

# SCIENCE SHAPING THE FUTURE?

- *Future opportunities in wealth creation.*
- *Making the most of science and engineering.*

The Technology Foresight (TF) Programme was a 'flagship' of the previous Government's science policy, intended to harness public spending on science, engineering and technology (SET) more closely to wealth creation and improving the quality of life. The Programme was launched in 1994, completed Phases I and II in 1995 and 1997; Phase III has just started. Planning is underway for the next foresight process envisaged for 2000.

*POST has carried out a review for the new Parliament of the TF Programme, its impacts and options for the Foresight Programme from 1997 onwards<sup>1</sup>.*

## BACKGROUND

The TF Programme's rationale flows from the fact that UK science accounts for only 5% of that carried out worldwide, making priority setting and good international networking essential to progress. At the same time, industry relies increasingly on technical innovation for competitiveness, making its own research and links with universities critical to success. TF responds to these modern 'facts of life' by:

- building a consensus on the various generic technologies which are likely to yield greatest economic and social benefits to the UK in the long term;
- breaking down barriers between different parts of the UK and its institutions (between industry and academia; between the City and high-tech industry; between markets and technologies);
- influencing the funding patterns of publicly-funded research - through the Office of Science and Technology (OST) directly, via the Research Councils (RCs), universities and government departments, as well as within industry and other organisations.

The full background to the TF exercise is described in the full report, and can be traced to the example set many years ago by countries such as Japan and the USA which looked at future scenarios for the ways in which technologies and markets might develop. The White Paper "Realising Our Potential" (May 1993) decided on the programme and OST launched TF in 1994 (**Box 1**).

The outcome of Phase I was a set of 15 panel reports covering the areas in **Table 1**, and an overview by the TF Steering Group (TFSG). The actual work had involved many thousands of people and had brought together university and industrial scientists, technical and mar-

<sup>1</sup> The full report "Science Shaping the Future? - Technology Foresight and its Impact (70 pp)" is available from POST, 7 Millbank, London SW1P 3JA (free to Parliamentarians; £12 otherwise).



**POST**  
REPORT  
SUMMARY

**97**  
June  
1997

*This is a summary of a 70-page report available from the PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (extension 2840).*

### Box 1 TECHNOLOGY FORESIGHT - PHASE I

To oversee the programme, OST assembled a Technology Foresight Steering Group (TFSG), chaired by the Chief Scientific Adviser and including members drawn from the industrial, scientific and engineering communities, research charities, and from government departments. The TFSG's job was to translate the remit in the White Paper (see full report) into a practical programme. The main programme was pursued through fifteen sector panels which engaged whole sectors of the economy.

Panels addressed questions such as:-

- What are the likely social, economic, environmental and market trends of the next 10-20 years?
- Which areas of R&D and underpinning SET best address these future trends?
- How best can public funds be used to sustain an innovative science base to support national wealth creation and quality of life?
- Should regulation, skills, educational facilities and other factors be taken into account?

The panels assembled reviews of markets and technologies and consulted widely via sub-groups, regional workshops as well as through large-scale 'Delphi' surveys. Each panel published its own report during 1995 - between them over 360 recommendations were made, ranging from increasing support to specific initiatives in SET, through to addressing future skill requirements and obtaining policy and regulatory changes. The Steering Group then identified generic themes and priorities emerging across the different panel sectors, and evolved their own list of priority themes which cut across the panel sectors.

**Table 1 FORESIGHT SECTOR PANELS (1995)**

Agriculture, Natural Resources and Environment (ANRE)	Energy Financial Services Food and Drink Health and Life Sciences (HLS) IT and Electronics	Manufacturing, Production and Business Processes Materials Retail and Distribution Transport
Chemicals Communications Construction Defence and Aerospace	Leisure and Learning	

ket forecasters, government departments and business managers, social forecasters and development engineers etc. This collaboration had been an aim of the process itself, but the panels had also made 360 recommendations for areas they concluded were of high priority for the UK's future; in addition the TFSG had flagged 27 generic priority themes, which arose as cross-sectoral issues - e.g. communicating with machines, catalysis, and materials. There was thus ample material for Phase II which, as described in the full report, involved:

- The panel subject areas were restructured - for instance 'environment' was upgraded into a Na-

tional Resources and Environment Panel. A new Marine Panel was set up.

