have got investment or the cost, either for the individual person joining in or for the overall system versus the benefits. With the Internet, the costs are relatively low. It costs about £1,000 or £1,500 to get a web-surfer up on the web, and e-mail is much less if you've got an existing computer. The benefits grow relatively rapidly with relatively small further investment. The trouble with electronic data interchange, like NHS Net, is that you have got to invest a very considerable sum, either as an individual or as the NHS itself, before you begin to get any benefit. So there is a heavy exposure of risk for the individual small NHS organisation. I think that this explains why it has been difficult to bring some of those organisations in on the NHS Net. Of course, the Internet did not exist n its current form when the NHS Net was proposed, so this is one of the reasons why the NHS Net exists.

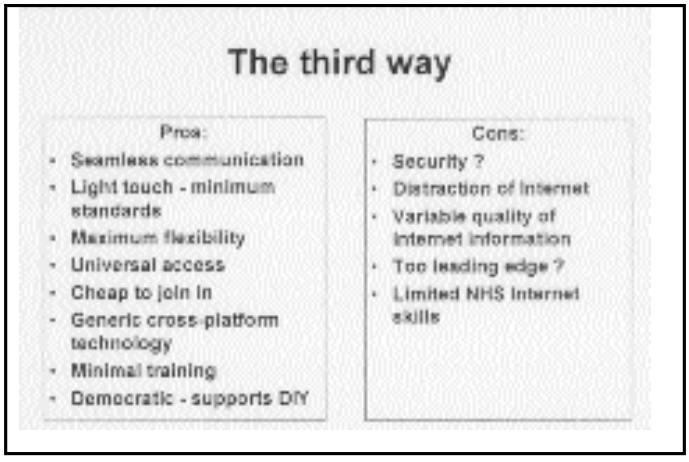
It is interesting that *The Economist* had an article in which they quoted extensively from a report from Cambridge Technology Partners that service providers like the NHS are increasingly turning to the Internet because of the ability to get ubiquitous access to real time data. There are a number of other benefits (see Fig. 8). I think we do need to think more carefully about where we can use the NHS Net and where we can use the Internet, bringing in a wider community, a wider health community.

It has been suggested that one of the major reasons for the success of the Web is not because it is very tightly defined but because it is loosely defined. Because it is simple, it is the minimum standard that is needed to be able to exchange documents and information. The simplicity of the browsers, of the languages, the fact that you can freely copy other people's web sites and so on, certainly has helped it all to take off. (See Fig. 9)

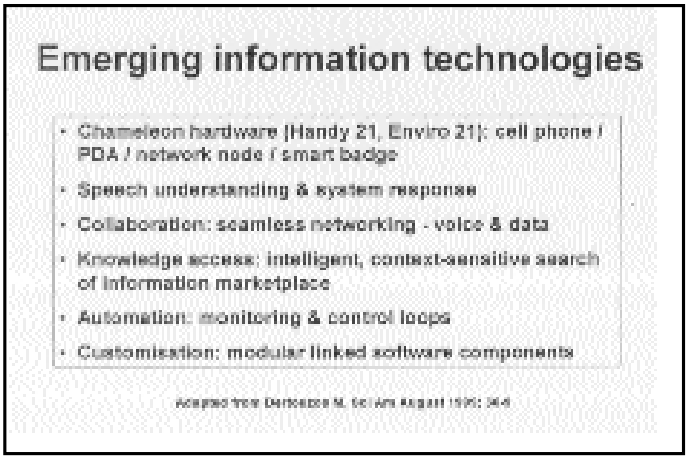
Of course, once you get this critical mass effect, then that does help as well. Is there a lesson perhaps from this for IT and the NHS? If you think of the broad strategic option for IT and the NHS, the first option is very much as we are at present: the NHSE has responsibility to decide and disseminate technical standards, standards about privacy, standards about data and so on. It provides a central core information structure for the NHS Net. The individual organisations, whether they are health authorities, trusts, individual general practices, have to find out enough to be able to purchase systems wisely, and that is difficult; it is quite a challenge for many of them.

An alternative view, perhaps a rather Stalinist view, would be to say, "Right, surely the responsibility of the NHSE should be to decide that there will be a system for general practice, a system for trusts, a system for health authorities, and then procure that centrally – we'll have 250 of those, please". Then disseminate them round the NHS. (See Fig. 10)

That is very much against the 'light touch' philosophy and it also fails to recognise that there are some real genuine differences between trusts, between general practices around the country, even between neighbouring trusts and practices. So, for many reasons, I think, we can see that it would not be a very successful strategy. It has been tried, for example, in Wales, and part of the problem was that over the roll-out phase of that single system, the needs changed, the structure of the NHS changed and therefore the last group of organisations which was going to take the stan-



▲ *Fig. 11.*



▲ *Fig. 12.*

dard system said, "We won't have it – it is no longer suitable".

However, we see perhaps an inkling of that in NHS England and Wales. For example, there has been an announcement of a standardised general practice desktop system and I think that we have to wait and see – as long as enough GPs are convinced of the value of that, it could be very useful but it could, equally, be a little bit over-centrist and it raises the question, "Is there a third way?" A third way? Perhaps there is, perhaps that web model, with just enough standards, and leave the individual NHS organisations to sort out, to shake down using more standardised, open web technology could be one way forward. (See Fig. 11) I think that there are certain potential advantages in that, for example, it would be much cheaper for people to join in, and it does have this great advantage of universal access. But there are some questions – for example, the bottom of the list on the right: 'limited NHS Internet skills'. Having said that, at least if we train NHS IT staff in the Internet, those are generic skills that they can use elsewhere and they don't have to feel that they are learning about something which is NHS specific. There are, of course, issues of security but I think that increasingly we are beginning to see some solutions, even using the Internet, which are just as secure.

Emerging technology

I have taken some quotes here (see Fig. 12) from an article in *Scientific America* by Michael Dertouzos from MIT "The Oxygen Product", looking forward five years to what kind of technology we will have. Some of these are quite advanced and you can see how this would be useful in the NHS. Knowledge access, using intelligent searching and context sensitive searching, automation of routine processes and customisation, to allow different people to pick and choose whatever system they want, would be very useful.

What kind of systems could we actually build with these kinds of technologies? Well, one possibility is a health kiosk. We have already heard about the NHS direct contact helpline and, using interactive television, maybe in Sainsbury's, there could be a health kiosk which would interview a patient, maybe actually perform some tests if they put their finger on a plate which could do some simple chemical analyses of sweat. It could also capture some images and communicate with a remote medical centre, use multi-media databases of various kinds and then, on the right hand side of the box, it could in fact dispense drugs. (There are already automated drug dispensers in use in American hospitals.) It could also give counselling by computer. In fact, all these technologies do exist, so it is not far fetched to say that we could see some shift in the way that we hold the primary access to the NHS, the primary contact. Some of this could be prompted by a home monitoring system. If you have a chronic disease, for example, it could actually say that you need to go to the health kiosk some time this week to make sure that your diabetes management is up-to-date.

What would be the implications of this? Well, for the patients and for the public, it would certainly lead towards what Richard Smith wrote about two years ago: the inversion of the power pyramid. This is something that I think many governments around the world are seeing in terms of health care. That we are moving from the hospital doctors and GPs being in command of the resources, the knowledge, to shifting more responsibility and more resources out into the community to patient self-help groups and to patients and their families at home. The kind of technology that we have been discussing could lead to facilitating that shift, not in five years but perhaps over twenty years. But it is important to decide if that is a route that we want to follow. It would, of course, have quite a severe impact on clinical practice but I have listed a number of different ways that this kind of technology and shift in social use of health care facilities could actually change the size and the responsibilities, the remit of the medical profession.

In conclusion, I think we are seeing the more inclusive approach to the health service. I think that is a radical change and it will probably need some fairly radical solutions. I do believe that clinical engagement is important but I am not sure that we've yet solved the problem of how to achieve that. I think that we need to think hard and long about that because it is a key issue. I've mentioned the importance of the Internet as a communication medium for bringing in that wider range of producers and users of health information and also the potential model of the web – the light touch – freedom within wider limits. I think it is clear that technology itself is advancing very fast, today's technology particularly, and that is not going to be any kind of barrier; in fact, it will probably disappear.

