TECHNOLOGY INNOVATION AND SOCIETY

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TECHNOLOGY, INNOVATION AND SOCIETY

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THE FOUNDATION GOES TO JAPAN

An overall impression by Mr David Firnberg FBCS

In April 1998 the Foundation provided a high level contribution to the year-long UK Festival '98 in Japan. This was the first time the Foundation had ventured beyond Europe and the party consisted of 22 members led by the Chairman, the Rt Hon the Lord Jenkin of Roding. In addition to industrial and academic research visits there were two main events. On Tuesday 21 April an all day Symposium and Workshop in the Japan Academy co-organised by the Foundation, the Japan Society for the Promotion of Science and The British Council considered the 'New Partnership between Universities and Industry in the 21st Century'. The keynote speakers from the UK were Professor George Gray, CBE, FRS, FRSE, Research Consultant, Merck Ltd, and Professor R F Boucher, FEng FIMechE, Principal and Vice-Chancellor, UMIST. In support there were three UK panellists: Dr Kenneth Edwards, Vice-Chancellor University of Leicester, Dr Brian Newbould, Chairman UK Japan High Technology Forum, and Professor John Sizer CBE, Chief Executive Scottish Higher Education Funding Council.

On Wednesday evening 22 April there was a Foundation dinner discussion at the British Embassy, hosted by the Ambassador Sir David Wright. Here the topic was 'Company Innovation and the Role of Government'. The initial presentations were given by Dr Geraldine Kenney-Wallace MD and Vice-Chancellor of the BAe Virtual University, and Mr Tsuneo Nakahara, Executive Advisor to the CEO of Sumimoto Electric Industries Ltd. After dinner there was an additional presentation by Professor Sir Robert May, the UK Government Chief Scientific Advisor.

Throughout both events there were substantial contributions from and active participation by many distinguished Japanese academics and industrialists leading to much lively discussion between the British and the Japanese. In this article David Firnberg presents an overall impression rather than a report on the individual meetings.

Summary: Active University Industry collaboration in the UK contrasts with Japan where until the recent Basic Law it was difficult for Japanese Universities to collaborate with industry; this is changing slowly. The Japanese were more disciplined than the British about registering patents, but both countries had problems with IPR for university work. Exploitation of science and technology requires an informed public, ethical standards and trusted institutions.

Twelve hours in the air. Twelve hours which encompassed day, then night, then day again. The tomorrow of today. Tokyo morning!

Opening of the symposium

'There has been a long and distinguished history of scientific exchange between Britain and Japan, and Britain is today one of the countries of Europe to which the Japanese feel the closest affinity'. Mr Teiichi Sato, Vice Minister of the Japanese Ministry of Education, Science, Sports and Culture (Monbusho) gave this greeting at the opening of the Symposium.

In the last century much of the Japanese infrastructure was provided by Britain; indeed, in the 1870s Henry Dyer from one of the forerunners of the University of Strathclyde was invited to establish the Imperial College of Engineering in Tokyo. In 1886 this became the Faculty of Engineering in the University of Tokyo, arguably the world's first Engineering Department. This provided a cultural impetus to the concept of engineering and technology in Japan that helped lay the foundation for 'diligent engineering' which contributed so much to Japan's economic success.

Japanese cultural traditions of courtesy and respect for one's elders has been carried through into applications of the new technologies. Not only is bowing the normal greeting, with the level of bow symbolising the standing of two parties, but throughout the magnificent New Otani Hotel, where most of the group stayed, there was a generous supply of 'bow girls'. At either side of the main entrance, at the lifts, and wherever visitors were likely to congregate, 'bow girls' were there to give their deferential greeting.

During the tour of the Toshiba Science Institute we were treated to a demonstration of precision by two robots: one presented a samurai sword, sharp edge uppermost, onto which the other accurately placed a spinning top. Once we were all suitably impressed. The two bowed sufficiently low to indicate deference, but not so low as to indicate inferiority! When buying a ticket at the station in preparation for experiencing the Japanese underground 'crush hour', one has to interact with a ticket dispensing machine. Select the destination, insert the money and the ticket emerges. This is followed by a cartoon 'bow girl' on the display screen!

Lord Jenkin explained at the pre-visit briefing that by providing a scientific input to the year-long UK Festival '98 in Japan, the visit was intended to complement the cultural events by demonstrating the excellence of British research, emphasising that Britain takes science and technology extremely seriously and seeks to continue and extend the existing fruitful collaboration with Japan.

The Chatham House rule was exercised throughout and this encouraged a remarkably open and free discussion on both sides. Comments are only ascribed to individuals in this article if they appeared in some document.

University / industry co–operation

The Japanese showed great interest in the descriptions by Professor Bob Boucher and Professor George Gray of research funding and the British approach to university-industry collaboration. One British academic claimed that "Easily the most important advantage to a company of a company-university partnership is the convenient access to lively people with interests similar to those of the company". There was much discussion about the contrasting approaches in Japan and Britain to this collaboration and the Japanese were keen to

Pictures from Japan

(left) Sir David Wright KCMG LVO welcoming the Foundation and guests at the British Embassy in Tokyo for the lecture and dinner discussion: "Company Innovation and the role of Government".

(Right) Sir Robert May, Chief Scientific Advisor, addresses the Foundation's lecture and dinner discussion, hosted by Sir David Wright (Picture courtesy of Mr David Firnberg)

◀ *Mr Tsuneo Nakahara, Sumitomo Electric Industries, and Dr Geraldine Kenney–Wallace, managing director and vice–Chancellor British Aerospace Virtual University, gave introductory talks at the Foundation's lecture and dinner discussion on "Company Innovation and the role of Government". The Rt Hon The Lord Jenkin of Roding, Foundation chairman, is centre.*

◀ *After Dr Hiroyuki Yoshikawa, Dr Yasutsugu Takeda, Professor George Gray and Professor Bob Boucher had spoken at the main symposium held in the Japan Academy, a British panel of The Rt Hon The Lord Jenkin of Roding, Professor Kenneth Edwards, Dr Brian Newbould and Professor John Sizer (lower picture), and a Japanese panel of Mr Shiuchi Saba, Professor Makoto Nagao, Dr Azusa Tomiura Mr Tadashi Amemiya (upper picture) raised questions and comments to stimulate discussion.*

learn about the British experience.

During the visits to the University of Tsukuba and the Tsukuba Advanced Research Alliance (TARA) it was explained that TARA was formed to help the University of Tsukuba develop industrial S&T links and support the exploitation of university research. In Japan this is a unique approach and contrasts with British Universities, almost all of which have some formal industrial liaison function.

One distinguished Japanese academic and university president, however, was not wholly convinced that the Japanese should follow the British model. Whilst acknowledging the importance of university-industry collaboration, he felt greater emphasis should be given to university-society partnership. 'Industry', he said, 'does not have a wide social view'. He was also concerned that money received for contract work would restrict the freedom of the academics to submit papers on their findings. A Japanese industrialist commented that company people were wrong when they claimed that university research was irrelevant. Opportunities arose from intermediate- and long-term research for spin-off innovations but these needed early evaluation and imaginative management. "University research should be assessed against social values and its contribution to the nation's economy or advances in the science of the world", suggested another.

The view that on the whole in Japan professors were not interested in industry gained general support and a prominent Japanese industrialist was somewhat sceptical about the potential for collaboration as he felt that there was a mis-match between industrial and academic research objectives. The Managing Director of a Japanese laboratory in Europe supported this, adding that Japanese universities were directed towards responding to public concerns whereas the British were driven more by financial considerations. It was felt that this might change as under the influence of the second stage of the UK Foresight programme there would be a greater emphasis on quality of life issues.

There were other important differences between the Japanese and British approach to science and technology (S&T). In his briefing to the group Brendan Barker, Science Officer of the British Council in Tokyo, contrasted the Japanese reputation for the successful application of S&T with the British reputation for creativity. He explained that the current emphasis in Japan, through the Basic Law and Plan, is to enhance creativity, whereas in Britain the emphasis is on enhancing relevance. Further, in Japan there has been a substantial increase in public funds for S&T, whereas in Britain funding is at best in a 'steady state'.

Professor Boucher explained that the success of British universities in forging links with industry is helped not only by their independence which encourages institutional innovation, but also by government support schemes, by an increasing acknowledgement in industry of the value of such collaboration and the squeeze on research funding. Dr Ken Edwards, Vice-Chancellor of the University of Leicester, supported this and emphasised the considerable freedom enjoyed by individual professors in Britain. Not all universities necessarily benefit, and Dr Sue Ion F Eng, Director of Technology Development at BNFL, explained that there was a trend among larger companies to reduce the number of universities with which they work in order to achieve economies of scale which can benefit the university as much as the industrial partner.

In Japan it is different. Many universities are state owned and academic staff are civil servants. Until the Basic Law it was difficult for academics to work with industry or make facilities available for collaborative research; in addition, industry did not generally respect the quality of much of the academic research. The Basic Law as well as the new initiatives in a 1997 Monbusho White paper eased these restrictions and made substantial research funds available. However, the cultural obstacles remain and industry finds it easier to collaborate with research centres in British universities with well over 100 Japanese R&D centres already established in the UK.

The collapse of the 'bubble economy' is reducing the level of private sector research, especially basic research, and this may lead to greater reliance by industry on basic research in universities.

Until the Basic Plan government funding for university research in Japan was spread thinly throughout the university sector and awarded on the basis of seniority, linked to the institution. In Britain there has been a history of building up centres of excellence and supporting able individuals and teams, reinforced by the research assessment exercise.

The Japanese 'Basic Law and Plan'

There was considerable interest amongst the British of the opportunities which might arise through the recent 'Basic Law and Plan' which were giving new impetus to S&T in Japan. The Science and Technology Basic Law was enacted in 1995. This requires action plans to be implemented and the first of these Basic Plans was published in 1996 covering the period to the year 2000. The Law and Plan are a major component of the national policy to convert Japan from a 'catch up' to a 'leading edge' economy. The law marked a sharp change in the Japanese government's attitude to science and technology policy. Key points include a doubling of R&D expenditure, the creation of centres of excellence, encouraging co-operation internally and internationally and promoting the public understanding of science and technology. One side effect of the new arrangements has been that whereas a professor might get a substantial increase in the research budget and extended research facilities, there remain restrictions on recruiting more research staff. In describing the current situation in S&T in Japan Yasutsuyu Takeda, Senior Executive Managing Director at Hitachi, used the phrase "Big Bang" in science and technology to explain moves in Japan towards the "reconsideration of conventional systems and the introduction of revolutionary change in them according to global standard values".

One member of the British team expressed some concern. He noted that the Plan was full of good intentions for significant changes in the relationship between universities and industries but he wondered if and when these would come about as they will require a cultural change in the universities. He asked those present what they would do that would be different as a result of the Basic Plan?

The President of a Japanese laboratory responded that there had recently been some small signs of change. Professors now can, and a few do, act as consultants; however, the management and financial structures of the universities need to change, and this is slow in coming about. He explained that many Japanese banks have been established in London because of the environment of de-regulation and, similarly, Japanese industry forges links to overseas universities because of their freedom. When asked why Hitachi had invested in research facilities at Cambridge, Yasutsuga Takeda said it was because they liked the professor concerned, valued their freedom of action and respected the reputation of the laboratory. He was encouraged by Professor Howie, a former director of the Cavendish, who was reported as saying, "The present research, within the collaboration, was the most satisfying work currently being carried out in the Cavendish Laboratory. The basis for good collaboration was trust and the scope for wider impact research".

There was some discussion on the question of research assessment and the importance of striving for global standards. Indeed, it was felt that despite the costs involved there was an increasing need to involve international assessors. A Cancer Charity was described which used only international assessors for research proposals. Although Japanese academics acknowledged that research assessment should be undertaken by a variety of people with a variety of viewpoints and that research should be multi-disciplinary, the use of international assessors was quite rare in Japan.

IPR and Universities

At a symposium in New Jersey on university-industry collaboration it was clear that the need for universities to protect their IPR in order to raise funds inhibits collaboration with industry. There was general agreement that ownership of IPR from collaborative research was an important issue. One British Research Director explained that

although in the past British scientists considered research results should be available to the international community, British universities now take a more disciplined view, influenced by industrial collaboration. This was reinforced by a professor who explained that the UK trend is for research-based universities to commercialise their own IPR. In general, industry is content for universities to retain IPR as long as they can have an extended period of exclusivity on its use. It was emphasised that these matters need to be addressed early when collaborative arrangements are being negotiated, and for trust to be generated between the two sides. It was felt that further discussion on this between Britain and Japan would be beneficial.

Impact of globalisation

As a result of increasing globalisation in S&T research as well as S&T markets industry seeks the most appropriate country for their investment in R&D and manufacturing. This 'hollowing out' of the home base increases the need for local innovation and the creation of new high-tech industries. University and industry collaboration makes an important contribution to this. Other pressures include the ageing society, which is particularly acute in Japan with a sharply falling birth rate; the pace of scientific innovation and the emphasis being placed on the sustainable environment.

Globalisation and progress in S&T raise new issues of international regulation and the formulation of ethical standards. Public understanding of S&T and their trust in national and international regulatory institutions will do much to further effective applications. The Basic Plan acknowledges internationalisation of Japanese science and technology as a priority and there is much to be gained by both Britain and Japan through scientific collaboration as equal partners in facing the opportunities and challenges of the future.