- Panels worked to disseminate and refine their findings, stimulating discussions and networks which linked science and business, and encouraging joint action by business, academia and Government.
- A new programme - Foresight Challenge - was launched in May 1995, and allocated £40M of DTI funds over three years, to support collaborative investment in Foresight priorities.
- Steps were taken to encourage publicly funded bodies (RCs, Funding Councils, and Departments) to take into account TF priorities in their own work.

We are now moving into Phase III, where the main focus will be to spread awareness of Foresight in UK business, together with a coordinated approach to foresight between panels, government departments, and other organisations. Phase III is also the final phase of the first Foresight Programme, and it is intended that a second complete cycle start in 1999, involving a new survey of technology and priorities (called 'Foresight 2000' - F2000).

## WHAT HAS FORESIGHT ACHIEVED?

Technology Foresight represented a considerable investment of both public expenditure and professional time from academia, industry, charities, national laboratories, etc. Overall costs of the programme in terms of OST staff time and consultancy were over £6M; the contribution of time and effort by panel members, workshop participants, respondents to questionnaires, etc., probably exceeded this. The full report thus looks at what were the impacts of TF in the UK, and also reviews recent developments in Australia, USA, Japan and South Korea. Various options for improving the effectiveness of TF are also discussed.

### Networking

Improving networks was a primary objective of foresight, and there is a wide consensus that this has been a real success. Barriers have been reduced, not only between academics and industrialists, but also between different disciplines and between different companies. However, this progress does not disguise the fact that much remains to be done to reduce further the cultural barriers between academe, industry, government and financial institutions. In the latter context, mechanisms by which venture capital supports technology-based start-ups are still not working well. Foresight can improve appreciation of technology and markets, and enhance networks between those administering such funds and the science and engineering base (SEB), and also help financiers to properly assess the promise and risks of new products and technologies.

2. For example, the National Creative Technologies Centre takes film, video and computing into the new age of multimedia.

## Research Council Priorities

Since RCs report to OST, they have been the main focus of efforts to redirect the public spend on the SEB to foresight priorities, increasing the priority given to objective-oriented or directed programmes with a clear end application in mind, relative to more basic 'curiosity-driven' research aimed at creation of knowledge.

OST claim to have influenced RC priorities greatly, pointing to the large proportion of RC budgets related to Foresight priorities. The full report points out, however, that this would probably have happened anyway, and that the impacts of TF have been more at the margins. Given the concerns at the outset that TF might steer the RC agenda too far towards the short term, some see its more limited evolutionary impact as reassuring. However, concerns remain that TF may still be squeezing out more speculative blue skies research of high quality, and there is still a widespread view that the main focus for RCs should remain the support of innovative research, discovery, and international excellence, **whatever the areas of research.**

This leads to one of the main areas of contention over Foresight. The previous Government's policy was to use the results to steer research in the SEB (RCs and universities), and to limit follow-up funding to encouraging collaborative research between academia and industry. Many however argue that **TF should be used to build on the science base rather than redirect it.** For instance, TF can identify areas of special promise or areas which have been neglected. Equally it is well-suited to identifying barriers to effective use of the science base, throwing up ideas and opportunities for additional activities and investment through industrial and technology policy (see next section). The full report also discusses the use of TF by the Funding Councils.

### Foresight Follow-up Programmes

At the outset, many saw the logic of the TF process leading to greater government involvement to bridge the 'development gap' between promising scientific ideas and their incorporation into marketable products. The main 'new' programme addressing the SEB/ industry interface has been **Foresight Challenge**, with £40M of public funds available over 3 years for joint research between universities, research organisations and industry on subjects flagged by TF. This attracted a huge amount of interest, and over 500 applications were received in the first round, of which only 24 could be funded with available budgets<sup>2</sup>. The mismatch between the ideas for collaboration and available funds suggests that **the full potential of foresight is not being realised.**