I think, finally, that we should be careful and cautious. As the Audit Commission said, we must be very careful not to allow technology to be driving the information management process – it should only serve it.

PROFILES OF COUNCIL MEMBERS

Robert Hawley CBE DSc DEng FRSE FREng

Dr Hawley's early days were unpropitious: he was evacuated from his birthplace in Wallasey to Somerset and on his return, he lost almost a year of primary schooling when near-fatal peritonitis followed a minor operation for tonsils removal and then he caught scarlet fever. However, he was one of only two from his year to transfer to the Grammar School where, he says, he struggled. After two years, he was second to bottom of his class yet he and the bottom boy were the only two of that class to go to university. Dr Hawley left school at 16 to undertake an apprenticeship with BICC Ltd and, while studying for one of his two Ordinary National Certificates, he discovered a gift for mathematics.

It must have been about that time, and perhaps emboldened by real academic success, that he decided that he must go to university if he were to scale the heights. He won one of forty UK technical state scholarships which took him to King's College, University of Durham (as it then was) for a First Class Honours Degree in Electrical Engineering, followed by an IEE Ferranti Scholarship for his PhD, awarded in 1963. It was that University College, after it became the University of Newcastle upon Tyne, which awarded him, in 1976, a DSc on the strength of his books and papers on various aspects of power generation and dielectrics. He joined CA Parsons & Co Ltd in 1961, becoming a director in 1973 and Managing Director in 1974, by which time he was acknowledged as an international expert in power generation and energy. He became Director, Production and Engineering, of the subsidiary, NEI Parsons Ltd, in 1974 and its Managing Director in 1976. In 1984, he was appointed to the main board of Northern Engineering Industries plc and Managing Director of the Power Engineering Group. In 1989, he became Managing Director responsible for all trading activities of NEI plc and, as NEI then merged with Rolls Royce plc, he joined the Rolls Royce main board. In the subsequent sixteen years, he was to serve as director of some fifteen or more associated companies.

It was with considerable courage that he moved in 1992 from the Group with which he had spent his life, to become Chief Executive for Nuclear Electric plc where he was to serve a five year term, translating a loss-making company into an international one which was privatised in 1996 as British Energy. He relin-

* *Fellow, Science & Technology Policy Research, University of Sussex*

quished this appointment in 1997 and is now Chairman, Taylor Woodrow plc and advisor to HSBC Investment Bank plc. He is non-executive Chairman of INBIS Group plc and of ERA Tech Ltd, a non-executive director of Tricorder Technology plc and of Colt Telecom Group plc. The list is lengthy and would fill the time of most but Dr Hawley matches it with an equally long list of past and present public appointments of which the current ones are: membership of the Court of the University of Newcastle upon Tyne (since 1974); member of the Industrial Development Advisory Board (DTI); President, Partnership Korea (DTI); Chairman CBI/UK Korea Economic Co-operation Council; Chairman of Council of the University of Durham and Vice-President of the Durham University Society; member of the Court of Benefactors, University of Oxford; Chairman of the Particle Physics and Astronomy Research Council, and Chairman of the Engineering Council.

He is, of course, a Fellow of the Institute of Physics, of the Institutions of Electrical and of Mechanical Engineers, of the Royal Academy of Engineering, and of the Royal Society of Edinburgh, in addition to having received the Honorary Fellowship of the Institution of Nuclear Engineers. He has served the Institution of Electrical Engineers assiduously, including holding its Presidency in 1996. He was appointed CBE in 1997, has been awarded honorary doctorates from four universities, and holds several medals, including two from overseas. He is the author of numerous papers on the topics of electrical breakdown in vacuum, liquids and solids, electrical machine design and power generation. He has co-authored four textbooks, and has delivered numerous prestige lectures.

It is axiomatic that those who are the subjects of these profiles have achieved much which has to be recorded for both interest and completeness. Dr Bob Hawley's achievements are legion but what of the man himself? He is physically a big man as one might expect from one who has achieved so much. He has two grown-up children who are also high achievers and of whom he is transparently proud. His recreation is limited to gardening and one may be forgiven for wondering how he finds time to do even that. He recognises how very lucky he has been in life with natural abilities – particularly a good memory and good reading skills, encouraging parents, and good health, although he reflected (as other profile subjects do) as to how much we make our own luck.

This is a matter on which he touches in his Presidential Address to the IEE (*Leadership Challenges in an Engineering Environment*) where he asks if the great leaders in history were great by intent, by instinct or just by fluke. He pays tribute to the especial influences in his life – his father, who gave both inspiration and support, two lady mathematicians who awakened his interest and ability, Sir James Woodeson, whom he regarded as one the great leaders of industry, and particularly John Collier, Chairman of Nuclear Energy, whom he found to be a brilliant scientist, a thorough gentleman and an excellent role model. He was conscious of the debt that he owed to his university and to the IEE and opined that his continuing service to both institutions was a reflection of that consciousness. It is for these reasons that he is deeply involved in the promotion of the benefits of science and engineering.

▲ *Dr Robert Hawley. Courtesy of Five Valleys Photography.*

He describes himself as not a cultured man, yet he is interested in art – (at 16, he almost took up an art scholarship) – and music (although he says he is not musical but he knows what he likes). He is a member of the Church of England, although not as regular an attender as he would like: despite his scientific background he has no problem with the conflicting tenets of beliefs within the Christian Church because he feels that Christianity requires a bedrock of uncritical belief, and this he has comfortably. He feels that things happen for the best: he has found that his own hurts and rejections have opened new pathways, and he has then been able to travel forward again enriched by the experience. He is certainly a humane man: his Presidential Address to the IEE was concerned at least as much with behavioural as with technical and economic matters where he spoke of tomorrow's leaders as being consensus managers and role models. It is clear that those characteristics are his managerial goals and his ready use of such words as 'empathy', 'flexibility' and 'concern' reflect a man who, in training his subordinates for future management, really believes in what he described in his Address as the coaching style.

He hopes to continue with a portfolio of activities for several years, reducing his contribution as he wishes, but he is not a retiring man. As a good engineer, he likes problems to solve and, as a good man of commerce, he seeks business with which he can combine pleasure – obviously crossword puzzles by the fire are not the ultimate enjoyment for Dr Hawley.

FOUNDATION NEWS

New Associate Members

The following have become Associate Members of the Foundation for Science and Technology:

Rolls Royce plc
Contact: Dr S J Garwood, Director of Technology

Marconi plc
Contact: Dr David Grant CBE FREng, Director, Technology

Human genome project

If "Human Genome Project" had lacked immediate excitement, in cold print, to any Foundation member, then all was changed by a visit to the Wellcome Trust Sanger Centre, south of Cambridge, on 5 November, from which [my] [the] abiding memories are scale, enthusiasm and humanity.

No visitor could be other than overawed by the sheer scale of the task – the ordering of the 3 billion components of the human "instruction book" – or of the computing power brought to bear upon it – coming up shortly to 1.4 megabytes. This is a £100 million plus (capital) project, expending some £40 million per annum, with a staff of 300 collaborating with other scientists world-wide, notably with Japan and the USA, and working to an

accuracy standard of 1 in 10 (and achieving a magnitude better).

Nor could the visitor miss the enthusiasm and the sense of anticipation among staff as the 90% completion target nears its realisation in Spring 2000 and the date for final completion – 2003-looms ever closer.

And the humanity of the project stands out no less. This is a collective effort dedicated to the provision, free and in the public domain, of networked databases of the human genome sequence – a vital forerunner in helping individuals avoid diseases to which they may be predisposed. The genome may define Homo sapiens, the organism, but the project and all involved reflect, no less, the recognition of humanity as individual beings. Science and morality in ensuring the broadest and best use of the results go hand in hand. This was a message to register with the public, in response to their inquiries, and, along with the patenting of gene sequences, the practicalities of doing so filled much of the discussion session that completed a most enjoyable and instructive visit.

Peter Warren

Mr David Firnberg comments:

The Genome project is a model of human/machine synergy on a massive scale. An electronic display in the foyer at the Sanger Centre continually shows new 'bases', the building blocks for DNA, as they are isolated. It is estimated that there are 3 billion of these bases, and they all have to be identified, annotated, stored and made available for sequencing, searching, analysing and comparison. The rewards are huge: the bioinformatics task awesome!