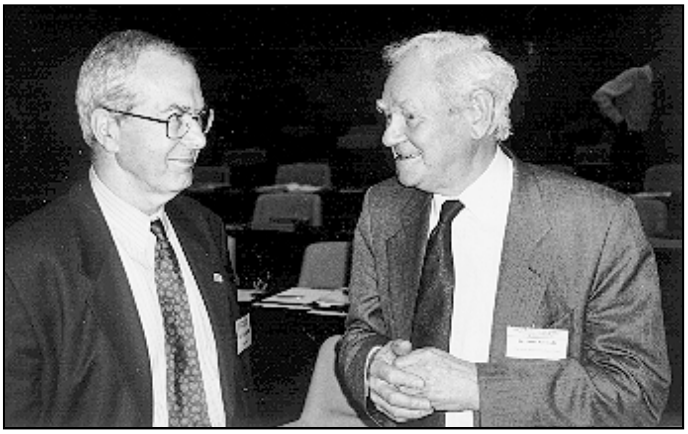
During all these discussions the outside world maintained its momentum of 'progress' towards something, sometime (some form of 'world order' perhaps), despite the hot house debate on science and technology, university and industry. The world financial authorities continued to 'advise' the Japanese government to increase the pace of deregulation. Prime Minister Ryutaro Hashimoto and President Boris Yeltsin, during his state visit to Japan, sought a peace agreement by the year 2000 through an agreement on the long-standing territorial dispute over the four islands off the eastern coast of Hokkaido; each proposed a compromise which the other undertook to consider (one suspects that neither had any intention of accepting the other's proposal!). An environmental scandal was uncovered with a garbage incineration company discharging dangerously high levels of dioxins into the Inagawa river. Tokyo remains one of the safest cities in the world, but there was a familiar ring about the report that elderly people living alone had been cheated by men disguised as electricity or gas inspectors.

Conclusion

By the end of the visit those who took part, research leaders in academia and industry, science and technology and Britain and Japan had all gained a deeper understanding of each other's experience and all agreed that we must strive for applications of science and technology through university-industry collaboration which will help solve some of the world's problems. "Today's rapid pace of change and innovation is turning the world upside-down, transforming industry, economics and society itself", explained Mr Shoichi Saba, Supervisor of JSPS and former Chairman, President and CEO of Toshiba Corporation, "History reminds us that science is one of the most powerful tools we have for finding solutions that contribute to social improvement. The rational approach of science and the solid achievements of industry have always broken through old conventions and opened up new worlds to a higher quality of life".

▲ *Professor Bob Boucher, Professor Ken Edwards and Mr Patrick McHugh caught on camera during the symposium (picture by courtesy of Mr David Firnberg).*

▲ *Three young British scientists working in Japan attended the symposium with the Japan Society for the Promotion of Science and the Foundation at the Japan Academy in April 1998.*



◀ *Mr Mike Barrett, director of the British Council, Tokyo, with Dr Brian Newbould, a member of the Foundation's team at the symposium in April 1998. The British Council gave much support to the Foundation, making it possible to organise and hold the symposium.*

THE DIGITAL RACE TO THE HOME

The Foundation held a lecture and dinner discussion at the Royal Society on 14 May 1997 on the subject "The Digital Race to the Home: Winners and Losers". The meeting was chaired by The Lord Butterworth CBE DL and sponsored by Science Systems and SGS-Thomson Microelectronics. The speakers were Dr Alan Rudge CBE FEng FRS, Deputy Managing Director, British Telecommunications plc, Dr Abe Peled, Chief Executive Officer, News Digital Systems, and Mr Huw Jones, Chief Executive, S4C.

Dr Alan Rudge CBE FEng FRS*

Summary: Dr Alan Rudge discussed the opportunities and challenges of the digital multimedia era for all the players, BT's strategic response to these and the key role seen for digital broadcasting in providing affordable interactive services in the home. Dr Peled gave facts and figures on digital broadcasting and the likely trends and applications. Mr Jones, using S4C as a microcosm, showed how digital broadcasting might develop in the future. He believed, just as technology had energised the music industry, digital television had enormous potential.

Introduction

Over the past few years topics such as the Digital Revolution, Superhighways and Multi-media have received increasing attention from the world's media. Unfortunately, amongst this there has been a good deal of hype that has inflated expectations by confusing what is technically possible with what is feasible on a commercial basis. There is no doubt that the new digital technologies can make possible many exciting new services delivered directly into the home. However, the real challenge is to identify the right services and to provide them on a viable economic basis.

In the introduction of new services, the cost of the terminal equipment in the home is a key factor. In the UK there are around 2 million modern (networkable) personal computers, although not all of them are equipped with modems. While the PC population is growing fast, the number of networkable computers in the UK is still relatively small compared to the 44 million analogue TV sets. With the addition of a suitably priced set-top box of electronics, all of these sets could, in principle, be adapted for digital broadcast or for interactive multimedia services.

In this paper I propose to touch upon three themes: the opportunities and challenges of the digital multimedia era for all the players; BT's strategic response to these opportunities and challenges; and the key role that we see for digital broadcasting in the provision of affordable interactive multimedia services into the home. I should emphasise that for BT it is the interactive services which are of most interest.

The players

The convergence brought about by common digital technology has resulted in a range of competing organisations with diverse backgrounds, all of which are seeking to build their position in this emerging marketplace. A selection is shown in Fig. 1.

Clearly, all of the competing organisations believe that potentially a profitable business can be built in this new service area. But there are many uncertainties surrounding the issues of what new services, over what networks and with what technology?

Multimedia services

All networked multimedia services require some combination of interactivity and bandwidth for their delivery. We can position a range of such services graphically in a space which indicates the level of interactivity on one axis and rate of information delivery or bandwidth as the other. An example shown in Fig. 2.

For conventional telephony, the level of interactivity is high but bandwidth requirements are low. Telephony therefore lies at the top left hand corner of this space. Conventional broadcast television requires very little interactivity, other than to change channel. It does, however, require a relatively large bandwidth, and so is in the bottom right hand corner. And other services such as video telephones and the Internet lie somewhere in between. However, the most exciting services are the fully interactive broadband services, which lie at the top right hand corner. But, of course, these are also the most costly to develop and to provide.

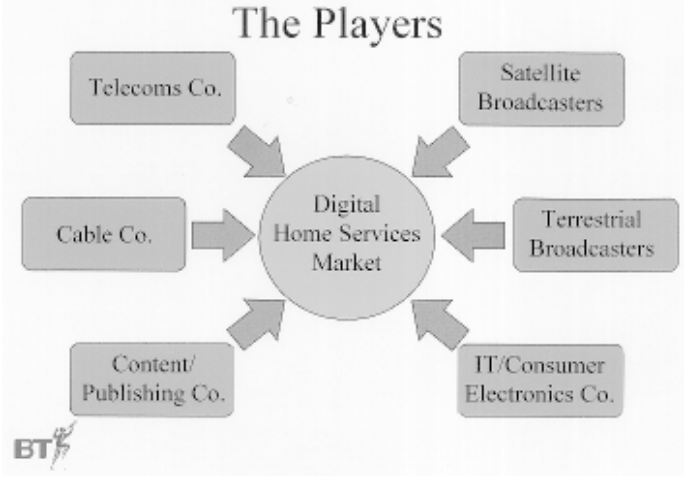
The reality is much more complex than this, since few of the new services can be provided by a single player alone. For example, in BT we know a great deal about the networking, service provision and billing aspects of these services, but others are better qualified to produce the multimedia content. While others again must manufacture the appropriate terminal equipment, be it television sets, personal computers or games machines. For this new market to develop successfully a new multimedia industry structure is required.

Digital multimedia industry structure

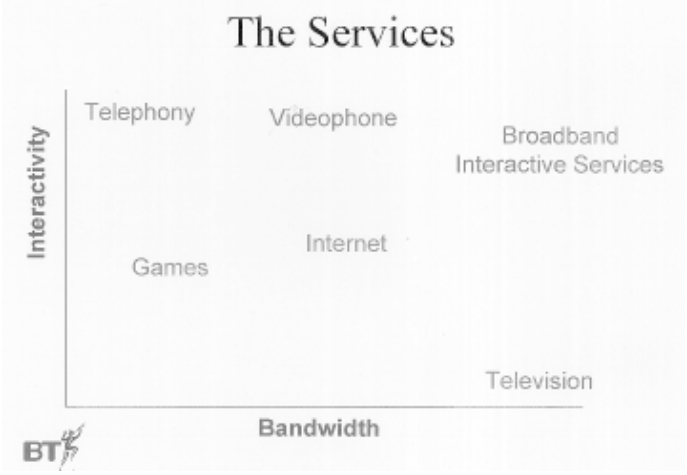
To understand the structural requirements more clearly we have found it helpful to separate the marketplace into four sectors, as illustrated in Fig. 3. The Content Sector is concerned with multimedia content providers such as television and movie studios or other creators of information or entertainment content; The Service Provi-

▲ *Dr Mike Love (right), Group Managing Director, Science Systems, speaks with Mr A J Shipton (centre), Managing Director, SGS-Thomson Microelectronics Ltd, the two sponsors of the evening, and Mr John Evans, Grundig Satellite Communications MFG Ltd.*

** Deputy Chief Executive, BT plc*



▲ *Fig. 1*



▲ *Fig. 2*

sion Sector involves the businesses associated with conceiving, packaging and providing the new services; The Service Distribution Sector incorporates the businesses providing the network platforms over which the services are distributed; finally, we have the Consumer Electronics Sector which includes businesses involved in the manufacturers of TV sets, computers, videophones and other terminal equipment.

For BT, the Service Distribution business is, of course, a natural fit with the Group's core competence. This is a highly competitive area and in the UK it not only includes the telecommunications companies, but also cable TV and broadcasting companies, all of whom anticipate serving the same customer base by developing their version of an interactive broadband distribution network.

Before entering any new market it is necessary to understand how the services will be paid for and where the revenue flows. In this model the consumer pays the service provider and the service provider in turn pays the content provider. The content provider may also pay the network operator for the delivery or, alternatively, the consumer may pay for the network delivery directly.

In this emerging market the direction and scale of these money flows is not clear. How much the consumer will be willing to pay for a given service and how that will be shared between content providers, service providers and the network operator is still unclear. How this payment might relate to the costs incurred by each segment is also not certain.

To connect to the network the consumer will also need the appropriate terminal equipment and the cost of this and the network access cost are two key factors which will strongly influence the growth of the market. Both of these factors are heavily dependent on the size of the market. As volumes grow the costs will decrease.

Basic considerations

Any commercial telecommunications operator entering this new market faces a number of challenges, not only those associated with developing and acquiring the appropriate technology. Within BT we first gave some thought to which of the sectors we would seek to operate in. In making these strategic judgements, it is advisable for any company to consider what core competencies they have and how they intend to develop them in the future.

Our first decision was that we were not well equipped to enter the 'content provider' business. The running of a Hollywood studio, for example, was not something we felt competent to undertake. Similarly, we felt that the large volume manufacture of customer electronics equipment was another area in which we were not well qualified. In these areas we would strengthen our capabilities through alliances, partnerships or supplier agreements with multimedia content providers and equipment manufacturers.

From the outset we decided to focus our attention on Service Distribution and the Service Provision businesses. In both of these areas we were confident that we could demonstrate a high level of core competence. The next question was 'where and how do we start?' The position in which we found ourselves was rather akin to a crowd of holidaymakers approaching a large maze. Everyone believes that there's an easy route through - but where and how are they going to find it?

Digital multimedia services

There has been much attention focused on broadband networks, particularly optical fibre, but this is not where the consideration has to start. The network is a key part of the Service Distribution business, but if there is to be any financial justification for the very large investments required then we must first consider what services we are planning to provide.

If the digital multimedia home service market is to become a commercial reality then which are the best areas to begin prospecting? Is it in electronic games, education, travel, shopping, financial services, local services, videophone - or all of them - or something else entirely? The selection and timing of the introduction of new services are critical factors if they are to be a financial success. Finding a route through this maze of possibilities - many of which are simply expensive dead-ends - is not easy.

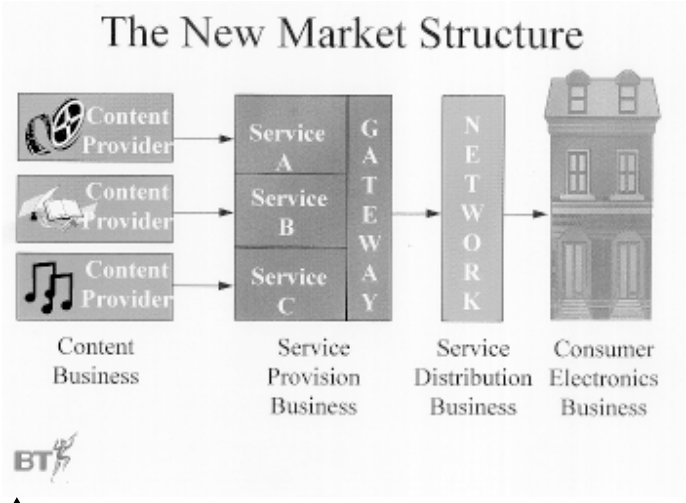
Who are the customers for these services? What do they need? And what are they willing to pay? These are all questions which must be answered to the best of our abilities. However, despite extensive market research and trials, in an emerging market such as this there will always remain very large uncertainties, against which large network investments must be made. Every potential player in the Service Distribution business is wrestling with this problem and seeking to reduce the cost and risk profile.

