UNIDO TECHNOLOGY FORESIGHT MANUAL

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UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO TECHNOLOGY FORESIGHT MANUAL

Volume 1

Organization and Methods

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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WELCOME TO THE TECHNOLOGY FORESIGHT MANUAL

The UNIDO Technology Foresight Training Manual is part of the UNIDO Regional Initiative on Technology foresight for Central and Eastern Europe (CEE) and the Newly Independent States (NIS).

The manual is mainly based on papers presented at a series of events organized by UNIDO as part of this regional initiative. The manual consists of two volumes, divided into seven modules, each devoted to a particular aspect of technology foresight, as follows:

Volume 1 Organization and Methods
Module 1 Introduction to Technology Foresight
Module 2 Organizing a Technology Foresight Exercise
Module 3 Technology Foresight methods

Volume 2 Technology Foresight in Action *(published in a separate book)*
Module 4 Technology Foresight at the National Level
Module 5 Technology Foresight at the Supranational Level
Module 6 Technology Foresight at the Subnational Regional Level
Module 7 Technology Foresight at the Company Level

Making use of the manual

The modules may be studied individually, grouped to suit your own individual requirements, or as a complete course. For example:

- As a busy decision maker who requires only to understand what technology foresight is, the potential benefit that can be gained from setting up a technology foresight programme and how it may be able to assist you in making decisions about technology, but not to delve into the detail, you will probably find module 1 Introduction to Technology Foresight sufficient. Should you wish for more detail on particular aspects of technology foresight the other modules should provide it.
- If you are involved in setting up a technology foresight programme at a particular level, or may be considering whether to do so, you should study module 1 Introduction to Technology Foresight and the appropriate modules 4, 5, 6 or 7.
- If you have been charged with setting up a technology foresight programme you will find module 1 Introduction to Technology Foresight and module 2 Organizing a Technology Foresight Programme, plus the appropriate modules 4, 5, 6 or 7 most helpful.

- If you have responsibility for running a technology foresight programme you will find module 1 Introduction to Technology Foresight, module 2 Organizing a Technology Foresight Programme, module 3 Methods in Technology Foresight, plus the appropriate modules 4, 5, 6 or 7 useful.
- If you wish to obtain the fullest possible understanding of technology foresight you should study the complete manual (volume 1 and volume 2).
- If you wish to know about any of the methods used in technology foresight then module 3 Technology Foresight Methods is probably the place to start, but you may also find other blocks which deal with the application of methods in particular situations also helpful.

Each module is based around a number of papers and readings, most of which were prepared for events organized by UNIDO as part of the technology foresight initiative.

The manual may be supplemented by visiting the UNIDO website www.unido.org where you will find details, in English, of the technology foresight initiative and copies of the presentations made at the events held that include in most cases the slides and videos used to illustrate the presentation.

A recommendation: keeping a journal

At the start of module 1 Introduction to Technology Foresight it is suggested that you should write your own definition of foresight. You will then be able to compare your initial definition with those offered in the technology foresight manual.

It is recommended that you write your definition as the first entry in a learning journal and that as you work through the modules you note any thoughts and reactions that occur. Some things you may find particularly useful and wish to be able to refer back to them, noting where they are and why you considered them useful will both assist your learning and make finding them again easier. But at other points you may disagree with a particular point and find it useful to set down your reasons for doing so. Equally, working through the material is likely to encourage your own thoughts about technology foresight that will be useful to note before you move on and forget them.

Keeping a journal should not be seen as a chore that you have to undertake but a useful adjunct to your study that allows you to become active in your learning as opposed to simply passively reading the manual.

UNIDO Technology Foresight Initiative for Central and Eastern Europe (CEE) and the Newly Independent States (NIS)

Technology foresight (TF) is regarded as the most upstream element of the technology development process. It provides inputs for the formulation of technology policies and strategies that guide the development of the technological infrastructure. In addition, technology foresight provides support to innovation, and incentives and assistance to enterprises in the domain of technology management and technology transfer, leading to enhanced competitiveness and growth.

TF has increasingly been recognized worldwide as a powerful instrument for establishing common views on future development strategies among policy-making bodies, bridging the present with the future. Its unique feature stems from a wide participation of a large number of stakeholders and experts, namely, the government, science, industry and civil society.

The application of TF has become of crucial importance for strengthening the transition process in Central and Eastern European (CEE) countries and the Newly Independent States (NIS) in narrowing their competitive gap in the global economy.

In response to requests by member countries, UNIDO is implementing a global initiative on TF that draws on regional initiatives. The result will be the capability of using TF as a practical tool in designing policies and strategies that exploit emerging and critical technologies for the benefit of countries with economies in transition.

Although technology development planning was traditionally carried out by the State, the change of socio-economic systems in the CEE/NIS region necessitates the introduction of a new approach for consensus building and decision making encapsulated in TF processes. Applied at the national and regional levels, these processes would allow the countries in this region to benefit from the globalization process and integration of the region's economies in Europe and the global market. In the CEE/NIS region some countries such as the Chech Republic and Hungary made efforts to promote TF at the national level, and increasingly more governments recognize the need for a regional approach, which can contribute in shaping a regional long-term development vision in cross-country areas.

In this context, UNIDO was requested to formulate programmes at the regional level to both support national initiatives and create the basis for strengthened regional cooperation. Following this request, UNIDO launched the Technology Foresight Initiative for Central and Eastern Europe and the Newly Independent States in 2001. This initiative benefits from previous experience of UNIDO in promoting a TF Initiative for Latin America. Along this line, UNIDO is building up the bases for a global initiative for TF, as other developing countries and regions are showing growing interest to master and utilize TF methodologies and applications to better drive and focus their industrial development sectors, anticipate future opportunities, define strategies for sustainable economic growth and prepare their local enterprises to enter the global market.

UNIDO approach

The UNIDO TF approach focuses on industrial development issues. In so doing it assists developing countries to upgrade their industrial sectors from resource-based to technology-based in order to better integrate their production into the international economy. Such an approach shall be instrumental in identifying risks and opportunities thus enabling governments to respond successfully to the present and prepare for future challenges and opportunities.

Indeed, to deal successfully with the challenges of, and risks from, globalization developing countries must improve their market access capacity by adopting new strategies to counteract threats from the tremendous competition in international provision of products and services.

Only if a country is fit technologically and industrially can it compete to increase its share of international markets. However, due to continuous changes and innovation from advances in technology and applied research, international market preferences are continuously shifting in trends over the long term. This implies that without continuous monitoring of societal needs and consumer expectations, stable market shares today can be in danger tomorrow.