In this age of well publicised computer failures it is hugely encouraging to witness the exploitation of computing power and storage capacity so successfully integrated into the intellectual task of unravelling the 'code of life'.

▲ *Those who visited the Sanger Centre learnt something of the immense computer power required for the Human Genome Project, and have visited the computer rooms.*

PROTECTION OF KNOW-HOW

The Foundation held a lecture and dinner discussion on "Protecting Know-How – Is the Present Regime Adequate?" at the Royal Society on 17 November 1999. The Rt Hon The Lord Jenkin of Roding was in the chair and the evening was sponsored by Brownell Ltd, Microsoft Research Ltd, and the Foundation's Shared Sponsorship Scheme (ABPI, Comino Foundation, Esso Petroleum Co Ltd, Glaxo Wellcome plc, Premmit Associates Ltd and Science Systems (Resources) Ltd). The speakers were Dr RF Coleman CB, Intellectual Property Institute, Ms Maggie Mullen, European Leader, Intellectual Asset Management, PriceWaterhouseCoopers, and Professor John Adams, Professor of Intellectual Property, University of Sheffield.

How Industry Protects Its Know-how

Dr Ron Coleman CB*

Summary: Dr Coleman concluded that patent counts were a poor guide to innovation in companies; that IP management practices were specific to industrial sector and company size; and that universities were not a significant source of IP for exploitation by businesses. Professor Adams, in discussing the ETAN Report, said it was believed that there had been too much focus on formal IPRs and the type of knowledge they protected. There needed to be a greater focus on the people who embodied both formally protectable and informally protectable knowledge, and on the way the interaction between people could facilitate that process.

Introduction

The protection of know-how is of critical importance to companies in order to gain and retain competitive advantage. The Intellectual Property Institute (IPI) has conducted several research studies showing the importance of intellectual property to the UK economy. For example, patents are essential or very important to companies generating 4.2% of GDP. Additionally, companies totally dependent on copyright generate 3.6% of GDP and companies substantially dependent on copyright generate a further 1.8% of GDP. It is not surprising, therefore, that the Government and the European Commission devote considerable resources to ensuring we have an effective regulatory regime to protect these businesses.

Whilst I do not wish to suggest that these resources are not necessary or inappropriate, what is being done for the remaining companies which generate 90% of GDP? Is the assumption being made that they are not innovative and therefore do not have any know-how to protect?

Between 1996 and 1999, the ESRC, DTI and IPI sponsored The Intellectual Property Research Programme, one of the biggest research studies of intellectual property and its protection ever mounted. The aim of the research programme was to learn how the prevailing system for protecting intellectual property was working for the bulk of companies not as dependent on patents and copyright as recorded in the studies mentioned above. The research focused on small and medium sized companies, on new business sectors such as electronic publishing, on knowledge-intensive business services, and on the academic-industry interface. In general, these are businesses seeking to come to terms with the management of innovation and know-how.

About £1 million was invested in the 12 research projects chosen by open competition. The successful applicants were not the gurus of intellectual property rights, the academic lawyers, but a

* *Intellectual Property Institute*

diversity of social scientists with backgrounds in business studies, economics, sociology and information management. One reason for this was that industry generally recognised that lack of a multi-disciplinary approach had been a weakness of earlier intellectual property research. The sponsors wanted to address this deficiency and find ways of helping all innovative businesses, not just the 10% of businesses who are major users of the present regime.

Most of the conclusions arising from the research programme apply to specific business activities and can be grouped under six headings.

SMEs

Blackburn from Kingston University concludes from interviews with the principals of 400 companies, in the software, electronics, design and mechanical engineering sectors, that SMEs have realised the importance of know-how and do know how to manage their assets. They are making little use of formal methods of protection requiring registration, such as patents. They prefer informal methods because they are successful, cheaper, and within the control of the company. The principal method of maintaining confidentiality is through working with customers, suppliers and employees who can be trusted.

There was a significant difference in some protection strategies depending on the sector: in software, lead time over competitors rates highly, in mechanical engineering, contractual undertakings are important, in software and design the conspicuous display of copyright signs are common. Many companies in all sectors try to serve a market niche not readily accessible to competitors. When asked what they saw as the greatest threat to their IP, nearly half replied it was the loss of key people.

Thomas from SPRU at Sussex found that biotechnology SMEs rely on patents to protect their IP. The long development times for new products means that companies will require substantial external funding from venture capitalists and international pharmaceutical companies. This will not be available unless it is clear that the know-how is secure and cannot be copied by a competitor without a licence.

Dickson of Brunel University concluded from interviews with textile design houses, mostly very small firms, in the UK, the US and Italy that textile designers are not sufficiently aware of design law and the protection it can offer. Imitation, both legal and illegal, is rampant among designers. UK designers rely heavily on automatic copyright protection and working with companies and individuals they feel they can trust. 40% of firms interviewed had found evidence of copying of their products in the last three years. However, half did nothing about it. Only 10% were prepared to go to court, then mainly to protect their reputation because the copies are of inferior quality.

New technology, such as digital cameras, scanners and computer-aided design, is reducing the time it takes for copiers to reach the market thus making infringement easier. Designers know that attitudes must change and maybe the UK should follow US practice and put its faith in design registration and use the courts to obtain injunctions as soon as the copy is found.

Patent Databases as an Aid to Innovation.

The patent system is a bargain between the inventor and society. In exchange for a monopoly for a period of 20 years, the inventor must disclose the invention in such a way that it could be reproduced by competitors with similar skills. This encourages further development and innovation for the benefit of society. Macdonald from Sheffield University concluded from surveys of over 1000 SMEs that most believed that they were innovative but rarely, if ever, used the patent system as an information source. Customers were their most important aid to innovation, followed by suppliers and competitors.

Oppenheim from Loughborough University had a similar response. In face to face interviews, he found that some SMEs used the system occasionally for protection or checking on infringements, but the searching for technical information was "insignificant". In his opinion the Patent Office databases are for professionals, either patent agents or IP professionals in the large firms. SMEs that have used patent agents generally found them poor value for money, particularly in obtaining technical information relevant to the specific needs of the company. Oppenheim did find a few SMEs who had taken the time to develop the skills required to access the databases themselves. In these cases they found the effort worthwhile. However, with so many demands on the time of the SME managers, the Patent Office will need to change its marketing strategy if it is to have any impact on the real needs of small companies.

Electronic publishing

Dr Tang of Sussex University defined electronic publishing for the purpose of this project as the production of CD-ROMs and on-line databases. She created a comprehensive database of 1000 companies covering this new business sector and interviewed a sample of 31. Technologically, the UK companies compare well with those in the US and form the most advanced electronic publishing activity in Europe. With a single exception, the companies are satisfied that the current copyright regime is adequate to protect their publications.

Half of those interviewed relied on exploiting a market niche and/or technical systems – usually passwords or encryption – for protection of their IP. Many saw the current technical systems as "user unfriendly or too complicated" as they inhibited access to electronic publishing, at a time when the sector was still seeking to expand rapidly. Companies in this sector do not appear to be concerned about piracy such as occurs in the music industry. Access to knowledge-based resources, creativity and specific marketing skills are seen as barriers to entry to electronic publishing.

Multimedia Industries

Wallis of City University spent many years in media activities -as composer, journalist and analyst – before becoming an academic. He concludes that the present copyright regime may not survive the changes taking place in the multimedia industries. The convergence of firms in the film, radio, TV, music, book publishing, consumer electronics, computers and telecoms has squeezed out medium-sized companies leaving only small single activity firms and global multimedia giants. The principle of the collection of IP royalties through collecting societies is threatened. If the global players offer better deals to the international artists, then the collecting societies' income will be drastically reduced. Their charges to less well-known artists and small firms may then be prohibitive and cause the system to collapse. Currently neither the UK government nor the European Union have grasped the magnitude of the radical changes taking place in the structure of the multimedia industries and the possible consequences for national cultures and tastes, as well as fair competition.