The technology challenge

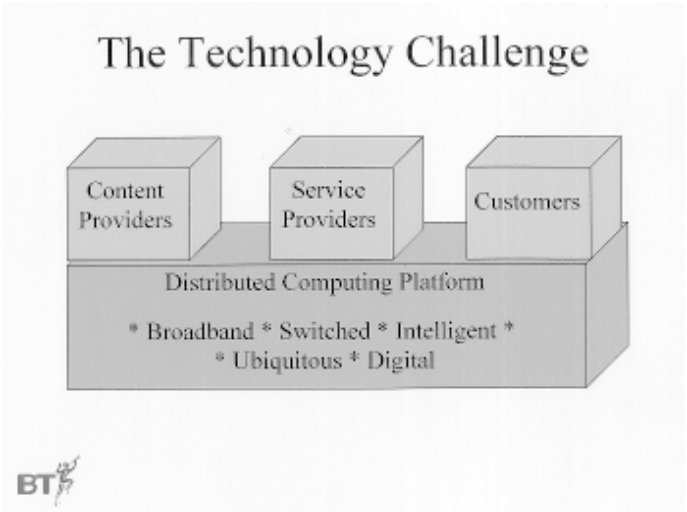
The Service Distribution business, and therefore provision of a network with broadband capability, is central to BT's interest in this area. The network of the future is not merely a matrix of wires and switches. Our vision is rather one of a giant distributed computer: an all-digital, intelligent, broadband platform; a platform which underpins the content providers and connects the service providers to all of our customers (Fig. 4).

BT's challenge has been to develop a strategy which allows us to evolve from our current narrowband network to the broadband future, and to do so in an economic fashion which reduces the large risk profile to an acceptable level. It is critical that the initial network costs are low enough to allow the emerging digital multimedia services market to develop.

Up until four years ago, together with telecommunications companies all around the world, we believed that this broadband future could only be delivered by a mass 'change out' to an all fibre access network. But within the regulatory framework of the day we were never able to construct a commercially viable business plan to balance the costs of a new network against the potential revenues. Our regulatory exclusion from the broadcast TV market made even a marginally viable plan totally impossible.



▲ *Fig. 3*



▲ *Fig. 4*

A revised broadband strategy

This blockage drove BT to think again. With the aid of our technology foresight, particularly the anticipated advances in digital transmission, we developed an alternative dual-approach strategy, a strategy which addressed both the issue of achieving lower network entry costs and the need to stimulate and develop the initial 'market pull' for multimedia communication services.

The key technological breakthrough has been duly achieved through advances in high speed digital transmission and digital compression. These advances have made possible the transmission of broader bandwidths directly over the copper-wire access network. Broadband services can now be delivered to those customers who choose to take them, over the existing network and without the huge up-front costs of installing optical fibre to every home. Clearly, as the market develops and demand grows, the progression to optical fibre can be made wherever and whenever it is appropriate.

In parallel with these technological developments BT has commenced the a drive to stimulate and accelerate the digital multimedia services market. The new multimedia products and services are carefully geared to the evolving capability of the network. A new strategy has been defined which entails a progressive network evolution, from today's 'lowband', through 'midband' to 'highband'. This strategy allows the immediate deployment of new multimedia services on the existing network and the development of a pipeline of new and increasingly broader bandwidth offerings, in phase with the evolving market need and network capability. Fortuitously, the rapid progress of the Internet, and particularly the Internet Protocols, has opened up a diverse range of new services which can be offered with today's lowband capability.

This parallel approach of progressively upgrading the bandwith capability of our copper pair network, and simultaneously developing the market for multimedia home services, allows BT to better align incremental investment with incremental revenues, thereby reducing the investment risk profile which has repeatedly halted the 'big bang', all-fibre approach.

Within BT we still retain our ultimate vision of an all-fibre access network, but now we have an evolutionary, rather than revolutionary, route to get there - a route which is commercially viable and one which is essentially invisible to our customers.

Lowband services

In the BT local network as it exists today, every home is connected to a local exchange by a copper pair. The street cabinet is a point of cabling flexibility between the two. The copper pair can support either an analogue or digital (i.e. the Integrated Services Digital Network or ISDN), telephony service.

Customers can connect personal computers or similar terminal equipment via modems, operating over the analogue telephony service, or via ISDN. Basic modem technology now supports bit rates up to 56 Kbit/s. ISDN can provide bit rates up to 128 Kbit/s. In fact, a new residential product offering 128 Kbit/s service is planned for next year.

'Lowband Services' refers to a range of digital services recently launched by BT into the home market that can be accessed using modems or ISDN. The BT Internet access service was launched just over 12 months ago and is now in the top three of the 50 access service providers in the UK with the best service rating. We anticipate that it will become the largest UK access provider in due course.

BT Internet connects to our national Internet Backbone service - BT Net - which, in turn, connects to our global Internet backbone - Concert Internet Plus. So our customers benefit from fast and reliable local access to the Internet using BT's world class communications infrastructure.

LineOne is an on-line service targeted at the mass market that was launched in January this year by Springboard, a joint venture between BT and News International. It creates and delivers - via the Internet - entertainment, information and education to UK homes. LineOne content is drawn from major News International and News Corporation brands, such as The Times, The Sunday Times, The Sun and the News of the World.

Springboard works with third party partners to provide a broad spectrum of useful services including up-to-the-minute local and national news, weather, sport, events, listings and ticketing, as well as games, retailing and a definitive reference library. The venture combines News International's expertise in publishing, multimedia and news gathering and BT's experience in multimedia and communications. The Springboard objective is to build LineOne into the UK's premier Internet-based online service.

'HomeCampus' is the latest addition to BT's 'Campus World' portfolio, the world's largest on-line network education service. 'HomeCampus' is a service for both parents and children at home, providing educational resources to support learning, with educational materials designed by education professionals, to enable children and adults alike to participate in exciting projects and activities.

HomeCampus activities include moderated discussion groups and interaction with experts, homework help, revision aids and a fun on-line magazine aimed at the younger user. HomeCampus also offers links to hundreds of external World Wide Web sites, which have been selected for their usefulness to the learner.

When the children (and their parents) have finished their homework they can play *with* and *against* one another, on our Wireplay interactive games network. This is the next step in computer games. Instead of playing alone against the computer, children - and increasingly adults - can play against one another over the network either as individuals or in teams. The service offers all sorts of games from chess to football to science fiction space battles.

All of these services are distributed over BT's network today.

Midband services and the market trial

With interest in multimedia services beginning to grow, BT is preparing to move its network capability up from the current narrowband to an intermediate midband capability which will allow the delivery of up to a 2Mb/sec service on an economic basis from mid 1998.

Implementation of midband technology involves connecting additional digital boxes to each end of the copper pair, that is in the exchange and in the home. This technology is an overlay to the existing telephony service provided over the same pair of copper wires, allowing our customers to make telephone calls at the same time as they surf the Net or engage an interactive service.

This technology allows faster services and TV quality video to be delivered into the home. Working with its key suppliers BT has developed the necessary technology based upon derivations of ADSL (Asymmetric Digital Subscriber Loop) technology. Work is in hand with these key suppliers to get the unit costs down to an appropriate level for implementation.

This midband technology concept was tested in BT's recent full-scale Interactive Services Market Trial. The trial involved over 6,500 customers in Colchester and Ipswich. It used ADSL technology to provide a 2 Megabit interactive video service over the standard telephone lines. The service included a full range of education, information, entertainment, shopping and banking services. More than a hundred content providers were involved, ranging from Hollywood studios, through retail stores and high street banks, down to local charities.

The trial used a specially developed large Video Server which stored thousands of hours of video information and allowed hundreds of users to have simultaneous access to any piece of content. Using a TV style remote control, the viewer could navigate around pages of information and select from various menus. The digital picture quality was judged to be excellent by all of the broadcasting experts involved.

The BT Market trial was the first full-scale trial of its kind in the world and the results were extremely valuable in planning the way forward. The technology was successfully demonstrated, but, more importantly, invaluable understanding of the market characteristics of these new services, and customers preferences, was obtained.

Highband services

The third step in our planned evolution is to deploy fibre from the exchange to street cabinets. From the cabinet rates of 12 Mbit/s can be delivered into the home, again over the existing copper pair. That's enough to carry a full range of services including multiple high quality video channels. The customer can also transmit upstream towards the exchange at rates of up to 2 megabits per second. Depending on the market requirements, we shall be ready to offer this service from 1999 onwards.

The street cabinet is a flexibility point in our network serving typically around 300 customers, and usually sited a few hundred metres from the customers' homes. It is very rarely sited more than 1 km away. A new broadband cabinet will be built alongside the old cabinet and connections are jumped across from the old cabinet to the new one to serve those customers wishing to take the broadband services. The broadband cabinet houses the optics for a fibre feeder system and the electronics to drive the high speed copper system.

This evolutionary approach has many obvious benefits. In particular, it offers us a means of meeting the needs of our customers as the market develops and avoids the economic trap which the big bang, up-front, all-fibre approach led us into.

Interactive digital broadcasting

In developing a strategy for the evolution of its Service Distribution capabilities, BT is not locked into any one technology exclusively. Each one will have its benefits and a time-window in which it may provide unique opportunities for delivering new multimedia services and developing the multimedia market.

BT is currently excluded by regulation from participating directly in broadcast entertainment services. However, it may well be that the integration of broadcast and interactive services is vital in the initial development of the multimedia market. The emergence of digital broadcasting over satellite, terrestrial or cable links may well be the key in the digital race to the home.

With respect to digital broadcasting, the UK is already lagging behind many other countries. Digital TV is already available in the Americas, both north and south, Western Europe, Japan and other Asia Pacific countries. Digital broadcasting in these early entrant countries certainly offers customers a unprecedented choice of hundreds of television channels, but it could also bring much more.

The set-top box, which is necessary to convert incoming digital signals into a format that can be displayed on any one of the 44 million analogue TV sets in the UK, can be extended to provide much greater functionality. It can, for example, provide the means of combining a two-way interactive ISDN capability, with a one-way highband broadcasting channel to provide a range of multimedia services based upon interactive digital broadcasting.

While IDB is more limited than a full interactive highband network, it offers the benefit that the capability is available now. Many of the interactive services which were included in the BT Trial, including education, information, entertainment, shopping and banking, could be delivered over such a platform.

This approach reinforces the new market structure and allows Content, Service, Distribution and Consumer Electronics Providers in the UK to offer services and begin to mount the learning curve. Without such an early stimulus it is unlikely that these new multimedia industry providers will develop in this country. As the market develops and becomes more sophisticated and demanding, it will help to pull through the fully interactive services which will demand a two-way high-band network capability.

British interactive broadcasting

However, while Interactive Digital Broadcasting offers many benefits, there is a major hurdle to be overcome. If the service is to appeal to the mass market then the set-top box has to be priced competitively, that is initially below manufacturing cost. As a consequence, the funding of a substantial subsidy in the early stages is called for if the service is to rapidly acquire the millions of customers necessary to make it an attractive option to Service Providers.

It is this reasoning that has driven BT to participate in the recently announced joint venture - British Interactive Broadcasting (BIB) - to address this market opportunity. Our partners - BSkyB, Matshushita and Midland Bank - bring the competencies in this new market structure that complement our own. Together we shall provide the necessary subsidy for a de-facto standard set-top box which will be common to terrestrial as well as satellite digital broadcasting.

In BT we are very excited about the prospects for this new venture. Not only for what it will offer itself, but also because it may well prove to be the key enabler in moving the UK to the forefront in the interactive services field.

Conclusions

To this point I have certainly failed to answer directly the question posed by the title of this paper. Who will be the winners in the race to provide digital services to the home?

The market for digital home services is at a very early stage, but it is, at last, beginning to emerge. Clearly, we believe that BT's strategy will provide an effective and commercial approach. Our plan to stimulate this new market with our current lowband network capability, while developing the technology to allow a progressive evolution to support fully interactive broadband services as the market emerges, has many good features. They are good not only for BT, but for many other companies in the various industry sectors identified above.

Across the UK and internationally, there are many competitors in this field. We can anticipate a wide range of products and services

with diverse technologies deployed and a wide range of partnerships and joint ventures as the new market structure takes shape. Since every player is starting from a somewhat different point, and has differing competencies, the outcome is hard to predict. The commercial winners will be those companies who choose the right route through their particular maze, and particularly those who get their timing right. One of the key objectives for successful entrants has to be to achieve a close alignment of investment plans with market revenues.

Regulation will obviously play a role and it is absolutely critical that regulation is not allowed to stifle innovation in this embryonic market. We shall all be the losers then. Not only the companies involved, but the end users, both business and residential customers alike. Whilst at the end of the road there will be rewards for the winners, or at least that is what we all hope, the market today requires much faith and vision and is certainly no gold mine.

The only sure winners in the digital race to the home will be the customers. They will have the choice of benefiting from an incredible range of innovative new services at very competitive prices. But there is another, even more important side to this issue. If enough companies are successful and we build a new digital multimedia industry structure in the UK then, undoubtedly, the UK as a whole will be the real winner in the international digital race to the home.

Dr Abe Peled*

Introduction

The success of the first Digital Broadcasting Satellite (DBS) service in the United States - DirecTV - the broad acceptance of the Digital Video Broadcasting (DVB) MPEG-2 standard has fuelled the current global race to establish additional DBS services. The expected emergence of digital terrestrial broadcasting systems in the US and the UK have the potential of altering the competitive landscape in the information superhighway battle to deliver a myriad of new digital services to businesses and consumers. While one telephone company after the other is announcing the scaling back of much publicized earlier plans to spend billions on new infrastructure capable of delivering several megabits/sec into every consumer's home, and cable companies are evaluating the results of early trials, in the hope of discovering glimmers of hope that consumers will be willing to part with enough additional dollars every month to recover the cost of the billions that they will need to spend on upgrading their infrastructure to deliver these services, digital broadcasting suddenly appears as an intriguing and promising alternative.

Digital broadcasting has not been considered a contender in the information superhighway sweepstakes and, indeed, any initial review of its qualifications as a promising contender would lead to an immediate dismissal of its chances as a serious candidate. After all, the main focus of the information superhighway is two-way interactivity at megabits/sec. making a myriad of new applications possible, removing the speed and bandwidth constraints limiting us today. Broadcasting, pundits will point out, is inherently a one way medium incapable of two-way video conferencing, immediate one-to-one interaction and many more limitations, and is therefore simply unsuitable to deliver all their dream applications.