The positive side of this development of accelerated competition is that there are many opportunities for developing countries and economies in transition. To be able to reap these opportunities and advantages, these countries have to make technology trends studies and assessments properly. They have to set in place institutional and structural arrangements as well as appropriate policies and strategies that enable entrepreneurs and productive sectors to play key roles in increasing core competencies and capabilities.

The level and capacity of each country to enter into international markets and improve their respective trade is closely linked to the domestic capacity to take advantage of new and innovative technologies. The adoption, absorption, mastering, adaptation and application of these technologies depend on the strength and efficiency of the national system of innovation in relation to indigenous R&D capabilities and related international networks.

In seeking an appropriate solution to the above issues that affect developing countries and economies in transition to different extents, UNIDO has further promoted the use and application of TF with a special focus on specific industrial sectors and production chains.

While it is important for developing countries and economies in transition to carry out TF exercises, making them an integral part in the process for their industrial development is another matter. UNIDO has combined the TF initiative with its core specialization in industrial development, industrial policy and technology change management. In supporting the post-foresight exercise UNIDO services should address the challenges that developing countries and economies in transition have to face to cope with the new international trade environment that globalization is bringing about, the complexity to carry out technology needs assessments, the intricacy and conflicting process to prioritize and target investment for R&D activities, the pressing demand for wide reaching training and education programmes, the mandatory requirement of institutional capacity to support and liaise between all the elements of the national innovation system.

In summary, the UNIDO TF approach is designed to capture complex variables, involve stakeholders from the highest level of decision making from Government, institutions and enterprises, and provide a durable basis for developing industrial policy. TF attempts to identify possible future development scenarios to: improve medium, long-term decision making; guide technology choices; generate alternative trajectories for development; improve preparedness for emergencies and contingencies; motivate change and innovation; and achieve broad consensus and strategic commitments. As such it is a decision support tool that facilitates anticipation and pro-active planning and policies. It provides strategic decisions and robust action plans combined with flexible tactics to enable restructuring and intervention in dynamic response to continuous changes at regional, national and enterprise level.

Development objectives

The UNIDO regional TF initiative provides assistance to countries with economies in transition, aiming at achieving more sustainable and innovative development, fostering economic, environmental and social benefits at national and regional levels. The regional initiative ultimately aims to develop policies and R&D programmes that deal with innovation, industrial growth and competitiveness which can be addressed through multi-country collaboration and joint exercises.

Immediate objectives

The immediate objectives of a regional initiative are: *(a)* to raise awareness of the critical importance of TF for improving the competitiveness of industry by exploiting emerging and future trends in science and technology; *(b)* to develop and adapt methodologies and tools for TF in the region; *(c)* to establish and strengthen national and regional knowledge as well as the capability of using TF for designing policies and strategies that focus on innovation; *(d)* to undertake demonstrations of regional studies for specific sectors or themes; *(e)* to assist national programmes to generate comparable data for possible aggregation at the regional level; and *(f)* to provide solutions to relevant problems in the region that can be addressed through the appropriate application of technology. Special attention will be given to those less economically advanced countries in the region.

Components

Awareness building and creation of foresight culture in the region

On the basis of a regional TF network, prepare and disseminate promotional and general information to demonstrate the utility of foresight approaches in countries in Central and Eastern Europe and the NIS context to policy makers, companies and R&D institutions, as well as the general public. This is done through conferences, forums, publications, electronic books, the Internet and the media. Special attention is given to motivating industry to participate in the initiative. In terms of the scope of the exercise, foresight work outside the region is to be examined, summarized, evaluated and adapted to regional perspectives; promotional materials and events should familiarize stakeholders with the concept, the practice and the results of regional foresight activities; hands-on experience shows how successful different approaches are, demonstrating the value of the results to stakeholders. The target here is to build the foresight culture into the thinking of future generations of decision and policy makers.

Development of national and regional capabilities

Create national and sub-regional centres of excellence on foresight process, which could be mobilized for the preparation of foresight studies. Develop a roster of regional and international experts on foresight and relevant areas of knowledge. Enhance skills of foresight practitioners through courses, workshops, seminars, fellowships and study tours. Develop exchange programmes with regional centres and institutions in other regions. Conduct selected foresight studies as sample cases to demonstrate the applicability of foresight approaches and their added value for the development of national and regional policies related to common issues or themes. A regional virtual "centre" (or network) will be established to function as a repository of foresight knowledge and experience to ensure long-term sustainability.

Coordination and implementation

Dedicated fund-raising to create appropriate financing mechanisms, such as a multi-partner trust fund. A regional steering party and national focal points are being established to coordinate and implement regionally conceived foresight projects. Such coordinating bodies shall harmonize regional foresight activities with a view to motivating national actors to adopt common foresight objectives, methodologies, infrastructure and management teams, and using foresight in the design of innovative technology policy. Ideally, the national focal points will be equipped with the necessary human resources, organizational capacity, knowledge in the field, mandate to represent the country and direct access to decision-making bodies. The regional initiative makes strong use of information and communication technology. UNIDO is available to play a role of overall coordination and the coordinating mechanism shall promote contributions that are both creative and innovative from members of the regional network of institutions and experts.

Implementation strategy and activities

The following steps and activities have been defined for the implementation of the regional foresight initiative:

- *Awareness building exercise*

  To mobilize interest and support to the regional initiative, a concentrated effort to disseminate the different events and their results, using electronic media and target communication.

- *Conferences and expert meetings*

  Following the recommendations of the regional conference (in April 2001) and the expert group meeting (in June 2001), the initiative supports different types of events. As a major event of the initiative, UNIDO organizes an annual summit to enable a regional exchange of experience and best practices of TF efforts and programmes. Expert group and focal points meetings have been organized to determine and monitor the scope, methodology, costs, time frame and related details of studies and other activities of the initiative.

- *Establishment of an electronic information exchange facility and tools*

  Taking the UNIDO Exchange Facility and the Information Centre on Technology Foresight of the International Centre for Science and High Technology (ICS) as platforms, a special web site has been developed for the initiative, with a view to creating a live knowledge-sharing process.

- *Elaboration of studies and capacity building*

  To provide an immediate contribution to strategic decision-making in the region, special foresight studies shall be promoted, focusing on areas of critical interest for the industry in the region. To facilitate the preparation of the studies, capacity building exercises shall be carried out both at the national and regional levels.

- *Mobilization of financing mechanisms*

  Different strategies for funding the initiative have been developed, using UNIDO funds, national and individual donor contributions, and financial support from industry. Countries in the region are expected to be committed in order to create the necessary strong support for the initiative as a built-in capacity for themselves as well as for the region.