The long-established LINK programme has also now been focused entirely on foresight priorities, and 15 new projects with total public funding of £67.5M over

their lifetime have started since 1995. Some of the many foresight priorities have thus moved forward, but the full report points out that progress has been rather slow on many others. Follow-through seems to depend very much on single (often voluntary and part-time) 'project champions' who have to persuade all the potential participants to get together, and then persuade departmental sponsors to allocate funds (e.g. via LINK). **One option would be for OST to provide more support for the project champion role.**

The key issue is however, to what extent the foresight process should be seen as a way of identifying important projects **to be followed up with vigour and significant resources.** Given the skills and effort which went into TF, many see it reasonable that Foresight should be '**picking winners**' and that more attention should be given to the Steering Group's recommendation that some of the more promising ideas should be taken through to technical demonstrators, where the projects could serve to catalyse market development and focus resources on areas of high potential. At present, some see the limited funds for follow-up being spread too thinly, and contrast the amounts available with the much larger cuts in DTI's Technology budget in recent years, and with the resources deployed in the USA, Japan and Korea on analogous national projects (see full report). In this context, AIRTO<sup>3</sup> and others recommend 3-4 'task forces' each year to push forward key priorities exploiting UK strengths and/or opportunities. This could be on the basis of new funding, or through a diversion of public funding through OST and Departments.

### **Adequacy of Foresight Priorities**

Whether 'winners' are to be picked, or reliance placed on Foresight Challenge, LINK and general priorities for the science base, it is important that the priorities to have emerged from TF should be 'right'. Here, even Foresight panel members recognise that the priorities emerged from a somewhat subjective process, influenced by the panel membership and the time available. While presence on a panel priority list does indicate importance, it is questionable whether absence should be a sufficient reason for its exclusion from all competitions. Nevertheless, the full report points to areas where absence from the priority lists (e.g. for nanotechnology) appears a fatal handicap in competing for support. **The important point to recognise is that technologies continue to advance and it is necessary for the original priorities to be continuously reassessed.** If funds such as Foresight Challenge are restricted to areas on the original list of priorities, this has the effect of 'freezing' the agenda to that seen in 1994 or earlier.

### **Foresight across Departments**

The full report pointed to concerns that Departments may not be responding sufficiently to TF, leading to a lost opportunity to implement a more coordinated science policy across Government. One of the problems is that the coordinating group responsible (the Whitehall Foresight Group -WFG) has restricted itself largely to departmental R&D priorities. One option would be to use Foresight as a guide **to re-ordering departmental priorities within overall public spending limits, to maximise contributions to industry, skills, infrastructure and new technologies** - to ensure that departmental policies are making the optimum contribution to wealth creation and quality of life. The WFG could also provide a useful forum for examining other issues raised by the TFSG. For instance, panels identified many areas where regulation interacted with technology and markets; yet OST is only just starting a dialogue with the main Regulators. **OST and the WFG could review systematically the regulatory constraints** within departments' jurisdiction and weigh the balance between panel recommendations and departmental interests. Such actions bring OST's trans-departmental role to the fore, and the full report discusses whether OST's ability to exercise an effective trans-departmental role has been affected by its move in 1995 from within the Cabinet Office to within DTI.

### **Foresight and Industry**

While there was much success in involving industry in the initial phase of Foresight, a perception exists that the 'message' is not reaching the boardrooms of large companies; nor is it reaching the smaller companies. Since policy has looked to industry to provide the main translation of TF into wealth creation, this is a source of disappointment. One response is to broaden Phase III of TF, and rename it 'Foresight'. This has the explicit objective of avoiding TF being rejected as irrelevant to a company not having a technology or R&D department. The full report looks at the process in Phase III, and how it can best be targeted at companies.

Key to this effort will be the role of industrial research associations and similar organisations, which will be increasingly active in analysing the significance of TF panel reports for specific industrial sectors (clothing, water treatment, printing etc.). Currently these activities rely very much on an informal and voluntary commitment by individuals, and **one option would be to create more of a formal follow-through by means of specific dissemination grants in specific sectors.** This would have as its objective promoting internal foresight exercises and help spread a culture of innovation.

Overall, however, UK industry continues to place a lower priority on R&D than many of its international competitors. Foresight should not thus detract from other policy measures aimed at the fundamental eco-

<sup>3</sup> AIRTO - The Association of Independent Research and Technology Organisations.