Knowledge-Intensive Business Sector

Miles from PREST at the University of Manchester investigated the management of IP in knowledge-intensive businesses. These included accountancy, architecture and engineering design businesses and the researchers examined current practice to determine how IP was managed. With hindsight, it is clear that more funds should have been allocated to research on the service sector. As this project has only scratched the surface, a much more detailed study of the different business sectors is required. Nevertheless, the research showed that these businesses were innovative and used a wide variety of methods of protection. Miles suggests that they meld generic professional knowledge with client specific requirements to develop innovative solutions. Professionalism, supported by their professional associations, is a critical factor, as is trust between the consultant and his clients. Most firms do not use a formal system for protection of IP but consider it on a case by case basis.

Academic-Industry Interface

For many years, there has been a feeling that universities create a lot of valuable research ripe for development by industry. Tom

Weyman-Jones from Loughborough University disagrees as most of research is not "appropriable". Industry benefits most from the transfer of graduates, secondly from non-appropriable research spilling over from universities, and licensing IP is a poor third. There are many factors which inhibit the transfer of technology from universities. Most of the research undertaken by universities is not protectable through patents. Current university incentives work against the greater use of IP. Exploitation of IP depends on investment in marketing and evaluation of the market for specific research products. Most universities lack both expertise and funds for these activities.

Although the results of this research may not be welcome news for the funding bodies, it corresponds with the limited receipts from IP in the past. Industry spends about £16 million a year on royalties and licence fees in universities, much less than 1% of its expenditure on research and development. It is unlikely that companies would pay so little if much IP relevant to the market place already existed in the universities.

Conclusion

In the time available I can only refer to the key conclusions of the research programme and, hopefully, stimulate some discussion on an important subject relevant to most businesses. For more detail may I suggest you consult the summary written by David Fishlock and me, available from the IP Institute. This will give you details of the researchers, their addresses, web-sites and key publications. The take-home messages I want to leave you with are:

1. Patent counts are a poor guide to innovation in companies. Many companies manage their IP effectively by relying on informal methods.

2. IP management practices are specific to industrial sector and company size. Concentrating IP policy support on patents and copyright inevitably ignores the requirements of the majority of firms in the manufacturing and service sectors.

3. Universities are not a significant source of IP for exploitation by businesses. Their primary role is to produce high-quality graduates and new knowledge through basic research.

The Etan report 'strategic dimensions of intellectual property in the context of S & T policy'

Professor John Adams*

Strategic thinking behind the Report

Over the last year, an independent European Technology Assessment Network ('ETAN') Working Group, established by DGXII of the European Commission, addressed the question as to whether current approaches to intellectual property rights ('IPRs') were assisting or impeding S & T policy in Europe. Its Report which was launched on 6 October 1999, benefited greatly from the outputs of the ESRC Intellectual Property Initiative, because so little had previously been known about the way in which the IP system was used. Although in many ways the Initiative only confirmed what we had previously suspected, the value of having hard empirical evidence to support one's suppositions cannot be overestimated.

The Report is very far ranging, and attempts to provide European governments and the Commission with policy options which would improve on the present situation in the various member states of the European Union. Its approach differs greatly from that adopted in the recent Baker Report.

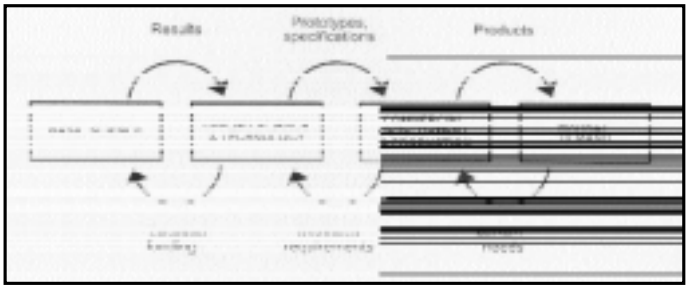
We distinguish between *formal* types of IP protection by registration – patents, utility modes and registered designs; and *informal* types of protection without registration copyright and neighbouring right protection for industrial designs, software etc, and trade secrets. In order to secure formal protection through registration, certain conditions must be fulfilled eg in order to secure a patent, an invention must be novel and involve an inventive step. Much information of value in the innovation process does not fulfil these requirements.

Overall we can summarise the strategic thinking behind our thesis as follows:

1. We believe that there has been too much focus on *formal* IPRs and the type of knowledge they protect;

2. that there needs to he a greater focus on the *people* who embody both formally protectable and *informally* protectable (and non-protectable) knowledge, *both* of which are important in the invention and innovation process, and on the way the interaction between people can facilitate that process.

The group was highly critical of the 'linear' model of the way in which innovation occurs. In this model, money is invested in HEIs/PROs which engage in basic research, and innovations filter down into the market place based on the outcome of that research. This model still has some validity in certain sectors such as pharmaceuticals, but it does not describe the way in which most innovations occur at the present day. This is the model our Report takes to be more relevant to innovation in a contemporary context and is one I understand most people here tonight will be familiar with:



Accordingly, what needs to be fostered is more *interaction* between those carrying out basic research in higher education institutions ('HEIs') and other research centres, in particular public research organisations ('PROs') and industry.

As noted above, we believe that there are dangers in overemphasis on patents. It may lead to the neglect of other elements which are essential to the innovation process.

In the final part of its Report the Group was concerned with three things:

1. Who should own IPRs resulting from publicly funded research;

2. Promoting a greater level of movement of personnel between the public sector and the private sector;

3. Encouraging greater entrepreneurship in all sectors.

1. To whom should the benefits of publicly funded research go?

Broadly, we feel that there has been too much inflexibility on this, and the efforts by funding bodies to secure a return on their investment have not been justified by the outcomes. As a general principle, we believe that ownership of the results, and responsibility for exploitation, should be left to the organisation carrying out the project, BUT subject to some basic obligations. These basic obligations may include the following.

1. That the owner of the resulting IPRs must either use the results itself, or grant licences with a condition that the licensee actually exploits the subject matter of the licence within a given period of time.

2. That the grantee may not use the exclusive rights obtained to

* *Professor of Intellectual Property, Faculty of Law, University of Sheffield*

obstruct other (publicly supported) R & D.

The advantages of this approach are:

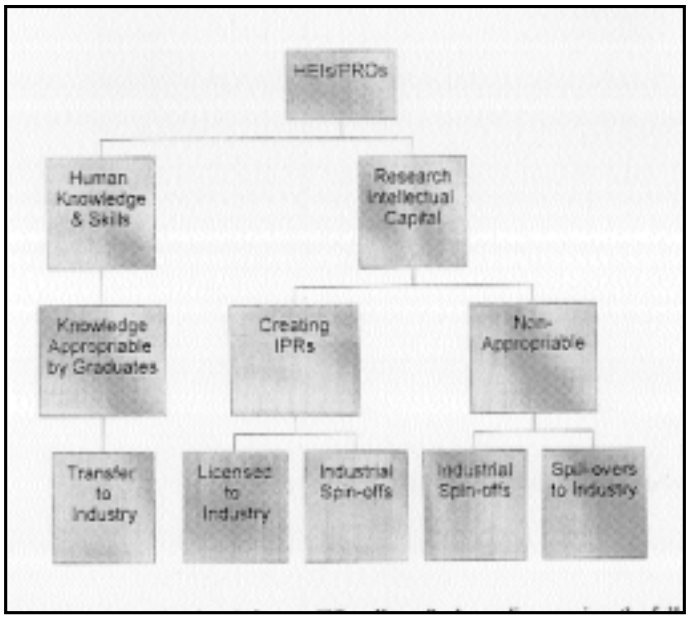
1. *High flexibility* allowing due account to be taken of the varying interests of the parties and of the particular nature of the project.

2. *Better motivation* for the exploitation of the results for both PROs/HEIs and industry. We also think it would encourage better and more valuable input into the projects and wider participation.

We also recommend that project proposals include a commitment to a detailed exploitation plan. The onus is thus on the IP *producer/owner* to push forward exploitation rather than passively (and even reluctantly) respond to enquiries from third parties.

2. Improving the role of PROs/HEIs in the innovation process

How institutionally funded research becomes appropriated by industry:



PROs and HEIs need to develop their own IPR policy. Such a policy requires the following issues to be addressed as follows.