- *Definition of counterparts and creation of the coordination mechanism*

  Following the initial commitment of a group of participating countries, UNIDO shall support the constitution of a virtual regional centre (or network) for facilitating the coordination and implementation of the regional initiative. In order to create ownership at the regional level, a strategic steering party shall be set up, involving governments, research communities and industry.

GLOSSARY

Analytical hierarchy process: a technique that uses so-called hierarchical networks to construct a model of the probability or the occurrence of each possible scenario.

The Bayesian model: a method used to examine the probability of occurrence of a number of scenarios

Brainstorming: a method used in groups in order to support creative problem-solving, the generation of new ideas and greater acceptance of proposed solutions.

Critical or key technologies: technologies which have a strong potential to influence national competitiveness and quality of life.

Cross-impact analysis: a method that forces attention to chains of causality: x affects y; y affects z to create a matrix of conditional probabilities.

Delphi: a method of obtaining a consensus of opinions of a group of experts by a series of questionnaires interspersed with controlled opinion feedback.

Environmental Scanning: a formal or informal process for monitoring change.

Expert panels: normally consists of 12 to 15 individuals who are mandated to use their collective expertise in addressing a particular problem or set of issues.

Extrapolative methods: begin with the present as the starting point, and move forward to the future.

Genius forecasting: the generation of a vision (or several visions) of the future through the insights of a gifted and respected individual or individuals.

Normative methods: start with a preliminary view of a possible (often a desirable) future or set of futures that are of particular interest. They then work backwards to see if and how these futures might or might not grow out of the present.

Qualitative methods: emphasize opinion and other issues that are hard to quantify.

Quantitative methods: place heavy reliance on numerical representation of developments.

Simulation modelling: Computer-based models allowing a system to be represented in terms of its key components and relationships.

Scenarios: consist of visions of future states and courses of development, organized in a systematic way as texts, charts, etc.

Scoping: a process of research and deliberation that contributes to the shape and timing of a given TF activity.

SWOT analysis: a technique based on identifying the strengths, weaknesses, opportunities, and threats in any situation.

Technology Foresight: "the process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits."

Technology roadmapping: a goal oriented technique for supporting technology management and planning

Trend extrapolation: historical data, such as that concerning population growth, economic development, social attitudes projected forward to form a forecast.

USEFUL SOURCES

Eurofore—Competence Mapping Project
http://les.man.ac.uk/eurofore/search

A searchable site offering links to European foresight projects, organizations and individuals.

European Union—Science and Technology foresight
http://www.cordis.lu/foresight

Information about European Union foresight activities and links to national and other projects.

Fistera—foresight on Information Society Technologies in the European Research Area
http://www.itas.fzk.de/eng/projects/fistera/overview.htm

Links to European foresight projects.

Institute for Prospective Technological Studies—IPTS
http://www.jrc.es/home/index2.cfm

Details of IPTS projects and links.

FUTUR—German Research Dialogue
http://www.futur.de

Details of the FUTUR project and links to other foresight projects.

OECD International Futures programme
http://www.oecd.org/department/0,2688,en_2649_33707_1_1_1_1_1,00.html

Details of the OECD programme and links to related websites, journals and think tanks.

Asia-Pacific Economic Cooperation Center for Technology foresight
http://www.apectf.nstda.or.th

National Institute of Science and Technology Policy, Japan
http://www.nistep.go.jp/

World Future Society
http://wfs.org

Shaping Tomorrow
http://www.shapingtomorrow.com

Commercial site offering links to a wide range of future related sources

Volume 1

Organization and Methods

Module 1

INTRODUCTION TO TECHNOLOGY FORESIGHT

This module aims to introduce you to technology foresight and to explain why it has become an important tool in the development of science and technology policy.

When you have completed the module you should:

- Have a basic understanding of technology foresight.
- Know about its development, particularly from the 1990s onwards
- Understand why it has become an important tool in S&T policy.
- Appreciate the potential value of technology foresight.
- Have an introduction to the processes and methods involved.
- Have an understanding of how foresight programmes have evolved.
- Have an understanding of the issues arising in the evaluation of foresight.

Before proceeding you should write your own definition of “foresight”.

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Figures

1. INTRODUCTION

The broad aim of technology foresight is to identify emerging generic technologies likely to yield the greatest economic and social benefits. During the 1990s, technology foresight became much more widespread. Japan has been engaging in extensive foresight activities since 1970, and there were several foresight initiatives in France in the early 1980s. Later that decade, countries such as Australia, Canada and Sweden also began to experiment with technology foresight. However, prior to 1990, there was comparatively little technology foresight in Germany, the United Kingdom and the United States. Around 1990, the situation began to change with Australia, France, Germany, the Netherlands, the United Kingdom, the United States and various other countries launching major foresight exercises.

Technology foresight at a national level may now be seen as a policy instrument which is approaching maturity. Since the early 1990s the practice has diffused widely to the point that most industrialized countries and several advanced developing counties have experience of some form of foresight exercise. Many have been through more than one iteration, while others are about to do so. Despite this spread of experience there has not so far been a serious effort made to understand the effect of the wave of foresight activity. In particular, foresight has not been systematically evaluated as an instrument of science and innovation policy.

As a starting point in assessing the international experience, it is important to stress not only what is common to foresight activities but also the ways in which they differ. In reality, term foresight covers multiple activities and purposes sharing a name. In terms of purpose, some common goals for foresight are:

- *Exploring future opportunities so as to set priorities for investment in science and innovation activities.* The degree to which priorities can emerge from foresight varies from “critical technologies” exercises where the whole discourse is focused on a priority list, through more general programmes from which priorities are derived, to targeted foresight where the priorities are in effect set before foresight begins. The real effect of foresight on priorities may be difficult to determine

- *Reorienting the Science and Innovation System.* This goal is related to priority setting but goes further. In such cases there may have been a preliminary diagnosis that the science and innovation system does not match the needs of the country. This was a common situation in Central and Eastern Europe in the immediate post-Communist period when, apart from severe resource difficulties, capabilities reflected an industrial system that no longer existed. Foresight has been used as a tool to re-orientate away from fields such as materials research and towards life sciences as well as to explore new institutional structures.

- *Demonstrating the vitality of the Science and Innovation System.* In this context foresight becomes a “shop window” to demonstrate the technological opportunities that are available and to assess the capability of science and industry to fulfil that promise.

- *Bringing new actors into the strategic debate.* A growing tendency is the use of foresight as an instrument to broaden the range of actors engaged in science and innovation policy. One example is the inclusion of social stakeholders or even sections of the general public such as youth.