In this paper we will re-examine this premise and make the case for the role digital broadcasting can play in the race to deliver new information, shopping and entertainment services to businesses and consumers. The advantages of digital broadcasting as a mass delivery medium for massive amounts of video, audio and data with substantially lower costs per bit and at a radically lower initial investment per potential customer are simply too compelling to ignore. They will serve as a powerful motivator to search for the services and applications that can be delivered effectively while overcoming the limitations the medium imposes. Electronic delivery of newspapers, magazines, books, software, games, music, movies, are only a few of the examples that come to mind. The fundamental fact that will allow digital broadcasting to overcome its most glaring limitation is the highly asymmetric pattern of information consumption/generation of individuals. With the exception of video conferencing, individuals consume vastly larger amounts of information than they generate. We believe that exploiting this asymmetry by careful selection and design of the applications and services, and by judiciously using the ubiquitous telephone network as the reverse channel, it will be possible to use digital broadcasting to deliver many of the most attractive applications and services promised by the information superhighway earlier, at lower cost and to everyone instead of the lucky few living in the initial infrastructure deployment areas.

Digital broadcasting - facts and figures

The digital broadcasting technology is applicable to terrestrial as well as satellite broadcasting. In this paper we will focus primarily on satellite broadcasting for purposes of the illustration of facts and figures, since it is better understood and is being deployed widely around the world. A typical DVB compliant digital satellite broadcasting system can deliver 34 Mb/sec per transponder, which is capable of illuminating a continent, thus reaching tens of millions of potential users. Satellite configurations vary widely. However, most will have at least 20 such transponders, providing every user in the area of coverage with the ability to receive video, data and audio at up to 8 Mb/sec out of an over 500 Mb/sec stream. The investment needed to build and launch such a system is of the order of hundreds of millions of dollars.

Fact: The investment per potential user is in the tens of dollars vs. over $1000 for the two-way alternatives being promoted for the "superhighway".

The PC card that will receive the satellite signal will benefit from the highly integrated silicon chips being developed to support the MPEG2-DVB standard, and which will be used in millions of digital set-top boxes. Several major suppliers, e.g., LSI Logic and VLSI Technology, have announced comprehensive plans for complete chip sets in this area and expect to have integrated most functions onto three chips by the end of 1997. These chips will provide all the RF tuning, demodulation, error correction, demultiplexing, descrambling and the necessary interface to Smartcard-based conditional access systems. This conditional access system will support subscription-based services, e.g., magazines or software updates, as well as pay-per-view for specific information, e.g. research reports.

Fact: PC cards that will be capable of receiving this massive datastream and depositing it on the local PC disk, will be widely available for less than $300 in 1997.

A single transponder can deliver over 300 Gbytes of data every 24 hours. This data can comprise of data sent out once every day, or once every hour, or any other repetition rate, providing a flexible match between the necessary timeliness of the data delivery and the cost of delivering it. A full digital daily newspaper requires 5 Mbytes of storage for the full editorial content, picture and ads. It could be downloaded into the PC in less than 10 seconds and occupy less than 1%. of the hard disk storage of the typical multimedia PC now being sold. Obtaining the same newspaper content from an Internet WEB server over a fast modem connection would take over an hour.

Fact: Simultaneous delivery of identical data, e.g., a digital newspaper, to thousands of users is close to a thousand times faster and over a thousand times less expensive than via a typical Internet connection.

The applications

Broadcasting is a highly effective one-to-many medium, and therefore the applications that will emerge are the ones that exploit this

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capability. They will involve the delivery of large amounts of multimedia data of interest to thousands of users. This data will be broadcast and picked up simultaneously by all the suitably equipped personal computers and stored on their local disk for subsequent use. The conditional access system ensures that only authorized users will receive the keys to descramble and view the data. This system provides a proven method (in pay television) for distributing valuable content electronically to end users in return for an agreed fee on the Internet, the current precursor to the future network-based information superhighway, such methods are only being developed.

The initial applications are likely to be simply the delivery of content currently distributed via paper, e.g., newspapers, newsletters, magazines, or similar content currently being placed on the WEB to consumers with advertiser support. The more interesting applications are likely to emerge as content providers grasp the true capabilities of this new medium. The confirmed effect of the multimegabit bandwidth and the rapid growth in the local storage capacity of personal computers will enable new types of media to emerge. For example, a newsletter aimed at football fans containing the in-depth text coverage found in the Monday paper and including MPEG compressed video highlights which are displayed on an eighth of the PC screen and decoded in the PC viewer software (as they are now in Internet browsers). Such a newsletter, containing approximately ten minutes of video highlights, text and numerous stills would occupy only 10 Mbytes of storage (or 1% of a typical hard disk in a current multimedia PC) and would be downloaded to the subscriber's PC in a little over 20 seconds on Sunday evening. Similarly, a newspaper advertisement could contain references to video or audio clips, describing merchandise or a resort.

The examples above illustrate an important concept, the massive bandwidth combined with massive local storage, and can provide the user the illusion of immediate interactivity. As a matter of fact if a user would dedicate 10% of his disk to information that would be downloaded via digital broadcasting he could "surf" over this data with immediate response. "Surfing" over the real Internet to reach the equivalent amount of data would take this user over 20 hours. Indeed, there is a major difference. In the broadcast case the "surfing space" has been preselected by the broadcaster and is packaged to appeal to a broad audience rather than to an individual's taste. Here the electronic editor that decides what is the content that will be packaged fills the same role as the traditional editor on the broadcast and print media, with one profound difference: the quantitative differences, the massive amounts of information, enabling hybrid media forms, the new delivery economics that make it affordable to deliver editions tailored to thousands rather than tens or hundreds of thousands, will result in a qualitatively new medium.

In addition to this perceived interactivity, applications can also exploit the return path via the regular telephone network, or even via the Internet. Individual customer requests and billing information can be fed back interactively, or batched and sent back overnight.

We expect that imaginative applications will emerge that will effectively use this powerful information delivery medium, fully exploiting the high speed forward channel and cleverly overcoming the limitations of the reverse path, in the process moving the applications that lend themselves to this medium away from the Internet. As this happens, digital broadcasting will assume an ever more prominent role in the information superhighway infrastructure.

Mr Huw Jones*

Introduction

A brief word first of all about S4C - Sianel Pedwar Cymru - The Welsh Fourth Channel. We are a statutory body, established in 1982 at the same time as Channel 4, to broadcast on the fourth channel in Wales a high quality television service which in peak hours is mainly in the Welsh language. The rest of the time we broadcast or re-schedule Channel 4. We receive public funding which until now has been calculated as a fixed percentage of total UK television advertising revenue. Under the 1996 Broadcasting Act, our public funding has been fixed at its 1997 value so that even if UK advertising revenue grows we will no longer share in that growth. At the same time we have been given new freedom to set up commercial ventures, the profits of which, if any, may be used to extend and expand our services. One of those ventures may lead to our playing a role in the mainstream of British broadcasting. More of that in a moment.

Before I went to work in television, I spent the first twelve years of my working life running a record company. I mention this not as a biographical detail but because I see similarities between the way the record industry developed in the late sixties and seventies and the way television is likely to develop in the digital age.

In the early sixties, the pop music charts were dominated by the products of three or four companies. The Beatles recorded for Parlophone, which was a division of EMI, the same company as owned Columbia which published Cliff Richard's records. The Rolling Stones recorded for Decca and Elvis Presley for RCA. The vast majority of chart records were to be found on the same labels. Recording studios were large, their equipment cumbersome and expensive; plants for pressing discs involved huge capital expenditure and distribution required a labour-intensive infrastructure. Even if you were a brilliant musician and songwriter, there was only one way to put your songs before the public and that was by striking a deal with a major record company.

In the late 60s and early 70s, however, new technology arrived, primarily from Japan, which made it possible. Creative musicians of all kinds were able to by-pass the £40 an hour studios and spend all day and all night if they wished perfecting their three minute masterpieces in their newly equipped cellars. The arrival of the audiocassette made it possible to enter the market with smaller initial publishing runs and independent distribution networks were formed to service the new breed of musical entrepreneur. In a short space of time the monopoly of the large companies was broken, leading to a flourishing independent scene which is still a striking feature of today's music industry. In Wales, at a time when the official media of radio and television gave scant exposure to Welsh language music, my colleagues and I were effectively able to create a third mass medium through the production of popular Welsh language gramophone records to the extent that if you entered any Welsh-speaking home in that period, alongside the Dansette gramophone would be a rack of 7 inch extended play records, the constant playing of which constituted a substantial part of that family's leisure activity. In short, we created a niche medium by identifying a specific audience which wanted something that we knew how to provide. What we did not do was entirely to displace the consumption in those homes of Cliff Richard's and Beatles' records, but we did find our place in the sun alongside them.

The same thing happened in other countries.

So, while the mass media technologies of radio and television and the gramophone had initially threatened cultural diversity by bringing the same glossy, attractive, popular products to audiences throughout the world, the democratisation of that same technology enabled local cultures to fight back and survive.

Today, we find television at a similar crossroads as it enters the digital age. There will certainly be winners and losers, but the record industry shows that they may not necessarily be predictable ones. As of today, we still live in a society where the majority of households -

* *Chief Executive, S4C*

75% of the UK total - content themselves with four or five television channels.

Multichannel television

Most viewers have not yet subscribed to multichannel satellite and cable television, although some parts of it are enormously profitable. Undoubtedly, it is the high perceived quality of British terrestrial television which has restrained the growth of satellite and cable. In other countries, such as Germany, France and Italy, where the basic fare was less fulfilling, new channels have achieved significantly higher penetration. But British broadcasters cannot complacently assume, however, that this state of affairs will last indefinitely. The significant statistic is that whereas satellite and cable services have only an 11% share of *overall* UK television viewing, their share of the viewing of the under 16 age group in homes which have cable or satellite is 51%.

Any parent with satellite or cable in the home will be very aware of the amount of time their younger children spend watching Nickelodeon or other specialist children's channels and the older ones watching MTV, the music channel. In the younger generation, the audience of the future, the pattern of regular viewing of three or four channels has already been broken, for good. This is the generation which grew up with a rattle in one hand and a zapper in the other, which plays video games not cricket and if given access to the Internet is only too happy to prove its technological facility by running up amazing telephone bills. It will culturally graze wherever it can find tasty fodder, and, let's be honest, there are many parents and even some grandparents who, once the resident five year old has shown them how to programme the video or access the Internet, will also find themselves enjoying the new offerings, albeit surreptitiously.

The arrival of multi-channel and multi-choice television and the gradual fragmentation of the massive audiences enjoyed by the mainstream broadcasters is therefore inevitable. Digital television will accelerate this process for two reasons: first, it makes it possible to offer a far greater number of channels; secondly, it will bring about a new type of viewing experience, through the introduction of interactive services of different kinds. Central to the question of how successful new services and methods of delivery will be is the issue of how much viewers are willing to pay for increased choice and what exactly it is that they are willing to pay for.

Digital service problems

These questions arise in respect of all three methods which will be used to deliver digital services, namely, satellite, cable and terrestrial, but they happen to be highlighted in the differing plans of the rival groups bidding for digital terrestrial multiplexes. BDB, the consortium which consists of BSkyB, Carlton and Granada, offers across three multiplexes a total of 15 channels, including some of the most popular sport and film channels currently available only on satellite. The rival consortium, DTN, offers 20 new channels with an emphasis on new, interactive services.

The Independent Television Commission will make its choice between these two rival offerings early next month. In an ideal world, the ITC might like to have the best of both. That, however, may be difficult.

It will have to balance the relative desirability of having such major players as BSkyB, Carlton and Granada on board rather than competing on satellite, against the fact that DTN appears to be drawing on the new technology's potential to a greater extent. There are important questions relating to competition and possible media domination to be considered while other players, such as the BBC and ITV, are looking for reassurance that if one company's technology becomes the industry standard then there is fair access for all to that technology. The Electronic Programme Guides which will be the main means by which viewers are given access to different services need to be fair to all channels, in particular those of the public services. There is concern that BBC1 might end up on Channel 98, for instance.

The ITC may be helped in its decision by consideration of what is likely to be offered on the other three digital terrestrial multiplexes, in one of which my own organisation has an interest.

Multiplex 1 has been given to the BBC, which has been allowed to sell off its transmitter network and to keep the proceeds of that sale, for the purpose of launching new digital services. Its main stated intention is to offer a free 24 hour news service.

Multiplex 2 has been gifted to ITV and Channel 4. There is room here also for additional services. The dilemma facing ITV and Channel 4 is that it actually costs quite a lot of money to create the programming for brand new services which are unlikely to have many viewers in the short term, at a time when there may be a need to strengthen their core services to face increased competition. ITV's most likely option appears to be a UK network channel based partly on repeats and partly on new programming. This may be subscription based or, more likely, free to the viewer supported by advertising. Channel 4 have indicated that they may introduce a film channel based on non-Hollywood material.

The position in Wales

Multiplex 3 or, Multiplex A as it is more properly known, is quite complicated and S4C, through a subsidiary company called SDN, has bid for the right to operate this multiplex across the whole of the UK. In Wales, and in Wales only, S4C has been given half of this multiplex as of right. Channel 4, whose programmes at present fill 70% of our total hours, will, on digital, be available as a separate service for the first time, so the first thing S4C will do is to offer an all-day service of our own, which will include substantially increased programming in Welsh for children and young people, adult daytime programming in Welsh for the first time, additional coverage of local and international sport and more drama and music from Wales and other countries. We also hope to offer an entirely new concept called the Digital College which will be a partnership between ourselves, educational institutions and others to develop lifetime learning and skills acquisition, targeting in particular the high numbers of those in Wales who leave school without formal qualifications.