1. Publication versus IPRs: a non-issue

- proper handling and sensitivity to the IPR issue would allow *protection* of research results without jeopardising early publication of research results.

2. Development of an IPR strategy: I. Establishment of a licensing policy. II. A distribution plan for licensing income.

Although commercialisation of research results alone probably will never form a major part of the income of PROs/HEIs, we think it is unacceptable to forego the opportunities which exist.

3. Researcher Mobility

A necessary complement to an IPR policy, if not an objective in itself, is to enhance the *mobility* of researchers. Science and technology policy should be attempting to encourage the mobility of scientists and other researchers between industry and academia in *both directions.*

Encouraging entrepreneurship

If inventors, innovators and entrepreneurs are discouraged from attempting high risk, high return, radical innovations, there will be a bias towards conservative, incremental innovation. Policies outside the 'science and technology policy' field are needed to change the cultural climate in favour of risk-taking to improve the mobility of researchers between parts of the innovation system. Accordingly, we would like to see a number of legal reforms in member states which would encourage more risk-taking.

Improving the fiscal environment

Research can be, and is, funded directly by government. But because governments operate at a distance from markets, this funding is not always well-directed. An alternative strategy is the use of tax incentives for undertakings to encourage them to invest in research.

Here are some examples of some improvements that could be made.

Adequate relief for *losses* arising from the acquisition of IPRs, and the carrying out of R & D

Scientific research allowances made available to firms buying in innovative research

Tax relief on investments in companies carrying out R & D

Deferring capital gains tax where the proceeds are reinvested in PRO research

A framework for the creation of security interests in IPRs

Raising finance is a major problem for PRO/HEI spin-off companies. IPRs are one mechanism for securing a loan, and one which is increasingly being considered by the accounting profession. Lenders need a simple mechanism by which they can create *Europe wide* security interests, but this does not exist. The system in place in the United States would provide a useful starting point for developing this.

Insolvency laws

The insolvency laws of many member states afford little protection to the entrepreneur. The United States' Federal Bankruptcy Code Chapter 11 is more favourable to entrepreneurship in that the debtor is afforded a 'breathing spell' at the outset of the insolvency case. This prevents one creditor such as a bank 'pulling the rug' from under the debtor company and the other creditors: it tries to keep the debtor company in business.

FOUNDATION NEWS

▲ *Jennifer Grassly, known to all who come to the Foundation's events, talks to Geoffrey Walker, an eminent orthopaedic surgeon.*

RAILWAYS IN THE NEXT DECADE

The Foundation held a lecture and dinner discussion on 21 June 1999 on the subject "Railways in the Next Decade- S & T and the Strategic Railway Authority". The Rt Hon the Lord Jenkin of Roding was in the chair and the evening was sponsored by Lloyd's Register of Shipping and Railtrack plc. The speakers were Sir Alastair Morton, Chairman, Shadow Strategic Rail Authority, Dr Peter Watson OBE, FREng, Chief Executive, AEA Technology plc, and Professor Tony Ridley CBE FREng, Head of Department of Civil & Environmental Engineering, Imperial College.

Sir Alastair Morton*

Summary: Sir Alastair pointed out that both passenger and freight traffic on the railways was at a higher level than pre-privatisation but that the railway system was using ageing rolling stock, obsolete signalling and so on. He concluded that it was a question of investment from seven sources that he listed. Dr Watson approached the subject from the viewpoint of the customer who wanted a punctual, reliable, safe and comfortable service. He argued for the increased application of technology.

Introduction

Someone asked me why I took on the burdens and high public profile of starting up and chairing this government's new Strategic Rail Authority. I replied that my 10 years working with André Bénard to get the Channel Tunnel financed, built and opened for business left me with a strong sense of "unfinished business" in Britain's railways.

1995-96, my final year at Eurotunnel, may have been spent torturing the world's banks, but over at British Rail it was a time of convulsion and fragmentation, labelled "privatisation" as BR was divided into 95 parcels, each to be sold or franchised to the public or the highest bidder. Like many others, I watched in fascination – how could a reliable, efficient and safe network come out of that process, even if private sector capital became more abundant?

Well, now I am technically Chairman of British Rail, though with no trains under my authority, I would like to say that it is all running a great deal better than I expected!

Many people will start and say "Doesn't the old chap read the newspapers; the railways are a disgrace and a disaster". Well, up to a point Lord Copper, says I to my political masters and their masters, the media.

To the dismay of railway enthusiasts, I sometimes liken our rail network to our sewerage system – confined to channels designed and built long ago, getting more dilapidated and nearer to capacity flow every year. In both railways and sewers, and for that matter motorways too, if an obstacle interposes itself – a tree branch in the drain, a crippled truck on the motorway or a defective signal on a busy rail route – then the flow backs up with disagreeable consequences for the user.

Back in 1989-90, traffic on the old BR peaked with the economic cycle. By 1995-96, the infrastructure was privatised as Railtrack; 25 operating franchises were segregated and in negotiation for separate transfer to the private sector. Traffic had risen above the low point of the cycle, say 1992, but not yet back up to 1989. Train builders were getting to the end of their 1,000 days without a single order. It was not a growth scenario.

Four years later, in the first quarter of 1999-2000, passenger traffic is 20% or more above the final year before privatisation, freight shows an even larger increase, over 1,000 extra trains are running every day. But the first new train sets ordered are just coming into service to supplement or replace clapped out rolling stock and a great deal more cash has flowed into replacement of clapped out infrastructure than into enlarging its capacity.

We have a growth scenario above and beyond the economic cycle. A modal shift towards rail has begun – with a very long way to go.

And our overloaded sewer, our deteriorating motorway, our clapped out rail system has any number of localised blockages in it – with very disagreeable backing up occurring more frequently! What a surprise!!

Attitudes and responses

Let me note three separate and important factors helping to form current public and political attitudes and responses.

First, is a remarkable rise in a complaints culture. In the old days it was useless to complain to BR. If you managed to get a complaint through to them, nothing would happen anyway – so why do it? Indeed, the public almost sympathised with managers caught between aggressive unions and an obdurate Treasury.

Now, however, we are very strongly invited to complain; we are furnished at every turn with guidance to complain; and, to our joy, we have absorbed the notion that our complaints can help bring punishment, i.e. fines, upon our tormentors on the rail system. Naturally, complaints have escalated at a rate far above the rise in causes for complaint on our increasingly congested network.

Second, of my ancillary factors informing public attitudes is the diversity of managements working, or failing to work, as a network under increasing pressure. There are 25 TOCs, there is Railtrack and its many contractors. Unsurprisingly, their managements vary in quality and skill, but our progress is hampered by the variations in the pace at which different boards expel poor managers. This complicates any attempt to give an overview. There is more, much more to be done to bring those promised benefits of higher paid private sector management skills into our rail system – and do it without rooting out the good parts of a very strong and in many respects sensible railway culture.

▲ *Dr Fiona Steele, a member of the Foundation's Council, chats with Dr Peter Watson, Chief Executive, AEA Technology, one of the speakers.*

* *Chairman, Shadow Strategic Rail Authority*

Third, of my complications is the profitability of Railtrack and most but not all the TOCs. It is like a red rag to the public bull to read of hefty Railtrack profits – £1.3m a day, we were told – or TOC profits just at the time when many people can supply so many war stories about poor service, and know that subsidies are a large element of those profits.

An overview

Those three factors complicate any readily digestible overview I can offer you – the complaints culture, the slow (although sure) pace of management change and the apparent profiteering from taxpayers' subsidies. Having noted them as I promised, let me return to fundamentals and look forward.

My chosen fundamental – no pun intended – is the sewerage analogy. Our aged, somewhat decrepit and quite substantially Victorian network, starved for 50 years of Treasury funding for improvement, is using ageing rolling stock, obsolescent or obsolete signalling and so on to support strong growth in traffic in the infancy of a strong modal shift into rail transport.

Can you imagine a simpler recipe for trouble? Our rail sewer is backing up, to our displeasure, as the flow nears current capacity over more and more of the network. We need, we absolutely need, more capacity offering a better quality service if we are to maintain the shift onto rail we so earnestly desire, to ease the strangulation of our roads. More and better supply of rail services. Very simple – it's fundamentally a question of investment, but investment in what?