- *Building new networks and linkages across fields, sectors and markets or around problems.* A different type of reorientation is sought when foresight is explicitly aimed at creating new networks and or clusters which break out of long-standing disciplinary or sectoral ties.

The modalities of foresight may also differ strongly. All of the above goals may be pursued at organizational, local, regional, national or supranational levels. The timescale of foresight ranges from the immediate future to the far horizon. The range of actors involved, the process and methods used, and even the status of the activity varies considerably. Foresight ranges from methodological experiment through to major politically driven initiatives.

2. TECHNOLOGY FORESIGHT DEFINED

What is technology foresight?

The terms "technology foresight" and "foresight" will be used interchangeably. The former has been largely superseded among policy makers by the plain label of "foresight", on account of the increasingly wide application of these sorts of techniques to non-technological domains. Indeed, there is even wide recognition that technology foresight exercises often take as much account of economic, social and cultural issues as they do technology developments, thereby rendering the label "technology foresight" as somewhat misleading.

Two popular definitions of foresight are provided by UK-based researchers. The most-oft quoted is that from Ben Martin (1995) at SPRU, who describes research foresight as "the process involved in *systematically* attempting to look into the longer-term future of science, technology, the economy and society with the aim of *identifying* the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits." Similarly, Luke Georghiou (1996) at PREST describes technology foresight as "a *systematic* means of *assessing* those scientific and technological developments which could have a strong impact on industrial competitiveness, wealth creation and quality of life."

There are five important aspects to these definitions:

- Attempts to look into the future must be systematic to be called "foresight". This distinguishes foresight from the endogenous scenario building that we are all engaged in when planning our everyday lives.

- Foresight must be concerned with the longer term, which is generally considered to be beyond normal planning horizons. Foresight time horizons therefore typically range between five and thirty years.
- Science/technology push should be balanced with market pull. Whilst this is a rather crude way to think about the innovation process, the point is that technology foresight should not be dominated by science and technology (S&T) alone. Attention also needs to be paid to socio-economic factors that are well known to shape innovations.
- Foresight concentrates on *emerging* generic technologies where there is a legitimate case for government support. This is because companies are often unwilling to fund the strategic research that underpins emerging generic technologies.
- Attention must be given to social impacts, not just those concerned with wealth creation. This has led to some recent foresight exercises to adopt more problem-oriented perspectives from the outset, for example, focusing upon issues such as crime prevention, education and skills, ageing societies, etc.

These aspects have been somewhat superseded in recent times, with definitions of foresight tending to place more emphasis on system building and process benefits. For example, according to the FOREN Practical Guide to Regional Foresight, foresight is said to involve five essential elements (2001):

- Structured *anticipation* and *projections* of long-term social, economic and technological developments and needs.
- *Interactive* and *participative methods* of exploratory debate, analysis and study, involving a wide variety of stakeholders, are also characteristic of foresight (as opposed to many traditional futures studies that tend to be the preserve of experts).
- These interactive approaches involve forging new social *networks*. Emphasis on the networking role varies across foresight programmes. It is often taken to be equally, if not more, important than the more formal products such as reports and lists of action points.
- The formal products of foresight go beyond the presentation of scenarios, and beyond the preparation of plans. What is crucial is the elaboration of a guiding *strategic vision*, to which there can be a shared sense of commitment (achieved, in part, through the networking processes).
- This shared vision is not Utopian. There has to be explicit recognition and explication of the implications for "*present-day decisions* and actions" (emphasis original).

Foresight is often confused with other future-oriented activities, such as forecasting, futures studies, and strategic planning. Foresight should not be confused with forecasting, which tends to be more fixed in its assumptions on how the future will unfold. Indeed, forecasters aspire for precision in their attempts to predict how the world might look at some point in the future. By contrast, foresight does not seek to predict: instead, it is a process that seeks to create shared visions of the future, visions that stakeholders are willing to endorse by the actions they choose to take today. In this way, foresight is not concerned with predicting the future; rather, it is concerned with creating it.

The important thing to note is that foresight does not replace forecasting, futures studies, or strategic planning. Each activity has its role, which in many instances can be mutually supportive.

One of the more flexible definitions captures key elements of the process that are usually neglected in some of the more commonly used formulations:

> "The foresight process involves intense iterative periods of open reflection, networking, consultation and discussion, leading to the *joint refining of future visions* and the *common ownership of strategies*, with the aim of exploiting long-term opportunities opened up through the impact of science, technology and innovation on society... It is *the discovery of a common space for open thinking on the future* and the *incubation of strategic* approaches..." (Jennifer Cassingena Harper, Malta Council for Science and Technology)

Of particular importance here is the stress placed upon the way in which joint foresight activities are linked to the joint formulation and ownership of strategies. This perspective avoids the treatment of foresight and its implementation as separate processes without serious attempts to build bridges between or to link the two.

3. THE DEVELOPMENT OF FORESIGHT

Historical evolution of foresight

Technology forecasting first came to prominence in the late 1950s in the United States defence sector and in work by consultants such as the RAND Corporation. The latter were responsible for developing some of the principal tools of technology forecasting, such as the Delphi questionnaire survey and scenario analysis. Large forecasting exercises were carried out during the 1960s by the United States Navy and the United States Air Force. Technology forecasting was also taken up by private companies (e.g., in the energy sector). However, the next developments, and the emergence of what we now term "foresight", took place in Japan.

Technology foresight in Japan

Towards the end of the 1960s, Japan decided that technology forecasting represented a potentially useful policy tool and a team was sent to the United Stales to consult with experts. In 1970, the Science and Technology Agency (STA) undertook its first 30-year forecast of the future of S&T. The aim was to construct a holistic overview encompassing all S&T, thus providing decision makers in both public and private sectors with the background intelligence on long-term trends needed for broad direction-setting. Several thousand experts from industry, universities and government organizations were surveyed (using a Delphi questionnaire) about possible innovations or technological developments, when they were likely to occur, their importance and the probable constraints on their realization. The results from the first round of the survey were synthesized and fed back to the same experts who in the second round of the Delphi exercise were given an opportunity to confirm or modify their views. These 30-year forecasts have since been repeated approximately every five years.

The results from these surveys are seen as having two main uses: *(a)* compiling background data for research and development (R&D) planning, in particular providing an overview of longer-term technological trends and identifying important emerging technologies; and *(b)* monitoring current S&T, including the level of current Japanese R&D activities in relation to those in other countries, highlighting areas where there is an emerging need for international collaboration, and identifying factors constraining technological development. The results have formed one of the inputs to decisions by the Council for Science and Technology of Japan on future government S&T policy. They also represent background intelligence for other government ministries and for industry.