## BOX 2 THE DELPHI QUESTIONNAIRE

One of the most controversial aspects of TF was the widespread use of a Delphi Questionnaire. Named after the Delphi oracle of ancient Greece, where people paid to hear pronouncements on the future, the Delphi questionnaire lays out many future technological scenarios, which respondents are requested to mark for feasibility, likelihood, etc. The initial round of results is circulated to all respondents to give them an opportunity to modify their initial view in the light of others' answers.

OST made the Delphi a mandatory part of each panel activity. This had the advantage that it involved thousands of people in the Foresight process. Many views were received on scenarios such as "word accuracy of continuous handwriting recognition systems is better than 99%"; "widespread use of intelligent road crossing to aid traffic flow". On the other hand, many found the whole process very cumbersome and panels made little use of the results. Whether or not there should be a repeat of the Delphi survey in any future foresight is an area of current controversy. Supporters say it is revealing many useful insights to individual companies as well as panels; opponents see it as costing time and money out of all proportion to its contribution to the process.

economic equations which influence companies' choices between concentrating on higher profitability over a narrow base, and seeking to expand market share by developing new products. While technology foresight generates ideas, **changes in fiscal and regulatory policies (e.g. tax structure on R&D, loans and grants, or measures to encourage long-term capital investment) may be needed** to persuade companies and investors to broaden their strategy and take a longer term view.

## THE FUTURE OF FORESIGHT

The OST currently anticipates a complete repeat of the foresight exercise starting in 1999/2000, and the POST report addresses:

**What is the need for F2000?** Here, a cost/benefit analysis of the outcomes of TF could identify ways of improving efficiency by focusing resources on the most productive areas.

**Should F2000 have a different focus?** The UK exercise is unusual (relative to other countries) in the degree to which it focuses on priority setting in RC and university research - indeed some have gone so far as to see it as aiming at the wrong target. Rather than continue in this vein, one option would be to direct F2000 towards contributing to a 'cultural' change in industry, among investors and managers; also engaging the next generation in looking at possible future developments and how they might affect our lives.

The UK exercise has also been primarily based on looking at future technology and markets in order to gain wealth. But there is more to Society than wealth - broader questions of sustainability could well form the basis of a panel in itself, or be added as a cross-cutting theme to all panels. S&T might be seen more as a

servant of society and as something to be harnessed towards national goals, which might include **addressing social needs** such as mobility, cohesion, disablement. This could lead to the next phase of TF being a more participatory process involving more 'stakeholder' groups in society, where societal needs and their interaction with technology become of equal interest.

**How could F2000 be structured?** Here the full report argues against a simple repeat of the 1995 exercise because in some sectors it would add little to what is already underway. One option would be to look on F2000 as an opportunity to refine and reinforce rather than to repeat the 1995 formula. **The TFSG could identify 3-4 areas each year.** These might be areas where the original foresight process was seen as in need of a repeat - either because industrial interest had been only partially awakened or because science and technological progress had been swift. Other areas would be to target interdisciplinary sectors which had been poorly served in the original round, to tackle emerging sectors, or to focus on areas of social need as already mentioned. Also at issue is whether to repeat the 'Delphi' process used in the first phase (**Box 2**).

**Towards a national science and technology vision.** This first exercise pointed to the benefits that come from all parties pulling towards the same goals, and the advantages of having a more coherent view of the role of SET in meeting national objectives. Future phases of Foresight could build on this by making more explicit their aim to develop a truly national vision of the interactions between SET and the nation as a whole, and how SET can be harnessed to influence different national futures. By broadening the objectives this way, the process could help catalyse a more coherent view of the national future, bringing together both technological market and societal futures, and delivering benefits beyond just a more coherent national policy for science and technology.

## IN CONCLUSION

Technology foresight has undeniably been a successful initiative in many respects. It has broken down barriers and improved communications, and can point to many areas where it has had an influence. Equally, it is apparent that many barriers remain to the efficient exploitation of science and technology, and that foresight cannot be seen as an isolated activity and has implications for other government departments, industry and the financial institutions. With a new Parliament, opportunities will arise for MP, Peers and Select Committees to participate in the debate over Foresight's future, and it is hoped this analysis will help in this debate.