What investment

Let me take one more detour before I respond to that question. It is into finance, so rather an important detour. There are only seven, I say only, groups of financiers of new capacity and improvement. There are:

- Railtrack, with its strong, quite large balance sheet;
- the 25 TOCs, a significant proportion of whom are parts of larger, much stronger groups;
- the rolling stock and other equipment suppliers, developing improved capacity;
- the major infrastructure maintenance companies, whose ability to deploy modern equipment is reduced by "cultural" practices;
- world capital markets as a source of long-term project finance into various structures of public private partnerships;
- Her Majesty's Treasury.

Six of those seven currently feed off the seventh, the subsidies from government – from us, the taxpayers – to the extent that revenues from fares do not cover costs. Thanks to the growth I have recorded, the developing modal shift, the 33% and growing decline in subsidy has been covered so far by rises in revenue earned. As a result, one can look forward to stronger financing from the six, as the Treasury pull-out reaches its term – at least for the busier routes. It is important that the City gets its mind round issues of longer-term capital investment. They are not good at it.

And so, finally, I come back to the basic question – it's all about investment, but in what?

The summary is simple, the delivery will be long, difficult and complex. It will take years to achieve what I ask, indeed as Chairman of the Strategic Rail Authority insist on. Heavy, slow-returning investment in larger capacity and better service on *and* access to the network.

First, Railtrack has to invest heavily in the upgrading and enlargement of the infrastructure. This is something quite different from maintenance, an operating expense. It will require project finance, project management and project delivery on a grand scale – often in cramped and difficult circumstances – mostly in replacement with modern equipment offering large capacity; and in debottlenecking, always a need in a production system reaching for an increased flow; and then in major new-builds of extra capacity – such as four lines to replace two, and so on.

Second, the TOCs – supported by leasing – must invest heavily in faster, longer and more larger-capacity rolling stock.

Third, both Railtrack and its principal maintenance contractors must equip themselves to deliver greater reliability with less disruption.

All the above add up to faster, higher capacity rolling stock moving more reliably and at a higher frequency around an enlarged network. Simple, isn't it? Though it is easy to agree it will take time and more than some good luck!

I do not believe the technology is lacking, whether we talk of track laying, signalling, rolling stock or control and communications. Delivery of the best technology almost certainly *does* require improvement – whether you look at the hesitant entry of moving block signals or the strange inability of rolling stock suppliers to deliver rolling stock that operates as reliably from day one as a new aircraft, or at a host of other bad stories.

So, Mr Chairman, we have a huge need for investment; there is sufficient technology somewhere in the world to make it useful, but, and it is a very big BUT, we are not yet positioned very we]l to finance and manage that larger flow of investment.

Let me not leave a misunderstanding: I am not just drawing attention to Railtrack's shortcomings. I do that, yes, because Railtrack, in my view, is not yet fully living up to the duties that accompany the privilege given it to make money under a very specific licence – let me read to you the key sentence in Condition 7 of that licence. It requires Railtrack to secure:

a) the maintenance of the network;

b) the renewal and replacement of the network; and

c) the improvement, *enhancement and development* of the network, in each case in accordance with best practice and in a timely, economic and efficient manner *so as to satisfy the reasonable requirements of persons providing services* for the carriage of passengers or goods by railway and *funders* in respect of the *quality* and *capability* of the *network*".

But, in addition to Railtrack, I draw attention as my final point to the new Strategic Rail Authority, already operating as a partnership of OPRAF, whose powers come from the 1993 Act, and the BR Board, whose powers come from the 1962 Act. The SRA will soon embark on what is likely to be a two-year journey through the jungles and swamps of negotiations with the TOCs, or rather their owners, aiming at:

- commitments to more and better services; and
- enhanced and focused capability of TOC owners to finance, or procure finance for the necessary investments.

Watch this space. We have to mobilise all seven of the financing sources I described earlier in this address.

If the parties succeed, Britain's modal shift towards rail will make a lot of progress in the coming decade. I submit: that it is very important we do succeed.

Dr Peter Watson*

Introduction

Considering the topic and the thrust of the four questions which guide the discussion, I wonder how often these issues have been raised in this or similar meetings. How many initiatives have been directed into this area – the ill fate tracked technology 2000 – DTI – None of the issues are new yet it is not obvious that we've managed to come to terms with the role of S&T in helping develop the railway service for many years. My experience only goes back to 1971, but I have detected little change. In other words this challenge problem is not new. Or to put it yet another way, it is not caused by, increased by or exposed by privatisation and the fragmentation of British Railways. That should not be a matter of dispute as it is clear that S&T or R&D was not a major consideration in the privatisation process.

So the challenge is to identify those aspects of S&T which can improve the service and, most important, to find a way for them

* *Chief Executive, AEA Technology plc*

to be implemented in a timely and cost effective fashion. Never forget that the railways are in a very competitive environment.

The questions:-

Q1 What can S&T offer to help reverse the historic decline of rail traffic?

A1 Not much without management commitment and the right management processes – processes dedicated to delivering continuous improvement.

Q2 Are there new technologies in signalling and information technology in control systems and rolling stock?

A2 Yes but the routes to implementation are long and arduous.

Q3 Can these technologies improve rail safely and improve track access?

A3 Yes but exploitation in this area require a strong, continued focus on improving what is already a strongly positive feature of rail travel – ie passenger safety. Track access and safety on the other hand is an area in which much development work is required.

Q4 Will the new S&T be imported or produced within the UK?

A4 From the point of view of the customer this hardly matters, but in any case the science and technology should be sourced worldwide. Let's learn from others. It should be located close to or from the supplier companies.

Customer requirements

Let's remind ourselves what the customers want. In the case of passengers this is relatively simple: A punctual reliable service. Timetable = facts not fiction.

Deliver the promise: they want clean, comfortable trains; they want frequent and reasonably quick services.

And, above all, they want these things at reasonable prices.

The list goes on and I'm sure my former railway colleagues could put it more succinctly but will agree, I'm sure, that I've picked out the most important.

How to achieve improvements

Hence, if the goals of the companies in the industry are to continuously improve the service they must address these customer requirements. In their never-ending search for improvement they will eventually stumble upon S&T like every other major industry. Incidentally, I'm not sure about the S. This is, after all, a pretty simple industry based on engineering.

What we must not do is to fall back into the habits of the past, though I do see some remaining signs. What I mean is the major initiative driven solution. Banish all problems by way of a major announcement of a new investment programme, a new rolling stock intention [note I didn't say order], devote lots of resources both internal and external to the development and spin it positively and then with time let it slowly disappear.

Too many resources have been devoted to projects that were never delivered, were never completed, ie 250, Class 48, Kings X, Heartlands etc. Let's learn from other industries and apply best technology to improve the existing, not abortive attempts to replace it.

Continuous improvement.

Small steps small wins. All of this will help improve one of the worst aspects of the railway industry. That is the relationship between the supply base and *their* customers or the procurement process.

If we drive the industry in the direction of the contracting industry, and there are signs, then abandon all hope of consistently successfully exploiting S&T. We must go in the opposite direction towards trust, towards partnership, towards stable profitable relationships between the supplier and his customer. Towards a mature mutually dependant relationship based on trust and success. Easy to say, but obviously not easy to deliver. But I have no doubt that without such a structure S&T will never be fully exploited in this great industry and we will fail to achieve continuous improvement.

No one company can do it alone, because exploitation of technology is a long arduous process requiring constancy of purpose and solid commercial relationships aimed at sensible financial returns.

Having agreed that S&T development is necessary, where should we expect to find it? I've got 11 candidates:

Government Programmes: No; SRA Programmes: No; Railtrack: Yes; Railtrack Suppliers: Yes; TOC (competition): No; TOC Suppliers: Yes; ROSCOS: No; ROSCOS Suppliers: Yes; ROSCOS Suppliers' Suppliers: Yes; Non-railway Co's: No, but; Universities: unlikely, but not without hope.

Let's step back. If the objective is to run a service that the customer wants, ie: punctual, reliable, safe, comfortable, all at a reasonable price, then my experience tells me (1) keep back from the leading edge; (2) make technical progress slowly; (3) avoid the new/new combination.