A few years ago, Japan's National Institute of Science and Technology Policy (NISTEP) carried out a survey of companies to assess how much use they made of the results from the fourth Delphi exercise. Out of nearly 250 respondents, 59 per cent considered the results "very important" and a further 36 per cent judged them "worthwhile". The main uses of the STA results include "planning for R&D and business projects" (72 per cent), "analysing medium-term technological trends" (61 per cent) and "analysis of the specific content of the topics surveyed" (60 per cent). NISTEP also assessed the accuracy of the results from the first Delphi survey in 1970. They found that 64 per cent of topics had been fully or partially realized in the intervening 20 years. Given the long time-horizon and the fact that this was the first Delphi survey in Japan, these figures are particularly encouraging. Where the forecasts had proved inaccurate, this was often not so much in relation to technological developments but as a result of subsequent political or social changes.

Three points should be stressed regarding Japan. First, the Japanese recognize that the main value from foresight is often not so much the direct outputs (forecasts, and subsequent policies based upon them) but the process benefits of foresight. These process benefits can be summarized as the "five Cs"—communication, concentration on the longer term, coordination, consensus, and commitment. Second, the STA surveys constitute just one of a wide range of foresight activities in Japan. Third, most of the other foresight exercises use techniques other than Delphi surveys, such as expert panels, brainstorming, scenarios, commissioned studies from consultants and so on. For example, the Ministry of Economy, Trade and Industry (METI) periodically produces "10-year visions" as well as organizing numerous other foresight efforts. At the next level down (meso-level foresight), industrial associations and informal ad hoc groupings of companies perform or commission a variety of foresight exercises for specific industrial or technological sectors. Finally, a lot of micro-level foresight is carried out within individual firms, with the major science-based companies devoting considerable effort to forecasts specific to particular product ranges or processes.

(Japan appears to have developed a foresight culture and is now planning its next exercise.)

Technology foresight in the United States

In the United States, the Department of Defence has continued to be an enthusiastic user of TF. For example, the U.S. Air Force has carried out some of the largest and most systematic foresight exercises. In the civil sector, one of the main approaches to foresight has been a series of reviews of individual scientific fields. In the 1960s and early 1970s, a dozen of these field surveys were carried out. Several more were conducted during the 1980s and 1990s by the National Research Council. In all of these, the approach was similar, with most of the work being done by a large committee of eminent scientists and a few industrialists. The resulting reports each set out the exciting scientific opportunities available in that field. However, with one or two exceptions, the reports shied away from identifying priorities. They also gave relatively little attention to "demand-pull" considerations, and they almost invariably ended up by asking the Federal Government to double the budget for that field over the next few years. As a result, they generally had little direct impact on the Federal Government.

Prior to 1990, the prevailing belief in the United States was that the Federal Government did not need an explicit technology policy; the country, it was argued, was rich enough to aspire to leadership in all areas of S&T. This meant that the demand for foresight in the public sector was generally less than elsewhere. However, at the end of the 1980s, there appears to have been a sea-change in attitudes as a result of increasing concern about United States competitiveness, particularly in relation to Japan. The emerging recognition that the United States needed to have a coherent technology policy largely explains the upsurge in interest in foresight during the early 1990s.

The favoured approach to foresight in the United States during this period was to draw up lists of critical technologies (i.e. those critical to the future of the United States economy or to national security). The Department of Defence turned out several such exercises, while others were conducted by the Department of Commerce, the Council on Competitiveness and the Office of Science and Technology-Policy. In addition, various industrial consortia (e.g. aerospace and computer systems) drew up more specific lists of critical technologies for their sectors and often produced "road-maps", setting out how each of these was to be developed. The methodology in all these exercises involved starting with an initial long list of emerging technologies, identifying explicit selection criteria, and then using those criteria to produce a short list (typically of around 10 to 20) of the most important technologies. These exercises provoked much discussion but were criticized for making only limited use of data, for involving relatively few people in the scientific and industrial communities, and for identifying technologies that were too broad for specific policy decisions.

Technology foresight in the Netherlands

TF in the Netherlands has taken a different form from that in other European countries. Among its characteristics are a high degree of decentralization, the use of a range of methods (although not Delphi surveys), close integration with existing policy processes and structures, and a focus on specific fields (as opposed to the holistic foresight exercises of the three large European countries). Technology foresight also has a longer history in the Netherlands than in Germany or the United Kingdom. It had its origins in attempts during the 1970s to examine and strengthen the relationship between science and society. Since 1980, the sector councils (for agriculture, environment and health) have carried out various foresight activities. In the 1990s the foresight steering committee assumed responsibility for coordinating these activities.

The Ministry of Economic Affairs began to carry out TF in 1990. Rather than looking at the whole of technology, these exercises were based on a few critical technologies. Three fields were analysed in 1990 (e.g. chip cards) and another three in 1992 (e.g. signal processing). The objectives were to produce an input to technology policy, to provide small and medium enterprises (SMEs) with an early warning of opportunities and threats, and to create networks. There were four main steps in the foresight process: *(a) consultation* to draw up a short list of technologies to be examined: *(b) analysis* to identify the key players, potential bottlenecks and opportunities: *(c) a strategic conference* to bring together the stakeholders, to test the preliminary results, to create consensus and to generate commitment to implementing the results; and *(d) follow-up* (e.g. launching a pilot project or creating a new institute).

For each field, consultants produced reports on how the technology might be exploited, in particular by SMEs. A range of mechanisms was used to implement the results including the creation of networks, improvements to the knowledge infrastructure, new training courses and publications. SMEs were the main target group, but the problem here is that the most innovative SMEs are generally already aware of the new technology, while less innovative ones tend not to be involved in the foresight process nor to be very influenced by the results. In order to evaluate the effectiveness of the first exercise, a questionnaire was sent two years later to participants. Of these, 75 per cent had found the information generated "very valuable", and a similar number had made new contacts as a result of participating. In addition, 60 per cent had taken follow-up action (e.g. developing a new product).

A number of lessons emerge from these exercises. First, they require much effort and the follow-up activities take a lot of time to organize, largely because of the need to identify a "product champion" responsible for implementing the results. Second, because SMEs are such an important component of Netherlands industry, it is vital to involve them, yet there are considerable difficulties in doing so because of the wide range in their technological and innovative capabilities. Third, the choice of foresight methodology depends on the objectives—an approach appropriate for identifying resource allocation priorities may be ineffective at stimulating companies to take advantage of the economic opportunities.