Because of the topography of Wales, digital terrestrial will not reach all parts of the country at least until analogue has been switched off. We shall probably therefore be securing space on satellite also so that all parts of Wales can receive S4C's digital services. In doing so, of course, S4C will become available for the first time in the rest of the United Kingdom thus enabling long-suffering Welsh exiles to regain fruitful daily contact with the Land of their Fathers and enabling the John Redwoods of the future to familiarise themselves with our National Anthem. It is one of the notable features of the arrival of many more channels that diaspora communities all over the world are being given the chance to see regular programmes from their countries of origin and retain cultural ties.

Multiplex A - the other half

That's half of Multiplex A - in Wales only. The second guaranteed broadcaster place has been given to the recently launched Channel 5 - throughout the UK. In Scotland there is a requirement that Gaelic programmes should be allocated at least ½ hour per day in peak viewing hours. The rest of the capacity on this complicated multiplex is free for commercial exploitation. This amounts broadly to 1/6th of the total capacity for which the two big groupings, BDB and DTN, are competing on the other three multiplexes.

This is the potentially valuable commercial asset which SDN, under the freedom granted to S4C by the 1996 Act, has bid for. This is the multiplex which technically will reach the third highest number of viewers in the UK and, in that respect alone, has considerable commercial attractions. The other interesting factor is that SDN is the only bidder for this multiplex. SDN's programming proposition for the UK, you will probably be glad to learn, is based on a pragmatic mix of English language subscription and free-to-air services, including a Nursery Channel for pre-school children, a Motoring Channel from ITN and a Nature Channel. The Information Channel, which we are also developing in association with ITN, is likely to be half way

between a television channel as we know it and an interactive information service of the new age. It will offer local, national and regional information and transactional services of different kinds so as to access additional commercial revenues.

This multiplex bid is seen by us as an essentially commercial venture, but I believe the mixture of public service and commercial motivation that we bring to the table is extremely relevant in consideration of the issues we are discussing today.

Extended digital service in Wales

While we have been laying our plans for SDN, the S4C home service, as it were, has had to look very hard at the implications of providing an extended digital service in Wales. We have no more public funding available but, after consultation with the 80 independent production companies who are our suppliers, we came to the conclusion that it *was* possible to extend the present service by offering suppliers longer contracts in exchange for more output and lower prices. The whole process of radically revisiting our methods of operation while at the same time investigating commercial opportunities on a scale which we had never previously considered, has energised the whole organisation to the extent that we are already talking to other European broadcasters about possible pan-European services which we might put together in partnership with them, and of expanding our already successful programme sales department.

Last year our programmes sold to more than 60 countries. Our animation in particular has won worldwide acclaim. The animated *Old Testament* stories are ours, as are the two *Shakespeare* and *Opera* series. Our next offerings will be *Religious Faiths of the World*, classic *Epics and Legends* and the extended *Life of Jesus*, with Ralph Fiennes providing the voice of Christ. Ambitious projects from Wales? It may be difficult for this gathering to appreciate, but places like Wales have long been benighted by the tradition which holds that in Britain talent gravitates to London and that if you chose to stay in the "regions" you should not have ideas above your station. Whatever happens to our multiplex bid, the simple fact that we may have seen an opportunity which others had dismissed has given us and other ex-centric broadcasting organisations a massive but hopefully not excessive boost in self-confidence. I doubt if we will ever again succumb to the self-doubt which maintains that if an idea is any good then someone in London or Los Angeles must already have thought of it.

The way things will develop

I appreciate that some of the foregoing may appear to be somewhat narrow and particular in scope, but what I am trying to illustrate is a centrally important feature of these digital developments: namely, that new kinds of organisations will emerge to meet the challenge of new technology.

S4C, in its much smaller way, is mirroring the BBC's efforts to redefine itself as an organisation in receipt of public funds but which is no longer purely a public service broadcaster but rather a hybrid - mainly public service, but increasingly with a commercial thrust and vision. I believe that such hybrids will be enormously valuable.

They will be driven by the need to justify the continuation of their public funding by providing programming which is clearly of high quality, is popular, but also offers wide variety and some content which would not be commissioned by commercial organisations. The limitations of public funding will drive them to seek efficiencies wherever they can be found, while the participation in commercial ventures will bring in money which will enable them to compete for the best talent and most valuable rights. They will also be driven by their particular remit to reflect and sustain the national cultures of their countries - a priority which cannot be taken for granted in transnational commercial broadcasting organisations.

[And as Michael Grade once said, it is the BBC and, I would add, all public service broadcasters, which keeps the rest of the pack honest].

Enormous potential exists

If I can return, as I close, to the picture I painted at the beginning of the way technology empowered talent and individualism in the music industry. I believe there is enormous potential for a similar outburst of creative activity in television. The Internet is a chaotic, anarchic, unregulated, time wasting but essentially democratic and creative mechanism, capable of undermining the world's carefully constructed communication structures. We have heard how television pictures can be broadcast down the telephone line and how BT hope to get in on the act as soon as possible. Microsoft has bought WebTV in recognition of the huge commercial potential of the convergence between computer and television technologies. Individuals, groups, clubs and societies already create their own web pages using text and graphics to communicate with each other, creating in a way their own little channels.

Soon, little cameras above the personal computer will enable pictures to be sent down the same lines. That is television, is it not? There is in this development an essentially healthy democratisation of the medium, akin to the liberation of knowledge with the arrival of the printing press. We should not seek to stop it even if we could. Neither should we broadcasters fall flat on our backs in terror. Radio in its many forms already offers us a model of a multiservice medium. Local radio stations abound but the demand for national and international services is still substantial. There are audiences for non-stop chat and entertainment which seeks to do no more than pass the time of day, but there are also very substantial audiences for programmes which are crafted, intelligent and challenging. There is a demand for services in Welsh and Gaelic as well as the languages of other, newer ethnic communities. Few listeners rely on one station alone. Most people form part of different listening communities at different times. We are all minorities sometimes.

In television, however, we have to recognise that there is a greater danger that the *cost* of making high quality programmes will continue to endow the major centres of population with overwhelming power and influence. There is a danger still that the ability of American television to fund its products on the basis of a vast, essentially homogenous home audience, and then sell these products abroad at marginal cost, will continue to enable the US to engage in a form of cultural dumping and that countries wishing to preserve their own cultural uniqueness will need to find the resources often from non-commercial sources in order to provide expression for their own cultures in the face of such competition.

The success of BSkyB has actually underlined the extremely good value for money which the licence fee represents and which ITV and Channel 4 provide from advertising revenue. ITV as a whole contributes £400m each year to the Treasury in the form of licence payments. If that money, or part of it, can be returned to programme making within the United Kingdom it will do a great deal to ensure that the high quality and diversity of British programming is sustained. The ITC and the Government would be wise, however, to consider very carefully how to provide for national and regional diversity through encouraging television production throughout the nations and regions of the United Kingdom and not just within the M25 circle. After all, it was the regulated regional structure of ITV which generated from Manchester the most popular British television series - *Coronation Street*. I fear that if such decisions had been left to the market researchers of the London-based companies, ITV back in 1955 would never have commissioned a series based on a grimy Northern terrace.

INNOVATION – AN EXAMPLE FROM PILKINGTON OPTRONICS

The Foundation held a lecture and dinner discussion on 15 July 1997 on the subject: "Innovation — The State of the Nation. What are we really achieving?" The evening was sponsored by the Department of Trade and Industry and the Economic and Social Research Council and The Rt Hon The Lord Jenkin of Roding was in the chair. The speakers were Mr Nigel Crouch, DTI Innovation Unit, Professor Frank Blackler, The Management School, Lancaster University, Mr Graham Smart, Strategic Development Director, Pilkington Optronics, and Dr Andrew Rickman, Bookham Technology Ltd.

Mr Graham Smart*

Summary: Mr Smart outlined the development of his company and the various phases of innovative development that had been undertaken since the late 1980s. A strategic review was undertaken in co-operation with Lancaster University (funded by ESRC) which led to the development of practical guidelines of help in looking at how people and organisations interact. Professor Blackler discussed the study, which had suggested an agenda for action that was both practical and urgent.

Introduction

Pilkington Optronics (PO) has a history of innovation. The company has had a series of "firsts" both in terms of product development but also in the advancing of technology which is, after all, so crucial to the development of products. Innovation is central to our business success. Not just production innovation, but our ability to introduce increasingly innovative management techniques in order to exploit our technological and business capacities faster and better in an increasingly competitive world.

Pilkington Optronics designs, develops and manufactures systems and products based on electro-optic technology for application primarily in the military field but increasingly with civil applications. It operates in three locations: Staines, Glasgow and St Asaph in North Wales.

The defence field has faced significant changes over the last decade and industry has had to adjust to a market place which is more discerning and less forgiving in judging a competitive offering. Budgets have been cut significantly in Europe and the USA and the pressure has been increasingly on cost and reliability to give customers increasing value for money – and not before time, many taxpayers around the world would say.

Defence was one of the last of the "sloppy" industries in the 1980s. Cost plus contracts and non-competitive procurement often led to under-performing products, with ever increasing costs and prices and ever extending lateness of delivery. The UK governments' focus on competitive tendering and later the end of the Cold War forged a new drive in industry for cost reduction and on-time delivery. No part of the industry was immune from this. Pilkington Optronics certainly was not immune.

The image of my company in the late 1980s as an innovator was well established but the image did not extend to other measures of customer satisfaction. Our business in Glasgow, Barr & Stroud, was known as the third university of Glasgow. However, the market place was not prepared to account much in value to this historical perspective. So-called "operational improvements" were needed. We embarked aggressively on gaining control of the fundamental business processes through the introduction of MRPII and developed our own processes from this to enable lead-time and cost reduction to be achieved on a significant scale with crucial improvements in quality and reliability. We innovated to take new ideas and translate them into processes to achieve results, which would in the first instance enable us simply to survive.

Innovation and growth

This was a different type of innovation to that for which we were known, but the tangible benefits kept us in business and created a new position from which we could genuinely plan future growth.

These tangible results showed that over a 3- to 4-year period up to 1994:-

- Stock and Work In Progress reduced to 30% of what it was.
- Average lead times in manufacture and engineering reduced to less than half of what it was.
- Delivery to schedule increased from 10% of our business to 97%.
- Added value per employee went up 3-fold.

And I could go on. It was a significant transformation. However, the balance sheet of change was not all positive. Job losses were significant. However, through these difficult change times the culture to seek continuous improvement was fostered. But not all innovation flourished. The days when new technology and product ideas could emerge from a broad array of R&D initiatives, many government funded, were behind us. Our externally funded development activity fell by 50%. Control was paramount and product and technology development needed to be more efficient, and that meant being more selective. We had to spend more of our own money, i.e. a higher proportion of our turnover, on our engineering developments. This is money taken from potential profit and was therefore, generated the hard way. Prioritisation, efficiency and sound justification were the key features of our processes.

Eventually, there was a growing sense that whilst the company was gaining competitive advantage in new approaches to the organisation of the business and its internal business processes, the technology and product innovations were not showing themselves as they used to do. The concern was that by facing up to the new challenges of competitiveness, which invariably involved job losses, that the company was becoming too inward looking and "playing safe" became more of the norm. The customer focus was operationally-led and not so much market-led. We had to assess future market needs and trends better.

The next phase

The next phase of the organisational development was put in place. The business was structured around Business Groups in 1994 with each group resourced to achieve its strategy and budget targets. This gave the business additional customer focus and a more balanced

** Strategic Development Director, Pilkington Optronics Ltd*

▲ *Dr Andrew Rickman, Managing Director of Bookham Technology Ltd, Mr Graham Smart, Strategic Development Director of Pilkington Optronics, and Professor Frank Blackler, Lancaster University, were three of the speakers at the event. Mr Nigel Crouch from the DTI Innovation Unit also spoke.*

approach, i.e. balancing the need for internal improvements with customer focus. This restructuring, together with other process improvements, led to an increase in product development and new technical innovations. The company introduced the concept of incubator groups where technical and design specialists could explore and prepare new approaches to future market opportunities. These people were given the time and budget to explore new product initiatives. Over the last few years, even with the need to improve profitability year on year, we have still increased the amount of money spent on private venture – that is, the amount the company spends of its own money on product and capability development. Furthermore, an acquisition was funded and integrated into the whole company. Coming out of this work, when we carried out our annual strategic review at the end of 1996 we could conclude with some satisfaction that a healthy proportion of business over the next five years was based on products or systems which did not exist inside Pilkington Optronics some two years earlier.

When we reviewed the reasons for this new healthier state and what were the underlying processes to sustain it, it was clear that the full understanding did not exist to enable there to be sustainability. There was not enough evidence that lessons were being learned and internalised. The work of Lancaster University, of whom more later, also highlighted some of these issues and these were fed into the strategic review at the end of 1996.

Strategic review

The conclusions to the strategic review highlighted that whilst significant gains were being experienced the demand from the marketplace for further competitive improvement would not lessen. The need to continue the internal performance and quality improvements would certainly have to continue in line with the strategy set 6 years earlier. However, there was the growing realisation that the business needed to differentiate itself from its competitors in more ways than cost and quality and whilst we were seeing gains in competitive differentials around design and technology we wanted more of it, but, importantly, we needed the effectiveness and efficiency to be maintained. For example, some of the concerns we had and which were also highlighted by the team from Lancaster University from its own work were as follows:

The Business Group Structure did have a tendency to achieve innovation in one particular area and then to "imprison" it. The culture was too "vertically" task driven and insufficiently "horizontally" network driven. It led to examples where part of the engineering organisation was "reinventing" an approach which had already been done to good effect in another part of the organisation. The management reporting system did not encourage the sharing of such knowledge but, more, encouraged a degree of business rivalry amongst Business Groups which led to protectionist behaviour, i.e. holding onto key knowledge but, more importantly, key people, and not marketing these to other areas in case they lost them. Furthermore, the opportunities from the market place were leading to ever increasing demands to increase resources, particularly engineers, but, clearly, some of this demand was feeding the allowing of duplication. Part of the output from the Lancaster University team was to highlight the area where although innovation was taking place there were barriers to the cross filtration of ideas and designs. The company's recent thinking has been to endeavour to take these positive examples and design an organisational model which reduces the inhibition to greater networking. The changes raise a number of new and interesting dilemmas we have to face.