The real questions is: How strong and widely distributed is the commitment to improve performance? If there is a strong commitment from Board Chairmen to most junior employee in every railway company, then we have a chance, and S&T will play a role. If that commitment isn't there then S&T will attract some interest and investment; there are always enthusiasts, as it always has, but it will not be effective in improving performance.

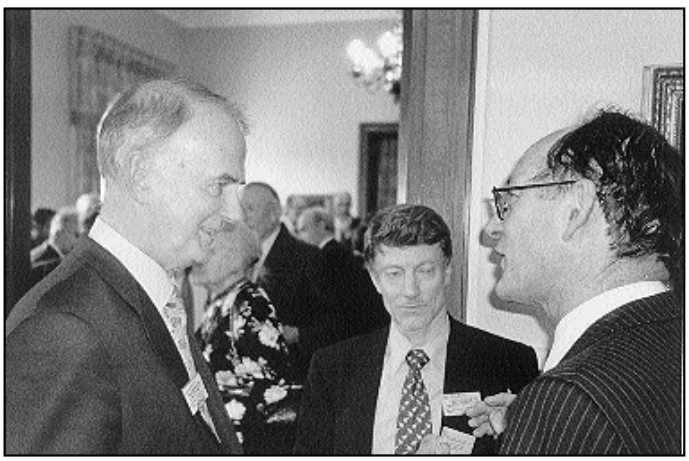
Why not? S&T on its own gets you nowhere. It's the old invention/innovation theme. The development or exploitation is the problem. Unless there is a way forward then S&T will not play a lead role.

Let me go back to procurement. The procurement practice of the 1950s was very slow, ponderous and defensive, ie typical public sector.

That's a description of BR B in the 1980s and 90s, but has much changed? Is procurement a major part of each company? Is there a group of skilled procurement professionals high up in each organisation? After all, most of the companies buy in much of their costs. Is there a commitment to assist the suppliers to improve their offerings? Is there sufficient trust to enable them to invest long-term? We'll need 'yes' answers to most of those before conditions are right.

So what do we need in place in order to improve the service through S&T development?

i) Commitment from the top to continuous improvement in every company
ii) Commitment to exploiting S&T as a contribution to this improvement in most companies
iii) Commitment to partnership in every company
iv) Understanding that progress will be slow – this is a hard industry to change – the practical barriers to change are considerable
v) Search from the very best ideas and technologies – we need to keep our heads up
vi) Expect all players to play a role
vii) Base procurement decisions on commitment to innovation
viii) Encourage long-term research into Railway Technology in Universities – a role for Government
ix) Avoid 'commitment without cost', eg ATP → TPWS



▲ *Sir Alastair Morton (left), Chairman, Shadow Strategic Rail Authority, was one of the speakers at the event.*

x) Link all technological developments to business exploitation plans

xi) Look for short-time winners, ie demonstrators of success; in other words, build up trust.

And, finally, focus all towards the most important person in the industry – Who's that? Not John Prescott, not SRA Chairman, not Railtrack Chairman. It's the guy who buys the ticket or pays the freight charges. Let's keep them in view. Let's strive for continuous improvement. Let's harness all our skills and look to S&T to deliver the improvements they deserve.

That's how I see S&T and railways in the next decade.

RETHINKING RISK

We recently received a copy of an interesting report by Dr Andy Stirling, Fellow, Science and Technology Policy Research, Sussex University. The full title of the report is "Rethinking Risk: a pilot study of a multi-criteria mapping of a genetically modified crop in agricultural systems in the UK". Although the study did not seek to impose an artificial consensus on the diverse set of views on this difficult subject, it did allow a series of quite concrete conclusions to be drawn concerning agricultural and regulatory practice. The following article is based on a summary prepared by Dr Stirling.

Application of a novel technique to GM crops

Dr Andy Stirling*

Introduction

The prospect of genetically modified crops and foods has become a political hot potato in Britain. Food industry executives, government advisors and biotechnologists have all been caught unaware by the strength and persistence of public concern. In such an overheated political arena, how can highly polarised disputants engage in constructive debate?

This innovative pilot study showed how people with very different perspectives can participate constructively in discussion and regulatory appraisal, In this project, funded by Unilever, twelve specialists – including highly placed government advisors, biotechnologists, and representatives of public interest groups – together helped to create a "map" of the debate surrounding GM crops.

The findings suggest that multi-criteria mapping can provide an illuminating and reliable reflection of the issues at stake in any controversy.

Emerging common ground

In the pilot study, disagreements were prominent, as expected, but surprising areas of agreement emerged as well:

Dissatisfaction with the status quo emerged as clear common ground: all the participants judged conventional intensive cultivation to be performing poorly;

Across all perspectives, the organic option performed relatively well, not only under environmental criteria (where it performed unequivocally well), but also more broadly;

Participants also largely agreed that a voluntary controls regime for GM crops would perform worse than other regulatory approaches.

These findings accurately reflect many established and some currently emerging trends in the debates surrounding both GM crops and organic agriculture.

What is multi-criteria mapping?

This technique is a systematic and transparent way of comparing policy options. It can tap into a wide range of perspectives and expertise, and produce an overview that "maps" the debate. It does not attempt to foreclose deliberations by coming up with a single solution, but seeks rather to foster the exploration of alternative outcomes. It carves a middle way between highly technical, purely quantitative analysis and qualitative, discursive approaches. It combines the transparency of numerical approaches with the unconstrained framing of discursive deliberations, harnessing the best of each approach.

Who participated?

For this pilot study, twelve individuals were recruited, chosen to reflect a wide range of institutional interests and perspectives. Their starting points ranged from strongly favourable to strongly opposed to GM strategies. Four worked in agriculture, plant biotechnology or the food industry. Two were academic scientists and two were government safety advisors. Four others represented religious and public interest groups.

How does it work?

It's as though participants were each given a big bag of beads to distribute across alternative options, depending on what's most important to them. At every point, the participants are in the driving seat.

First, participants choose "options" or alternative scenarios – in this case six ways that oilseed rape might be grown on farms in the UK.

An interviewer equipped with a lap-top computer and an audio tape recorder guides each participant through the appraisal process, which takes between two and three hours. Participants were asked to compare the performance of six basic alternative scenarios, and could also add six more of their own (see Table 1). These alternative scenarios are called "options". The six basic options in this exercise were organic agriculture, integrated pest management and conventional agriculture – all without GM crops – and three GM options: incorporating either segregation and labelling of the GM produce, post-release monitoring or voluntary controls on areas of cultivation.

Defining criteria

Next, participants list their "criteria": all the things they would want take into account in order to evaluate how best to fulfil a particular objective – in this case, the growing of oil seed rape.

Participants had a free rein, and could specify up to 12 criteria. Popular criteria included the use of chemicals, the impact on wildlife, human health and safety and cost to consumers. But many other considerations also come into play – with a total of 117 criteria in all – including issues such as biodiversity, genetic pollution, social benefit, cost to consumer and weed control options. In the final analysis, these criteria were grouped into broad categories – such as environment, health and economics – to give a qualitative picture of the major issues regarded as relevant by all the participants (see Table 2).

** Fellow, Science & Technology Policy Research, University of Sussex*

Table 1. Basic options and those added by participants

BASIC OPTIONS
No GM crop, organic agricultural system
No GM crop, integrated pest management system
No GM crop, conventional agricultural system
GM crops, with segregation and current system of labelling
GM crops with post-release monitoring
GM crops with voluntary controls on areas of cultivation
ADDITIONAL OPTIONS
1. LABELLING AND/OR OTHER CONTROLS
Government advisers
GM crops with segregation, current labelling and post-release monitoring
Religious & public interest groups
GM crops with segregation, full labelling and post-release monitoring and legally binding growing contracts
GM crops within controlled sectors (compulsory control)
GM crop, with legally binding threshold for gene transfer to non-GM stream
GM crop, with segregation and labelling according to means of production and source of gene, plus post-release monitoring
GM crop, with segregation, comprehensive labelling based on process and generic restrictions on some classes, eg in centre of origin
Agriculture & food industry
GM crops with segregation, full labelling and post release monitoring
2. AGRICULTURAL SYSTEM
Government safety advisers
GM crops, IPM system
GM crops, organic agricultural system, plus segregation, labelling and other regulations as required
Religious & public interest groups
GM crops, IPM system
Agriculture & food industry
No GM crops conventional and organic as now
GM crops in conventional and organic systems
3. ASSESSMENT CRITERIA
Religious & public interest groups
GM crops with assessment of indirect agricultural impact and assessment of need
Agriculture & food industry
GM crops with quality traits
OTHER
Academic scientists
Complete public control over choice
Religious & public interest groups
GM crops only in USA
No GM commodity crops

Assigning scores

In the next step participants judge how well the options perform in the light of each evaluation criterion.