The Ministry of Education and Science also became involved in foresight, setting up a foresight steering committee in 1992. It had two tasks: *(a)* to initiate, support and coordinate foresight exercises; and *(b)* to provide advice to the Ministry on options for S&T policy. Among the areas in which foresight exercises were initiated were chemistry, transport and infrastructure, agriculture, energy, nanotechnology, informatics, educational research, legal research, economic research, social sciences, and health. The methodology normally involved a preliminary selection of topics based on an overview of the committee members and requests from outside organizations. The foresight process was designed to ensure both close cooperation with key policy makers, and that priorities were based on an assessment of potential contributions of S&T to society. The design of the foresight process also took account of the characteristics of the research field—for example, whether it is concentrated in a few laboratories or highly fragmented.

The main conclusions to emerge from these foresight activities are three-fold. First, designing a foresight process geared to a specific field has two advantages: *(a)* it makes implementation far easier: and *(b)* it provides greater flexibility in dealing with specific issues and problems. Secondly, the main problems encountered involve: *(a)* setting priorities and "posteriorities" (i.e. negative priorities), especially at the national level: and *(b)* the fact that budgetary cuts tend to induce distrust in foresight. Third, the scenario methodology forces participants to think beyond their usual framework and ad hoc problems.

Technology foresight in Germany

The attitude towards foresight in Germany changed appreciably after 1990. Until then, there was comparatively little research or technology foresight. The reasons included the stipulation in the Federal constitution that science should be autonomous, the political climate under the Christian Democrat government, and the country's Federal structure with the division of responsibility for research between the *Länder* and the Federal government. However, around 1990 there was a major policy change that brought about the launching of various foresight activities by the government. The reasons for that change include problems associated with unification, recession and the structural crisis, and the renewed emphasis on TF in other countries.

Since 1990, several foresight exercises have been completed. In the exercise known as "Technology at the Threshold of the 21st Century", the first step was a review by the Fraunhofer Institute for Systems and Innovation Research (ISI) of the lists of "critical technologies" drawn up in the United States and the results of other foreign foresight initiatives. Next, a long list was prepared of 86 technologies with potential economic or social utility over the next 10 to 15 years. Using a relevance tree approach, experts from the Federal Ministry of Education and Research (BMBF) agencies (*Projektträger*) evaluated each technology in terms of such criteria as timing, economic importance and non-economic benefits, identifying the most important ones for Germany in terms of each criterion.

In another initiative, ISI collaborated with NISTEP in Japan which was conducting the fifth STA 30-year forecast. The first step was to translate the Japanese Delphi topics into German. (This proved to be a non-trivial task: after preliminary translation by professional translators, German experts had to check each topic to ensure that its meaning had been accurately reproduced.) The topics were sent to a large sample of experts from industry, universities and government. Comparison of the German and Japanese responses showed close agreement on the likely timing of advances, suggesting that the Delphi approach can be used reasonably consistently across countries. The differences between the two sets of results was over the relative importance of individual topics and likely constraints. Since both these are closely linked to the respective national research systems, such differences were not unexpected. Another result to emerge was confirmation of the earlier Japanese finding that experts in a particular sub-field sometimes put forward unduly optimistic views. One strength of the Delphi approach is that such a bias can be identified and taken into account.

Although the exercise was reasonably successful, in particular, enabling the views of German and Japanese experts to be compared, the approach had some weaknesses. The two countries therefore carried out a “mini-Delphi” exercise to develop an improved methodology. Among the changes were for the two countries to select the topics jointly, the distinguishing of different categories of importance (to S&T, on the one hand, and to the economy, the environment and society on the other), and the inclusion of questions on the conditions to foster innovation. The findings from this exercise included the following:

- The mini-Delphi is an important methodological tool.
- International selection of the Delphi topics is recommended for such joint exercises.
- Questions relating to market demand should be included in discussions of S&T policy.
- Delphi surveys should seek qualitative as well as quantitative information—for example, views on alternative solutions to particular problems.

Subsequently, Germany collaborated with Japan in the latter’s sixth Delphi exercise in the late 1990s.

Foresight in Germany has had an impact at several levels. First, at the Federal level it has influenced budget priorities within the Federal Ministry of Education and Research (BMBF), although TF is just one of many inputs. It has also played a role in strategic talks with industry and large research organizations. Secondly, a number of State governments have carried out investigations of the regional implications of the national foresight results. Thirdly, in industry, there have been more specific foresight exercises carried out by industrial associations. A pharmaceutical company has also conducted a Delphi survey of several thousand doctors, and a number of other companies are known to have performed in-house foresight activities. Lastly, foresight has had a wider impact on German society. The results have been published and widely discussed in the media. This has helped generate a more positive debate on future technologies, with distinctions being made between individual technologies and whether each of them is desirable or not.

Technology foresight in France

In France there were several interesting foresight initiatives in the early 1980s under a socialist government which gave high priority to technology as a means to achieving economic and social progress. For example, in 1981 there was a major technology consultation exercise in which 1,200 experts were involved and which yielded reports on five priority fields together with an overview report. A year later, the National Colloquium on Research and Technology was held which, together with various regional meetings, involved 3,000 people. It identified half a dozen key technologies and the government subsequently launched national “mobilizing” programmes to promote these.

Regular foresight was then used to steer or redirect these national programmes during the 1980s. Other examples of foresight include an exercise by the Centre National de la Recherche Scientifique (CNRS) in 1984 to identity 20 strategic themes and the Prospective 2005 conference organized by CNRS and the Planning Commissariat in 1985.

However, after the change of government in 1986 interest in foresight declined until 1994 when a Delphi survey on future technologies was launched by the Ministry for Higher Education and Research. This was carried out in parallel with another foresight experiment by the Ministry of Industry to identify key technologies, (this "key technologies" exercise was repeated five years later) an exercise which gave more emphasis to the needs of industry and society and rather less to a S&T push. The Delphi survey used many of the same questions as the earlier Japanese and German surveys so that the views of French experts could be compared with those of the Germans and Japanese. Among the aims were to see if a Delphi survey would work in France, to establish whether experts would participate, and to find out whether decision makers would be influenced by the results.

Questionnaires were sent to over 3,000 experts drawn fairly equally from industry, universities and public research organizations, and covering 15 sectors. Among the questions considered in analysing the results were the level of consensus among experts and, conversely, whether there were groups of experts with distinctly different views, and whether experts held different views from those slightly less knowledgeable on that topic. A comparison of the results with those from the Japanese and German surveys revealed that French experts held very similar views on the timing of technological developments or innovations to their German and Japanese counterparts.