The Company recognises that knowledge management is key to its future success and, in particular, how we build up a sound understanding of the way people and organisations interact so that individual talents can be brought to the front as and where needed. Our people clearly are the source of innovation. It is they in the final analysis who will make Pilkington Optronics competitive, not only by being better but also different. We need to be able to recognise what environment is best for nurturing creativity and what barriers need to be removed in order for the organisation to exploit more rapidly the ideas. We have therefore removed the Business Group Structure and thereby changed allegiances with the goal of achieving significant growth in the business.

However, moving away as we are from the long established hierarchical structures (which have served us so well) to more loosely structured networks in which we can access the appropriate talents does not always sit comfortably with those involved. The new value system needs to be reinforced as we currently seek to bed in this new approach. We are finding that the involvement of Lancaster University as part of the ESRC Innovation Initiative is providing many insights to achieving success in these changes. Frank will now describe his group's work in more detail – how by observing closely our innovation processes they have developed a new way of looking at how people and organisations interact, how they are developing practical guidelines to help apply this understanding and to indicate the relevance of this to other organisations.

Professor Frank Blackler*

Introduction

For the past eighteen months I have had the privilege to lead a multidisciplinary team that has been researching innovation processes in Pilkington Optronics. The project is funded by the Economic and Social Research Council (ESRC) as part of its Innovation Research Programme.

Two researchers are employed full time on the project. At various stages I have also been supported by three other colleagues from Lancaster University. Throughout the time of the project Pilkington Optronics have provided outstanding facilities for our work. For example, we have undertaken a number of retrospective and "real time" studies exploring the strategy that the company developed a few years ago to support its rapid modernisation programme, the ways in which design projects critical for the future of the company have evolved, how the company is integrating and developing essential new areas of expertise, the changing demands on leadership at various levels within the organisation, and the introduction of a new structure based on teamworking. In addition to regular discussions with managers from Pilkington Optronics, we have also discussed the general interpretations we have developed with a panel of industrialists who have met with us every six months. All this has meant that we have been able to study and to analyse relevant processes in the company in unusual detail.

The Management School, Lancaster University

Our aim has been to develop an account of innovation processes in Pilkington Optronics that is both practically relevant to the company and also generalisable to a wide constituency. Our findings underline the significance of the point emphasised by the DTI's Innovation Unit: innovation is best regarded as an ongoing process of renewal. As I sketch out below, one of the outcomes of our work is an account of the innovative management of innovation. We have also explored the view that the management of innovation depends upon the management of knowledge and have developed a workshop format that is designed to help managers apply this approach in practice.

General lessons from the project

Much of the excitement of the project stems from the general relevance of events in this company to other British organisations. The range of changes that the company has had to adapt to makes the point: like many other UK organisations, Pilkington Optronics has had to adjust to rapidly changing markets, global competition, the changing role of government, far-reaching technological changes, and new approaches to management. What is unusual is the extraordinary pace at which this company has had to change. Pilkington Optronics is at the leading edge of efforts to deal with problems that, in the face of significant economic, political and technological changes, many companies find that they are now having to face.

(a) The impact on organisations of changes in the wealth creation process

There has, of course, been no shortage of ideas in recent years about how companies might adapt to changes, for example, from recommendations of downsizing and 'business process re-engineering', through policies for the development of a flexible workforce and the adoption of new technologies, to appeals for 'organisational learning'. Such approaches can, no doubt, be of crucial value in particular situations, but one point that has unmistakably emerged from our studies in Pilkington Optronics that has only rarely been acknowledged in the management literature. In the increasingly complex, volatile and competitive environments of the present day organisations are likely to find themselves facing a range of competing demands for which there can be no straightforward solutions. Short-term needs for survival directly compete with the needs of long-term development. Established strengths must be balanced against changing customer demands and emerging technological possibilities. The need for advanced planning co-exists uneasily with the need for constructive improvisation. The need to utilise rules and standard procedures competes with the need for dialogue and reflection. These points are summarised in Table 1:

Table 1: Contradictory Pressures in Organisations that Compete through Innovation

Competitive Environments and Tensions in Work Organisations	
Short term needs for survival	*Long-term needs for development*
Established strengths	*New demands, new possibilities*
Advanced planning	*Constructive improvisation*
Need for rules and procedures	*Dialogue and reflection*

New approaches to understanding and managing organisations are needed to support the heavy demands on people's abilities to collaborate that this situation precipitates. A slogan used within Pilkington Optronics captures the challenge: the company aims to be 'better, faster and cheaper' than its competitors. In previous times such objectives would have been considered incompatible and companies would expect to address them in sequence over a period of time, for example, through a quality programme one year, an efficiency drive the next, a cost-cutting exercise the year after that. Now, however, these objectives appear equally urgent and all must be achieved at the same time.

(b) The need for new approaches to management

How can contradictory objectives like those listed in Table 1 be achieved simultaneously? The leadership of top managers is one crucial factor. In addition, the reality is that widespread commitment to the reconciliation of mutually competing objectives is essential. Familiar approaches to organisation that place a strong reliance on normal rules and established procedures are of limited value. As summarised In Table 2, responsibility for achieving contradictory objectives needs to be delegated to the creative endeavours of employees throughout an organisation. Our research suggests that for this to be possible staff need to develop an expanded sense of priorities, a broader sense of community, a sense of empowerment and the ability to engage in a collective process of problem solving.

Table 2: Changes in Approaches to Management Necessitated by Contradictory Pressures

Changes in the Processes of Wealth Creation Necessitate New Approaches to Organising
Away from a heavy reliance on:
Routines and procedures
Traditional role demarcations
Formal controls
Internal competition
Towards more emphasis on:
An expanded sense of priorities
An expanded sense of community
Improvisation and experimentation
Dialogue, collective problem solving

(c) Rethinking organisational processes: domain, boundary and contextual innovations

The general implication of this are clear: in the complex circumstances that many organisations find they are currently facing less emphasis should be placed on the structures and procedures of the formal organisation, more emphasis on organising processes and the development of self-adjusting systems. Nonetheless, exactly what this means for day-to-day practices needs to be spelt out. Our work in Pilkington Optronics has focused on this point. We have identified three, interrelated, processes which are, we believe, central to companies that are competing through knowledge and expertise. See Table 3.

Table 3: Innovation Processes in High Technology Organisations

The types of Innovation in Companies that Compete through Knowledge are:
Domain Innovations
Innovations within an area of expertise
Boundary Innovations
Innovations across the boundaries between domains
Contextual Innovations
New understandings of present priorities and of future possibilities
The Core Organising Processes are:
Perspective Making
Practices that develop knowledgeable communities
Perspective Taking
Practices that develop mutual understanding and collaboration between communities
Perspective Shaping
Practices that facilitate reflection and re-interpretation of collective priorities

Domain innovations are innovations that occur within groups of experts as members develop new approaches to problem solving.

Such groups can be made up of specialist professionals, functional experts, multi-disciplinary project groups or management groups. Much of the literature on innovation is concerned with this type of innovation and it is essential that organisations which seek to compete through knowledge should develop strong innovative groups.

Nonetheless, our research suggests that in the complex trading conditions of the present time two other forms of innovation are also vital. Boundary innovations occur when different groups of experts, each of which will have a distinctive contribution to make, develop new ways of working together. The advantages of cross-disciplinary working have been widely championed in recent years, but, in practice, such collaboration can be surprisingly difficult to achieve. Different specialists view the same problems in different ways, have been trained to utilise different concepts and problem solving approaches, often follow different behavioural norms and identify themselves with their separate communities. Close collaboration that is based upon improvisation dialogue and collective problem solving between, for example, marketeers, sales staff, designers, manufacturers, can prove elusive as such groups have strong but contrasting orientations. Collaboration that requires people to cross the boundaries between them is a creative achievement that needs adequately to be resourced.

Finally, contextual innovations occur when staff learn to appreciate the significance of their activities in new ways and to appreciate the significance of changes in the context in which they are operating. Like boundary innovations, it is often not easy to encourage contextual innovations; past successes can blind people to the significance of change and of the need to re-think familiar intergroup relations and the division of labour (and of knowledge) between them.

This threefold classification helps identify core organising processes in organisations that compete through knowledge. Expert groups need to develop their particular contributions to problems; perspective making is the core process here. Perspective making within an expert group is supported when participants develop a sense of shared identity, a shared sense of shared priorities, and when they feel empowered. Particular expert groups need also to develop their understandings and appreciations of other expert groups; perspective taking is the core process here. Perspective taking is supported by the cultivation of an overall sense of allegiance across groups, by familiarity between them in terms of their various contributions, and by managerial actions that support groups through the anxieties that develop when relations between groups begin to alter. Finally, perspective shaping to support new appreciations and approaches occurs when, for example, staff develop lively external networks, when they benchmark their practices against those of their competitors, and when they have some time free from the immediate pressures of the moment to reflect upon their activities.

(d) Applying the approach to the research process

Finally, it seems appropriate to point out that this general analysis is of direct relevance not only to business organisations but also to the conduct of management research. In reflecting on the lessons of our research over the past eighteen months, it is clear, I think, that any contribution that my colleagues and I have been able to make to Pilkington Optronics in particular and to the broader business community in general depends upon our abilities to innovate within our specialist fields. In the terminology I have used in this discussion, it depends upon our ability to achieve 'domain innovations'. At the same time, however, we have become increasingly aware of the need to find new ways of collaborating with those we have been studying. If our work is to be useful we have, in other words, to step outside our conventional roles as academics and work to achieve 'boundary innovations' with others. Further, we have come to recognise that in the context of significant changes to the wealth creation process academics and managers alike would be advised to reconsider their attitudes to management research and, through 'contextual innovations', to begin jointly to fashion a new approach to collective enquiry.

▲ *Dr Michael Sanderson, Chief Executive EMTA, looking away from the camera, talks to Baroness Platt of Writtle at the event on innovation. Also in the picture are Mrs Marie-Noelle Barton and Professor Chris Elliott, Hon Secretary of the Foundation.*

The close relationship that ESRC has supported between my research team and Pilkington Optronics cannot be classified in the conventional way either as detached academic enquiry or as management consultancy. It has been both these things and more, being based on the careful collection of data, extended debate about how such data should be interpreted, and an appreciation of the overriding need for forward-looking actions. Intensive case work in single companies presents a number of problems: managers may be reserved about the wisdom of giving an outside research team the necessary access, from the researcher's point of view detailed case work can be very demanding and, in advance of doing the work, it is impossible to be certain that any particular study will produce distinctive results. Yet, while there are risks in this kind of research detailed case analysis can, as in this case, produce exceptionally interesting data which can support a depth of understanding that cannot be obtained in any other way. When such research is undertaken in companies that are facing problems which are widely experienced elsewhere, it can produce results that are of broad significance.

In the uncertain and changing environment of the present day it is clear that new and unanticipated organisational problems are likely to develop. New forms of research collaboration such as the one that my research team has been privileged to develop in Pilkington Optronics promise practical benefits that will be of widespread applicability.

Summary

The research in Pilkington Optronics that the Economic and Social Research Council has funded has supported close study of the impact of recent economic political and technological change on an organisation that is well known for its design innovations. The research has developed from the insight that the key to successful innovations is an understanding of the nature of knowledge and how it may be managed. It has identified the central relevance not only of innovations within particular domains of expertise, but also of the importance of innovations between domains and of new understandings of the changing context of business activities. Study of these processes has suggested an agenda for action that is both practical and urgent. It features the significance of new approaches to management for the successful development and exploitation of new ideas, and has demonstrated the value of new approaches to research in this area

DISCOVERIES IN SPACE RESEARCH

The Foundation held a lecture and dinner discussion at the Royal Society on 23 April 1997 on the subject "Space in our Lives - Sound Business or Expensive Illusion?" The Lord Butterworth CBE DL was in the chair and the evening was sponsored by AEA Technology, British National Space Centre and the Foundation's Shared Sponsorship Scheme (BP International Ltd, Comino Foundation, Esso UK plc, Glaxo Wellcome plc and ICI plc). The speakers were Professor Sir Robert Wilson CBE FRS, Professor Emeritus Astronomy, University College London, Mr Iain Green, Matra/Marconi Space UK, and Mr James V Zimmerman, European Representative, NASA.

Professor Sir Robert Wilson CBE FRS*

Summary: Sir Robert gave examples from discoveries made in the regions of ultraviolet, X-rays and gamma-rays.

Introduction

It is important to realise that space research is not a single discipline but an advanced technique which embraces many activities ranging from the totally commercial (e.g. communications and broadcasting) to the purely cultural (e.g. astronomy). During my own involvement in space, both in teaching and research, I have been struck by the enormous interest and enthusiasm it engenders in young people. There are many reasons for this and I will present a few examples from my own subject - astronomy - which, together with the opening up of radio astronomy, entered a new golden age with the ability to make observations from above the atmosphere in the previously inaccessible regions of ultraviolet, X-rays and gamma-rays. I can only give one example of the many exciting discoveries from each of these fields.