This is the "scoring" stage. Participants were asked to assign a number in the range of 1 to 10, or 1 to 100, to each option under each criterion. For example, because no pesticides are used, the organic option will score highly under a criterion of pesticide use. Conversely, depending on technical judgements about economics, the same option will score differently under a cost criterion. Participants were also asked to give a measure of how uncertain or variable they felt matters to be by giving both an optimistic and a pessimistic score.

Adding weightings

The final step is to add "weightings": participants are asked to look at the criteria again and rank them in order of relative importance, from most to least important.

Participants could also vary the scale, by deciding that one criterion, say pesticide reduction, is 10 times more important than is cost to consumer or vice versa. To do this they also had to take account of the difference in performance between the best and worst options under each criterion. Deep seated subjective value judgements – for instance, the importance of wildlife or landscape, compared with farmers' income or human health – come into play in this step.

The grand finale

Using a simple formula, the scores under each criterion are multiplied by the criteria weightings to produce an overall pessimistic and optimistic relative ranking for each option.

Each person's appraisals are quickly calculated on the computer and displayed in a series of bar charts. The appraisal process is iterative and reflexive: participants were free to examine the results and decide to go back and alter weightings or include new options or criteria. The perspectives adopted at any one moment are not irrevocable, so participants are able to trust that particular weightings will not become reified, manipulated, or taken by political adversaries as hostages to fortune. Remarkably, no-one wanted to tinker with their results: the technique appeared to produce a robust reflection of peoples' evaluation.

What the pilot study found

The method works well even in a hotly disputed controversy. This approach included a diverse group of participants. In itself, this ability to secure wider trust and engagement in appraisal may count as a particular feature of this approach.

It brings in a brood range of perspectives. This project drew on a wider range of specialist perspectives than do orthodox risk assessment exercises.

Its transparency helps build trust. Anyone can go back through the numbers to see how a particular outcome was reached, and alter those scorings and weightings if the outcome does not accurately reflect their judgements. There is no sleight of hand hidden in the simple mathematics

Highlights areas of both disagreement and agreement. Significantly, multi-criteria mapping is capable of producing surprises: notably, that *across a broad range of perspectives the organic option performs very well*.

The initial choice and definition of criteria drives the end results. Assessments were most strongly influenced by each participant's early "framing" of the debate, rather than the weightings assigned later. This finding stresses the importance of ensuring that the entire spectrum of values and interests are represented. Yet many criteria chosen by the participants in this study lie outside the scope of official risk assessments, and for no participant is their whole range of criteria explicitly considered in the formal evaluation process of GM crops in the UK.

Uncertainty is acknowledged. The technique's pessimistic and optimistic ratings indicate how confident people are about the present state of knowledge and show that uncertainty is much more of a live issue for some participants than it was for others.

All sides of the debate support diversity in options – not putting all the eggs in one basket. However, GM and organic farming strategies are widely seen to interfere with each other and so appear to be mutually inconsistent. If the benefits of diversity are to be reaped, then options which compromise an ability to pursue other strategies in the future may be regarded unfavourably

Why multi-criteria mapping?

Conventional approaches tend to assume that decision makers can know in advance all relevant details and how important each is, and that consequences of action are always predictable. Yet usually we cannot know the future, and so forecasting is essentially subjective and unreliable. And even when information and assump-

Table 2. Criteria groupings

ENVIRONMENT
12/12 participants had at least one criterion addressing issues of: • biodiversity • chemical use • genetic pollution • secondary or broader effects • unexpected effects • ethical, aesthetic and visual
AGRICULTURE
10/12 participants had at least one criterion addressing issues of: • weed control • food supply stability • agricultural practice
HEALTH
11/12 participants had at least one criterion addressing issues of: • allergenicity • toxicity • nutrition • unexpected effects • manageability
ECONOMIC
10/12 participants had at least one criterion addressing issues of: • consumer price benefit • farmers' or commercial users' benefit • society benefit
SOCIAL
8/12 participants had at least one criterion addressing issues of: • individual choice, need • benefit and participation • institutional demands • social need, benefit and trajectory
OTHERS
4/12 participants had at least one criterion addressing issues of: • ethics • knowledge base

tions are held in common, there is no reason to believe that there can only ever be one rational response. Multi-criteria mapping can acknowledge and take on board both uncertainty and a plurality of possible outcomes. It actively encourages the exploration of alternative solutions.

In addition, this technique can help to bring into deliberations the many disparate perspectives held by different constituencies throughout society. In the 1960s, the Nobel-prize-winning economist Kenneth Arrow demonstrated (in formal mathematical terms) that there can be no one solution to a social controversy – no uniquely rational way to resolve contradictory perspectives, divergent values or conflicts of interests. In other words, no purely analytical procedure can substitute for democratic political process. Multi-criteria mapping does not attempt to usurp the role of due political process in the resolution of technoscientific controversies. What's more, because the technique can reflect broader views and values, it has a greater potential to inform democratic decision-making than do "scientific methods" alone.

Strengths of multi-criteria mapping

Pluralistic: it is possible simultaneously to contemplate several alternative solutions:
More realistically reflects multi-dimensional nature of reality
Pragmatically acknowledges uncertainty and the role of subjective judgements
Open-ended and reflexive, allowing for continual appraisal and review
Transparent and accessible, open to independent critical scrutiny and wider public participation

What next?

Multi-criteria mapping is an aid to deliberation and reasoned judgement. It is one way of elaborating scenarios and systematically clarifying the parameters of any policy decision that has to be taken under conditions of indeterminacy in nature, ignorance in our state of knowledge and plurality of values and interests. It encourages a multiplicity of perspectives and option spaces. In a discussion paper, the secretariat of the government's Advisory Committee on Releases to the Environment recently stated that "the present legislation does not take a strategic approach to regulating GMOs" and concluded that "the mechanism which allows the best environmental options to be identified needs to be developed".

When apparently simple verdicts of "safe" or "safe enough" fail to reassure the public, multi-criteria mapping might be a boon to decision-makers seeking both political legitimacy and democratic accountability. As *The Economist* commented recently (29 May 1999, p. 37), "After BSE, simply quoting scientific authority is no answer to the conundrum of public trust. What impresses the public in these matters is transparent and impartial decision-making based on wide consultation." The multi-criteria mapping technique enables politicians and civil servants to foster greater confidence that all relevant criteria have been considered at some point in any evaluation process.

This pilot project could usefully be expanded in scope in two directions. First, the technique described here could be developed to allow for *greater interaction and deliberation between the participants.*

Secondly, a dimension of public participation can be introduced by establishing *citizens' panels* selected on a regional basis, by age, sex or some other basis to bring different lay perspectives into the debate. The panels can identify additional options, criteria and weightings themselves, and also invite a variety of specialists to score criteria under various options. Such further studies that include wider publics are needed to identify any contrasts with the specialist arena and to confirm and enrich the map of the overall GM debate.

Industry and government bodies may find multi-criteria mapping to be a useful tool in a variety of different contexts. It can provide an important input to the "expert review" stages within regulatory processes, or enable companies to explore the implications of alternative R&D directions. At an early stage in development it could play a useful role in many aspects of the innovation process, as a way of identifying the broader social implications of new products or new technologies.

Of course, tools like multi-criteria mapping can only ever be a part of the solution to the difficulties of social decision making over technological risk. However, this technique does bring to the technology appraisal process a combination of the benefits of inclusive and deliberative approaches and the discipline and transparency of quantitative techniques. Such an approach may now be important in helping to garner widespread public support for decision-making in the political arena on new technologies like GM crops.

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