In some sectors there was also consensus on the relative importance of individual topics. For example, in life sciences, the list of 10 developments judged most important by French experts was very similar to that for the Germans, and likewise for the materials sector. However, for all the sectors combined, there was very little overlap between the top 10 most important topics for each country (with only one topic common to all three lists). Topics on which there were most difference between Japan and the two European countries included domestic robots, exploitation of the oceans and the development of supersonic passenger aircraft, differences which would seem to reflect economic and other national specificities.

In the question on which country was currently the technological world leader, there were interesting differences, with French experts having a surprising tendency to regard the United States as pre-eminent, while the Germans were more predisposed to see the Japanese as leaders. The question dealing with likely technological constraints also revealed national differences; for the French, the sector with the least constraints was agriculture, for the Germans transport, and for the Japanese architecture and construction. Lastly, the question on which topics most required international collaboration again revealed a lack of agreement between France and Germany, a finding with potential implications for the European Union's R&D policy.

One weakness often cited in relation to Delphi surveys is that they artificially create consensus and can, as a result, give rise to misguided policies. However, the French exercise showed that one can use the Delphi results to identify groups of experts with systematically different views. For example, experts employed in large firms tend, on average, to be less optimistic on the timing of particular developments than those working in SMEs. Finally, as in other countries, the national exercise has encouraged lower-level foresight activities. For example, a regional foresight exercise was conducted in the Bordeaux region, exploring the implications of the national results for that area.

Technology foresight in other countries

In the latter part of the 1980s, foresight began to spread to other countries, such as Australia, Canada, Norway and Sweden. In Sweden, for example, there were foresight initiatives by the Council for Planning and Coordination of Research, the National Board for Technical Development, the Royal Academy of Engineering Sciences, the Defence Research Institute and in industry. More recently, foresight has spread further afield, for example, to Hungary.

Figure I shows the chronology of national TF programmes up to 2002, indicating the main methods which they used (Keenan, 2003).

Figure I. Chronology of national technology foresight programmes up to 2002

Year	Delphi	Mixed	Panel/scenario
1970s	30 years in Japan		
1989			Ministry of Economic Affairs Netherlands
1990	1st German		
1991 1992			Critical technologies, USA and New Zealand
1993	Republic of Korea		Technologies at threshold of 21st Century, Germany
1994	France Japan/Germany Mini Delphi	1st UK TF programme	
1995			100 key technologies, France and Australia
1996	Japan-German Delphi		Foresight Steering Committee Netherlands 1st Italy Industry Foresight
1997		OPTI Spain	Ireland
1998	Austria	Hungary	South Africa and New Zealand Sweden
1999			2nd UK TF programme FUTUR Germany
2000			2nd French 100 key technologies, Portugal Industrial Association, 2nd Italy Industry Foresight
2001	7th Japanese Delphi		Czech Republic, Malta, Cyprus, Estonia
2002		Turkey	Bulgaria and Romania 3rd UK TF programme

Source: Keenan M. et al. *European Foresight Competence Mapping* (2003).

Evolution of rationales through three generations

It could be argued that foresight has evolved over the period through three generations (Georghiou, 2003). First generation activity was concerned with technological forecasting by experts, second generation bringing in industry and the market, and third generation foresight adding a social and user-oriented perspective. It should be stressed that these generations are ideal types and that an individual foresight activity may exhibit elements of two or even three generations.

The generations are reflected in different types of programme structure. The organizing principle of the first is fields of S&T, of the second industrial and service sectors in the economy and of the third thematic issues concerned with socio-economic problem-solving (for example the ageing society or crime prevention). These are usually populated by different types of actors: first generation foresight is the domain of experts, either in futurology or in the technological domains addressed, in the second generation, characteristic of the foresight wave of the 1990s, experts representing technology (academics) are brought into contact with market expertise (from industry). Futurology (or foresight expertise) moves into the background as a major aim is to bring the two mentioned groups into closer contact. The third generation retains the actors from the second but makes explicit attempts to engage another set of communities, what may be broadly termed social stakeholders. These are groups representing citizens, for example, voluntary organizations concerned with the welfare of old people or non-governmental organizations campaigning on environmental issues.

Implicit in these models were different approaches to evaluation. For the first generation the key issues are accuracy of prediction and diffusion of results (to non-experts). In the second generation the take-up of priorities and establishment of networks become key evaluation issues, while the third generation implies the involvement of stakeholders in evaluation and looks for evidence of the emergence of a foresight culture. It does however emphasize that the approach to evaluation is conditioned by the approach to foresight and the associated rationale and expectations.

The focus of foresight programmes

Not all foresight activities necessarily focus on S&T, although a recent review of 84 foresight exercises in Europe showed that S&T predominates (Keenan, 2003). The results of this review show that the next most popular orientation was business dynamics, (just under 40) followed closely by socio-cultural issues (36). Territorial vision and environment and sustainable development were both seen with 30 exercises each. Thus, it can be concluded that a wide variety of orientations are in evidence. It should also be noted that most foresight exercises have more than one orientation. This is borne out by analysing the pattern of orientation across the 84 exercises reviewed. Only 21 per cent of exercises reviewed had a single orientation (usually Science and Technology), whilst the remaining 80 per cent or so had two or more. Exercises with two orientations are the most numerous, although those with 3 to 5 orientations account for almost 50 per cent of the total reviewed.

The importance attached to action in foresight has already been highlighted, and unsurprisingly, this action-orientation is reflected in the results of the review. In more than 40 per cent of exercises reviewed, foresight was judged to be a direct input to strategic planning. In a further quarter of the cases, it was used as a basis for vision-building. In only 18 per cent of cases was an exercise judged to be explorative, that is, not formally linked to a process of decision making.

4. WHY HAS FORESIGHT BECOME IMPORTANT?

Global driving forces and the challenges for technology policy

The development of foresight has occurred as a response to changes that have taken place in the world economy. Some of the main drivers of change in the global economy over coming decades (Martin, 2001) are:

- Increasing competition.
- Increasing constraints on public expenditure.
- Increasing complexity.
- Increasing importance of scientific and technological competencies.

These factors also underlie the upsurge of interest in foresight, giving rise to its emergence as a global concept and policy tool.

Increasing competition

There is widespread recognition that we live in an increasingly competitive world. Over the last 10 years or so, many more market-economy "players" have emerged—in Asia, in Central and Eastern Europe, in Latin America and elsewhere. This has greatly increased the level of economic competition between countries as well as companies. At the same time, we are witnessing huge (and perhaps historically unprecedented) variations in labour costs (e.g. by a factor of 100 or more between Germany and China). These are occurring at a time when companies can much more easily shift resources and production between countries to benefit from lower costs or other advantageous local resources. For the richer and more industrialized countries, the key to success lies in continuous innovation to achieve ever-higher productivity and thus enhanced competitiveness.