Ultraviolet observations

Observations by the International Ultraviolet Explorer (IUE) satellite of stars in the Large Magellanic Cloud, a nearby irregular galaxy, revealed that our own Milky Way galaxy has a very hot (100,000°K) and very extensive (100,000 light years) halo. The mechanism by which this halo is heated is still a matter for astronomical study, but the discovery did explain a phenomenon that had puzzled astronomers for many years. Spectra of quasars, the most distant observable objects in the universe, revealed absorption lines formed by intervening media in intergalactic space. They were of two kinds: one indicated cold clouds of primordial hydrogen that had not collapsed to form stars and galaxies, but the other indicated clouds of very hot material showing the common elements, such as carbon, nitrogen and silicon, in multiple stages of ionization as in the halo of our own galaxy. What were being observed were the hot, extensive haloes of the intervening galaxies between ourselves and the quasars.

Cosmic X-rays

Before the advent of space research, astronomers did not expect any intense sources of cosmic X-rays. The only known extraterrestrial source was the solar corona, a hot (2 million °K) but very tenuous medium surrounding the Sun whose X-ray emission would be very difficult to detect even from the nearest stars. Hence, when proposals were being generated in the early 1960s for all other areas of space astronomy, there were hardly any for X-ray astronomy. This situation was to change dramatically after 1962 when an American rocket was launched with the apparently mundane objective of trying to detect X-rays from the Moon caused by the impact of X-rays from the Sun. It did not do so but, during its few minutes toppling above the Earth's atmosphere, it detected an intense source in the region of the constellation of Scorpius. This major surprise initiated the development of X-ray astronomy and all the great developments that accrued.

A large variety of cosmic X-ray sources have now been detected using major satellite missions. The first to be identified was the Crab nebula (the remnant of a supernova explosion in 1054) but the very brightest sources, including that in Scorpius and others in Centaurus and Hercules, defied identification until the first X-ray satellite, called Uhuru, observed that two of these disappeared on a regular basis with a period of about 2 days. The optical astronomers recognised this as the sign of an eclipsing binary system - two stars which are orbiting in a plane that lies in the line of sight, causing one to pass behind the other thereby obscuring its emission once every period.

Optical observations had already been made of these objects and by matching the periods unambiguous identifications were quickly made. The objects were binary systems in which a normal star was being orbited by an intensely hot (about 10 million °K) companion. The optical astronomers could only see the former and the X-ray astronomers could only see the latter.

But what could possibly heat the companion star to such a temperature? A clue came from the short period of 2 days (the Earth takes a year to orbit the Sun) which meant that the two stars were close and tidal actions would be heavy. The solution came from the discovery of pulsars by radio astronomers: these are very compact stars which are smaller than major cities and in which gravity has become the dominant force, condensing material to nuclear densities. In such a condition, protons and electrons cannot exist separately but are forced together to become neutrons - it is a neutron star.

The model that emerged is of a binary system composed of a normal star and a neutron star. The tidal effect of the latter on the former causes a transfer of matter from the normal star which falls into the intense gravitational field of the neutron star, forming an accretion disk and heating up by friction and viscosity. The velocities can reach ten or more per cent of the velocity of light providing enough power to heat the disk to several million degrees and explain the X-ray emission.

It is of interest to this audience to comment on this cosmic energy generator from a human point of view. The energy generation is at a higher level (by about a factor of ten) than that of a thermonuclear process converting hydrogen into helium. But the man-made generators need a specific kind of fuel - oil or coal for conventional generators, uranium or plutonium for nuclear fission generators, or

Professor Emeritus Astronomy, University College London

(whenever they are achieved) hydrogen for thermonuclear generators - the cosmic gravitational generator only needs matter of any kind. These are ideal properties for earth-based generators with inexhaustible fuel which could be waste-products and rubbish. But, unfortunately, the required technology is out of sight.

Cosmic gamma-rays

Gamma-ray astronomy developed quite quickly because cosmic gamma-rays were expected before the space age. This is because the Earth is bombarded by extremely energetic particles (cosmic rays) which produce showers of sub-atomic particles and gamma-rays in the Earth's atmosphere. Their effect on the interstellar gas should also produce gamma-rays, and the early scientific satellites confirmed this.

But the first observations of cosmic gamma-rays had been made earlier by the United States Airforce who had launched spy satellites with gamma-ray detectors in order to monitor any clandestine H-bomb detonations in space by the Soviet Union. (The United States and Soviet Union had already conducted one each.) The USAF detected a gamma-ray burst in 1967 and this news must have travelled rapidly up through the Pentagon to the White House. But after a few months, when several had been detected, such profligacy raised serious doubts about their man-made origin and, after some years of monitoring, it was concluded that they were cosmic in origin and the results were declassified and published in 1973.

The gamma-ray bursters have received extensive attention ever since by several scientific satellites, of which the Compton Observatory is the most notable and detects about one event every day. Most of the bursts last between one and 100 seconds and the energy flux reaching Earth at peak is greater than the brightest stars. Such high fluxes led astronomers to conclude that the sources must be within our own galaxy, but even here there was a considerable problem in explaining the very high energy bursts needed. But as the data have built up, a uniform distribution over the whole sky has emerged without the asymmetry expected of galactic objects, but more like that expected of extragalactic systems. The energy problem now becomes very great and is exacerbated by the fact that the bursts have not yet been identified with any known object. The true nature of these immense cosmic explosions is one of the intriguing astronomical puzzles of the day.

FOUNDATION NEWS

New Associate Members

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

Yamanouch Research Institute
Contact: Dr John Lackie, Director
Association of the British Pharmaceutical Industry (ABPI)
Contact: Dr Jeff Kipling, Director, Science & Technology
Napier University
Contact: Professor J Mavor FEng FRSE, Principal & Vice-Chancellor
Wates Technology
Contact: Michael C Beer, Divisional Manager
Research Fortnight
Contact: Ian Mundell, Editor
Emblem Research Associates Ltd
Contact: Martin Bloom, Director
Microsoft Research Ltd
Contact: Professor Roger Needham FEng FRS
R & D Efficiency
Contact: Dr David Fishlock OBE
UCAS
Contact: M A Higgins, Chief Executive
Mainprice Napier & Co
Contact: James Burchett, Partner

Annual General Meeting

The Foundation's Annual General Meeting was held in the house of the Royal Society on Tuesday, 19 May 1998, at 1215 hours with the Rt Hon The Lord Jenkin of Roding in the chair. Some 41 members and guests attended.

Dr Geoffrey Robinson, a member of the Foundation's Council, has been elected Deputy Chairman by Council on the retirement of Sir Richard Morris, who remains on Council.

Dr Geraldine Kenney-Wallace, Managing Director and Vice-Chancellor British Aerospace Virtual University, British Aerospace plc, has been elected a Member of the Foundation, and a member of Council on the retirement of Dr Brian Newbould.

Learned and Professional Society News

The Foundation has produced a paper summarising the Nolan Reports on Standards in Public Life which has been circulated with the latest Newsletter: copies are available from the Foundation on request.

The 1998 Salary Survey in respect of the staffs of learned and professional societies is now in course of preparation and should be available for purchase later in the summer. Plans are in hand for the publication of a 1998 edition of the Register of Learned and Professional Societies, although it is expected that its availability for purchase will be in the autumn.

HM Government has published a Data Protection Bill which is intended to come into force in October 1998. The Bill proposes several changes to the present data protection law, including its extension to some manually-kept records.

The promised White Paper entitled "Learning for the 21st Century" has not been published, apparently, because of inadequacies in its drafting and intention. However, there is an initiative of much interest to the academic community which has been launched already; it is the National Grid for Learning which is to be 'a mosaic of interconnecting networks and education services based on the Internet which will support teaching, learning, training and administration in schools, colleges, universities, libraries, the workplace and the home'. Managed services for the Grid will be available from this autumn with all institutions connected by 2002.

The Charity Commission is engaged on a review of its Register to ensure that all registrants are properly charitable under existing law and it will consider what developments to charitable status are necessary in response to changing social circumstances. This is part of the welcome development of the Commission's activities in recent years, which include its seeking to monitor, support and encourage improved standards amongst its charities.

CHAIRMAN'S REPORT FOR THE YEAR ENDED 31 DECEMBER 1997

Chairman: The Rt Hon Lord Jenkin of Roding

This is my first report, and I would like to start by saying what a pleasure it has been to take over from Lord Butterworth, and what a very hard act to follow! He did so much to develop the Foundation and to preserve and enhance our role. We are extremely fortunate to retain his interest and involvement in his position as President.

It has been a full and active year. We have taken a look at the Foundation's objects to see whether we are fulfilling them, and doing so as effectively as we would wish. Several things have emerged, not least the fact that we should keep the format and timings of the lecture and dinner discussions broadly as they are, but that efforts should continue to be made to attract more industrialists and more younger people to them. Dr Geoff Robinson, relatively new to the Council, proposed and has initiated a plan to hold a series of events under a single theme, that of "Quality of Life for the Millennium Generation". Each event would stand alone and would have a particular topic; on the day of the event some 18 younger engineers and scientists would meet to discuss their views of the topic. All would be invited to attend the evening event, and one would be asked to be one of the speakers. This will be one way of introducing some younger people in our work, and should also attract the interest of more industrialists.

Many ask what follow-up there is after our lecture and dinner discussions, and the answer is, of course, that it is up to each of those attending to take matters forward as they think appropriate. However, we have recently introduced a single sheet summary as an aide memoire which is sent not only to all those who attended, but also to those specially invited to the event but who were unable to accept. Here we are extremely fortunate in having the skilled assistance of Sir Geoffrey Chipperfield and Mr Jeff Gill, both of whom have agreed to help in this way. We are most grateful to them.

We took a hard look at our work with countries outside the United Kingdom and felt that we should be concentrating our slim resources on France and Germany since. Through the guidance and help of Dr Richard Haas, we already have a number of good contacts in those countries. During the year we held an event in London with the French Embassy and the Engineering Council when we had some two hundred engineers discussing matters of training and qualifications. The differences between the systems of the two countries were highlighted, and it might be that the conference will be followed up with some smaller meetings in Paris. In June last year the Foundation participated with an exhibition stand in the Munich Innovation Fair. Later, in October, Dr Haas arranged a meeting in Brussels with the Royal Belgo-British Union at which I spoke, focusing on the scientific collaboration between the two countries and on some of the issues concerning the EU Framework Programme in particular.

The evening events have continued at about the same frequency as in recent years, which Council feels is about the right balance. We have included subjects such as virtual markets in the City, IT after the Woolf Report, research and the Framework Programme, innovation in industry, meeting targets over carbon dioxide emissions, priorities in medical research, the food agency, and financing research. Jennifer Grassly continues to play her important role in looking after much of the administration and giving, above all, her warm welcome to those attending our evenings.

Keith Lawrey has brought new skills and great assistance to the Foundation's work with learned and professional societies. I know that his work and willing help over a number of matters is greatly appreciated by the Director. Keith continues to organise interesting seminars and workshops, and many will know his helpful two monthly "Learned Societies' Newsletter".

I am not going to mention all the aspects of the Foundation's work, but I would like to single out the Foundation's Journal. We often hear warm comments about it, and few know that much of the preparation is done by our Editor, Derek Eddowes, who works from his home in Surrey. He has been Editor since the Journal was initiated many years ago by Dr Haas. I thank him most warmly.

Members of Council are the Directors and the Trustees of the Foundation. They bear the responsibility for the Foundation as a Company Limited by Guarantee and as a registered charity. We are all grateful for the help and guidance they give so freely. Of course, much of the detailed work is done by the Honorary Officers, and I would especially like to thank Sir Richard Morris, our Deputy Chairman, Roger Davidson, our Honorary Treasurer, and Professor Chris Elliott, our Honorary Secretary. Today we lose Sir Richard as Deputy Chairman. He has been an enormous strength to the Foundation, and especially to me in my last year as Chairman. I am sure you would all like to show your appreciation for his generous work. Fortunately, he still has time left on Council, and I am confident that we shall feel his influence and benefit from his involvement for many years to come.

My thanks would, of course, be incomplete without expressing once again our gratitude for the huge contribution to our affairs made by the Director. I believe that we have a very lively appreciation both of the commitment and of the skill which he brings to his job of Director. David, we are extremely grateful to you.

The Annual Report and financial statements illustrate that the Foundation is in a strong position, and that it is developing the whole time.

We receive much greatly valued support from a number of other bodies, and together we all face a rapidly changing and challenging future in science and engineering and society; and there, my Lords, ladies and gentlemen, lies our future.

FOUNDATION FOR SCIENCE AND TECHNOLOGY
STATEMENT OF FINANCIAL ACTIVITIES
FOR THE YEAR ENDED 31 DECEMBER 1997

	Unrestricted Funds	Restricted Funds	1997	1996
INCOME AND EXPENDITURE	£	£	£	£
Incoming resources				
Donations	13,642	-	13,642	19,093
Sponsorship income	142,083	-	142,083	127,872
Accreditation fees and subscriptions	114,758	-	114,758	99,257
Learned societies activities	5,010	-	5,010	13,832
Fixed asset grant	967	-	967	967
Listed investment income	9,047	-	9,047	8,456
Bank deposit interest	24,132	620	24,752	17,441
Total Incoming Resources	309,639	620	310,259	286,918
Resources Expended				
Direct charitable expenditure	195,571	285	195,856	182,460
Management and administration	54,055	-	54,055	51,691
Total Resources Expended	249,626	285	249,911	234,151
Net Incoming Resources for the year	60,013	335	60,348	52,767
Other Recognised Gains and Losses				
Unrealised gains on investment assets	29,822	-	29,822	11,709
	89,835	335	90,170	64,476
Net Movement in Funds				
RETAINED SURPLUS BROUGHT FORWARD	543,323	11,096	554,419	489,943
RETAINED SURPLUS CARRIED FORWARD	633,158	11,431	644,589	554,419

TOTAL RECOGNISED GAINS AND LOSSES
The company has no recognised gains or losses other than the surplus or deficit as shown above.

CONTINUING OPERATIONS
None of the company's activities was acquired or discontinued during the accounting periods shown above.

	1997 £	£	1996 £	£
FIXED ASSETS				
Tangible assets		6,127		7,969
Investments		411,765		355,801
		417,892		363,770
CURRENT ASSETS				
Debtors	22,967		23,544	
Cash at bank – on deposit	210,417		189,669	
– current account	500		500	
– The Harold Silman Fund	11,687		11,132	
Cash in hand	122		38	
	245,693		224,883	
CREDITORS – amounts falling due within one year	18,996		34,234	
NET CURRENT ASSETS				
TOTAL NET ASSETS		226,697		190,649
Financed by:		644.589		554,419
FUNDS				
Unrestricted		633,158		543,323
Restricted		11,431		11,096
		644.589		554,419

Approved by the Council on 18 March 1998 and signed on its behalf by THE RT HON LORD JENKIN OF RODING and R G L DAVIDSON

PROFILES OF COUNCIL MEMBERS

Sir Walter Bodmer, PhD, FRCPath, FRS

Walter Bodmer is Principal of Hertford College, Oxford, formerly Director-General of the Imperial Cancer Research Fund, having been Director of Research at the Fund from 1979 to 1991. He was made a Fellow of the Royal Society in 1974 and received a knighthood in 1986. He is a Foreign Associate of the US National Academy of Sciences and a Foreign Honorary Member of the American Academy of Arts and Sciences.

He attended Manchester Grammar School and won a scholarship to Cambridge to read for a degree in mathematics. During this course, through his interest in statistics he discovered and became fascinated by the new world of genetics; he remained in Cambridge after graduating and researched for a PhD in population genetics, under the inspiring influence of Sir Ronald Fisher. He completed his PhD in three years, by which time he and Julia Bodmer had married and had two of their three children. During two more years at Cambridge as a Fellow of Clare College and a Demonstrator in the Department of Genetics, Walter Bodmer broadened his interests and expertise in genetics. He initiated what has become a lasting involvement in somatic cell genetics, ie the experimental study of genetics in cultured animal cells, an approach which allows the mapping of genes to specific chromosomes and the study of gene function. He began at this stage to be drawn to the more biochemical and molecular aspects of genetics: molecular biology attracted him to Stanford University, California, to the laboratory of Joshua Lederberg, Nobel prize-winner for his pioneering studies of gene exchange in bacteria. In the stimulating environment of this prestigious laboratory, over the course of his nine-year stay Sir Walter made substantial contributions to the area of DNA transformation of bacteria.

In 1970 Walter Bodmer returned to the UK to take up the chair of genetics at Oxford. Here he and his colleagues made significant advances in the understanding of the evolution, genetics and function of the human histocompatibility system.

In 1979 he left Oxford to become Director of Research at the Imperial Cancer Research Fund Laboratories in London and in 1991 was appointed Director-General of the Fund.

Walter Bodmer has worked for many years on the development and molecular and biochemical analysis of the HLA system and its association with disease, and now is interested in the variation in expression of HLA determinants in cancer. This, together with a much improved understanding of the mechanism of action of T cell recognition, provides a totally new approach to the understanding of the way the immune system attacks cancer cells.

His other chief interest is in the genetics and biology of the epithelial cells in the colon from which the majority of colorectal adenocarcinomas are derived. In collaboration with several other groups at the ICRF, his laboratory helped to localise the gene for the inherited colon cancer susceptibility, adenomatous polyposis coli. Now that the gene has been identified, his laboratory is involved in studying its mutations and functions. New models for differentiation of colonic epithelial cells emphasise the involvement of integrin receptors for extracellular matrix components and carcinoembryonic antigen CEA in the control of normal differentiation and abnormalities in the expression of these molecules in cancer cells.

Walter Bodmer has had a major interest in promoting public understanding of science and from 1990 to 1993 served as Chairman of an organisation committed to this: COPUS (the Committee on the Public Understanding of Science) was established in 1986 as a joint committee of the Royal Society, the Royal Institution and the British Association for the Advancement of Science to provide a focus for a broad-ranging programme to improve public awareness and understanding of science and technology, its achievements and limitations. Sir Walter is closely involved with the activities of the British Association for the Advancement of Science (of which he was President in 1988 and is now a Vice-President) and from 1989 to 1993 served as Chairman of the Trustees of the Natural History Museum in London. In 1995 Sir Walter was appointed Chancellor of the University of Salford. The range of his interests and concerns is reflected in the list of organisations he supports: as well as holding offices for a large number of scientific societies and publications, he is a trustee of Sir John Soane's Museum and of the Laban Centre for Movement and Dance.

Through his earlier work on human gene mapping and his current interests in genetics, Walter Bodmer is now extensively involved in the gene mapping project. This led to his Presidency from 1990 to 1992 of HUGO, the International Human Genome Organisation, whose aim is to foster collaboration between different countries in the Human Genome Project.

Sir Walter is an Honorary Fellow of Keble College, Oxford, and Clare College, Cambridge, of the Royal Colleges of Physicians and Surgeons, and of the Royal Society of Edinburgh, and he has been awarded a number of honorary degrees and prizes recognising his achievements in science.

His publications include, jointly, 'The Genetics of Human Populations', 'Our Future Inheritance: Choice or Chance?', 'Genetics, Evolution and Man, The Book of Man' and several hundred research papers.

Sir Walter's interests include playing the piano, riding and swimming. He and Julia have two sons and a daughter and four grandsons.

▲*Sir Walter Bodmer*

LEARNED AND PROFESSIONAL SOCIETIES ACCREDITED AND AFFILIATED TO THE FOUNDATION FOR SCIENCE AND TECHNOLOGY AS AT 30 JUNE 1998

Academia Europaea
Agricultural Economic Society
Anatomical Society
Antiquarian Horological Society
Architects and Surveyors Institute
ASSET
Association for Learning Technology
Association for Science Education
Association of Applied Biologists
Association of Clinical Biochemists
Association of Clinical Pathologists
Association of Medical Research Charities
Association of Project Managers
Association of Teachers of Mathematics
Bibliographical Society
Biochemical Society
Botanical Society of the British Isles
British Association for the Advancement of Science
British Biophysical Society
British Cartographic Society
British Computer Society
British Crop Protection Council
British Dental Association
British Ecological Society
British Entomological & N H Society
British Grassland Society
British Horological Institute
British Institute of Facilities Management
British Institute of Radiology
British Medical Ultrasound Society
British Mycological Society
British Nutrition Foundation
British Ornithologists Union
British Pharmacological Society
British Phycological Society
British Psychological Society
British Records Association
British School of Archaeology in Iraq
British Schools Exploring Society
British Society for History of Mathematics
British Society for History of Science
British Society for Immunology
British Society for Parasitology
British Society for Plant Pathology
British Society for Rheumatology
British Society for Strain Measurement
British Society of Audiology
British Society of Soil Science
British Sociological Association
British Sundial Society
Cambridge Philosophical Society
Challenger Society for Marine Science
Charles Close Society
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Chartered Institute of Building
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Chartered Institute of Public Finance & Account
Chartered Institute of Purchasing & Supply
Chartered Institute of Transport
Chartered Institution of Building Services Engs
Chartered Society of Designers
Chartered Society of Physiotherapy
College of Teachers
College of Radiographers
Consortium of University Research Libraries
Council for British Research in the Levant
Council for Professions Supplementary to Medicine
CSTI
Ecclesiastical History Society
Economics & Business Education Association
Egypt Exploration Society
English Association
Ergonomics Society
Experimental Psychology Society
Federation of British Artists
Fisheries Society of the British Isles
Galton Institute
General Optical Council
Geographical Association
Geological Society
Geologists' Association
Guild of Air Pilots & Air Navigators
Heraldry Society
Historical Association
Hydrographic Society
IEEIE
Incorporated Society of Musicians
Institute for Supervision and Management
Institute for the Management of Information Systems
Institute of Acoustics
Institute of Actuaries
Institute of Automotive Engineer Assessors
Institute of Biology
Institute of Biomedical Science
Institute of Brewing
Institute of British Foundrymen
Institute of Building Control
Institute of Chartered Shipbrokers
Institute of Corrosion
Institute of Cost & Executive Accountants
Institute of Energy
Institute of Export
Institute of Field Archaeologists
Institute of Fisheries Management
Institute of Food Science & Technology
Institute of Heraldic & Genealogical Studies
Institute of Highway Incorporated Engineers
Institute of Horticulture
Institute of Information Scientists
Institute of Leisure & Amenities Management
Institute of Linguists
Institute of Logistics
Institute of Management
Institute of Management Services
Institute of Marine Engineers
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Institute of Maths and its Applications
Institute of Measurement and Control
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Institute of Plumbing
Institute of Psycho-Analysis
Institute of Quality Assurance
Institute of Refrigeration
Institute of Risk Management
Institute of Road Transport Engineers
Institute of Science Technology
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Institute of Trichologists (inc)
Institution of Agricultural Engineers
Institution of Chemical Engineers
Institution of Civil Engineers
Institution of Electrical Engineers
Institution of Engineer Designers
Institution of Gas Engineers
Institution of Incorporated Engineers
Institution of Lighting Engineers
Institution of Mechanical Engineers
Institution of Structural Engineers
Institution of Water & Environmental Management
International Association on Water Quality
International Glaciological Society
Landscape Institute
Linnean Society of London
London Mathematical Society
Manpower Society
Marine Biological Association of the UK
Medical Society of London
Multimedia and Primary Education
Mineralogical Society
National Association for the Teaching of English
Natural History Museum
Nautical Institute
Newcomen Society
Nutrition Society
Oil & Colour Chemists' Association
Operational Research Society
Overseas Development Institute
Palaeontological Association
Palestine Exploration Fund
Pensions Management Institute
Photogrammetric Society
Physiological Society
Pipeline Industries Guild
Quekett Microscopical Club
Regional Studies Association
Remote Sensing Society
Research Defence Society
Royal Archaeological Institute
Royal Asiatic Society
Royal Astronomical Society
Royal College of Art
Royal College of General Practitioners
Royal College of Ophthalmologists
Royal College of Pathologists
Royal College of Physicians
Royal College of Speech and Language Therapists
Royal Entomological Society
Royal Forestry Society
Royal Geographical Society (with the IBG)
Royal Historical Society
Royal Institute of Navigation
Royal Institute of Public Health and Hygiene
Royal Institution of Great Britain
Royal Meteorological Society
Royal Microscopical Society
Royal Photographic Society
Royal Society for Asian Affairs
Royal Society of Chemistry
Royal Society of Edinburgh
Royal Society of Medicine
Royal Statistical Society
Royal Town Planning Institute
SCI
Scottish Association for Marine Science
Society for Applied Microbiology
Society for Computers and Law
Society for Endocrinology
Society for Experimental Biology
Society for Promotion of Roman Studies
Society for Research into Higher Education
Society for Study of Inborn Errors Metabolism
Society for the History of Natural History
Society for Underwater Technology
Society of Archivists
Society of Dyers & Colourists
Society of Environmental Engineers
Society of Food Hygiene Technology
Society of Genealogists
Society of Indexers
Society of Jewellery Historians
Society of Practitioners of Insolvency
Strategic Planning Society
Textile Institute
UACES
UK CEED
Zoological Society of London

SPONSORED LECTURES, LEARNED SOCIETY SEMINARS AND FOUNDATION VISITS
1 SEPTEMBER 1997 – 30 APRIL 1998

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"Using IT to Teach Science and Technology. Stagnation or Success?"	Dr David Moore Professor Stephen Heppel Mr Bob Ponchaud Mr Alastair Gittner	NORTEL – Northern Telecom
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"Information Technology: Towards an Integrated Criminal Justice System"	Mr Geoffrey Hoon MP The Rt Hon Lord Justice Brooke Professor Richard Susskind FRSE	EDS
"The Dearing Report and the Research Base" – Industry, Academia & Charities	Sir Richard Sykes DSc FRS Professor David Watson Professor Martin Harris CBE	British Council British Petroleum Company plc The Royal Society
"Success in Technology Ventures Through Science, Engineering and Technology"	Mr G R Wilson CB Professor Kevin Morgan Professor J F McClelland CBE FRSE	Scottish Power Scottish Enterprise
"Life Long Learning for an Industrial Society – Challenges?"	Professor M P Thorne Mr Chris Yapp Mr John Baumber	Engineering and Marine Training Authorit
"Science Keeping Pace with Society?"	Dr George Poste FRS The Rt Rev Stephen Sykes Professor Ian Kennedy	Health & Safety Executive Pfizer Central Research The Royal Society Zeneca
"How Many Public Funded Researchers should we Have?"	Sir David Davies CBE FEng FRS Sir Hermann Bondi KCB FRS Dr Barry Furr	Aerial Group Limited Department for Education and Employment The Kohn Foundation The Foundation's Shared Sponsorship Scheme
"Electronic Commerce – Is There a Future?"	Mr Nick Barley Mr Jonathan Steel Mr Tim Jones	Oracle
"Are we Preparing Students For a Changing Professional World?"	Dr Tom Inch Professor Dr H Konig Professor Sir Gareth Roberts FRS	Chemical Industries Association Council for Industry & Higher Education ICI plc The Royal Society of Chemistry
"The Private Finance Initiative: Its Impact on Science"	Mr Sanjay Ghosh Dr Richard Worswick Professor Chris Elliott	Foundation's Shared Sponsorship Scheme

FOUNDATION TECHNOLOGY VISITS

"An International Trading Treaty" – Visit to the British Standards Institution, Chiswick

SEMINARS FOR LEARNED SOCIETIES

VAT 1997
The Dearing Report
Defamation: The Cost to Learned Societies
Governance: The Relationship between Trustees and Managers

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