In this era of competition and increasingly rapid change, new technology is playing a growing role in relation to economic and social development. As we move towards the knowledge-based economy, industrial competitiveness is coming to depend to a greater degree on new technologies and innovation. However, emerging technologies and the strategic research which underpins them are often too far removed from the market, too risky or too expensive for industry to take sole responsibility for their support. Governments must assume at least part of the financial responsibility. Yet governments cannot afford to fund all areas of research and technology which their scientists or industrialists would like them to support. Choices have to be made, and technology foresight offers a process to help make those choices.

There is increasing concern about the interaction between economic competitiveness and a number of social factors such as unemployment and working conditions, inequality and social cohesion, environment and sustainability, and new risks (those associated with the introduction of new technologies) and their distribution across different sectors of society compared with the distribution of benefits. There is therefore a need for new national S&T policies that balance competitiveness against unemployment, inequality, sustainability, risk and so on. This requires new policy tools such as technology foresight.

Increasing constraints on public expenditure

Governments in many countries, have been experiencing significant public expenditure constraints because of the need to balance their budgets (for example, to meet the Maastricht criteria for European monetary union). Those constraints are likely to grow over time for a number of reasons, including demography and the ageing population, and the increasing costs of—and rising expectations concerning—health care, education and social welfare. Another possible factor is that we may have reached the politically acceptable limits to tax-raising; if a government attempts to extract taxes above a certain level, companies or more affluent individuals may take their business off-shore to a country where the tax system is not so burdensome, something that has been made much easier by new technology and the growing use of electronic transactions.

These constraints on public spending will result in increasing demands for greater accountability and for better “value for money” from all areas of government spending. In the case of research and technology, this requires new policy tools, along with a better justification for government funding of research and technology. We also need policies to develop technologies to deliver health care, education and social welfare more effectively.

Because of these trends and the escalating cost of research and technological development, no government can afford to do everything in research and technology, not even the richest. Governments now realize that they must be more selective—they must have explicit policies and clearer priorities for research and technology. Choices have to be made. In the past those choices tended to be made tacitly—they just “emerged” from the policy process. The question now is whether we should continue with this approach, or whether we should attempt to devise a more systematic procedure for priority setting in relation to technology and research. Foresight offers a tool (but not a panacea) for helping to identify those priorities.

Increasing complexity

The trend towards growing complexity is driven by greater coupling and closer interactions of systems of a variety of forms, including interactions between:

- Local, national, regional and global systems—for example, between national systems and the European Union, and between each of these and world bodies such as the World Trade Organization (WTO).
- Research and Technology, on the one hand, and the economy, politics, culture and environment on the other (as described above under "increasing competition").
- Public and private sectors in such areas as health care and transport.
- Different technologies—here, Kodama's notion of "technology fusion" (1992) is particularly important. Often the most important radical innovations arise when two or more previously separate streams of technology come together and "fuse".
- Different producers of knowledge—according to the thesis of Gibbons et. al. (1994) in the so-called "Mode 2" form of knowledge production (characterized by its application-orientation and growing trans-disciplinarity), a far wider range of knowledge producers is involved and there is considerable blurring of the institutional boundaries between them (e.g. between the industrial and university sectors) (Gibbsons et. al., 1994).

As a result of these growing interactions between systems of different forms, there is a need for the following:

- A better understanding of complex systems.
- Flexible policies, responses and systems.
- Policy tools linking different partners and their needs, values and so on.
- Increased and more effective networks, partnerships and collaboration.
- A clear division of responsibility between national, regional and global bodies and their respective policies.

TF provides a process for addressing several of these issues in a systematic, open and collaborative manner.

Increasing importance of scientific and technological competencies

The final point in the list of key drivers of change in the global economy is the increasing importance of scientific and technological competencies. Here, one can distinguish between knowledge and skills. As argued above, scientific and technological knowledge is becoming a strategic resource for companies and countries. It is also increasingly vital to improving the quality of life. As many science policy studies have demonstrated, at least as important as codified knowledge (encapsulated in textbooks, scientific papers, patents etc.) is tacit knowledge. Such tacit knowledge is not easily transferred: generally it requires people or organizations to be brought together, ideally with individuals working together at the same location for a period of time. Again, TF can forge the connections that help bring this about.

Scientific and technological skills or expertise are also becoming ever more important in relation to wealth creation and improvements in the quality of life. Here, matters are complicated by the fact that new technologies not only demand new skills, they also make old skills obsolete (arguably, at an increasing rate). This points to the need for continuous learning, both at the level of the individual (with a shift away from the notion that the individual is educated only in the first 20 years or so of life to one of “lifetime learning”, a shift in which new technologies can make a major contribution), and at the organizational level (with the creation of the “learning organization”). In addition, because of the growing complexity and interaction of systems described above, we need new generic or system-wide skills—skills such as interdisciplinary approaches, team-working, networking and collaborating, all of which can be fostered or exchanged through the TF process.

The changing social contract between science and technology (S&T) and society

What the above factors may be producing is a shift in the “social contract” between S&T, on the one hand, and the State or government, on the other. In the 40 years after the end of the Second World War, the “science-push” model exerted a dominant influence on funding policy for research. According to this model, advances in basic research give rise to opportunities in applied research, which, in turn, make possible the development of new technologies and innovations. Society therefore, supported basic research in the expectation that it would ultimately generate benefits in the form of wealth, health and national security, but governments were fairly relaxed about exactly what form those benefits might take and when they might occur. Now, faced with increasing industrial competition, tighter financial constraints and demands for accountability, governments are expecting more specific benefits in return for continued investments in research. Foresight represents one way of linking the interests of the scientific community in pursuing the most promising research opportunities with the needs of industry and society in relation to new technology and innovation.

This leads to another reason why governments have become involved in foresight—namely, that the successful use and exploitation of S&T depends increasingly on the creation of effective networks between industry, universities and government research laboratories. Foresight can help to establish and strengthen those links. As is argued later, this might be seen as part of the process of “wiring up” the national or regional innovation system so that it can learn and innovate more effectively.

Some further reasons for the increasing popularity of foresight

It is perhaps worth saying a few words about systems of innovation before presenting the arguments associated with foresight’s systemic benefits. The concept of systems of innovation has proved popular with academics and national policy-makers alike over the past decade, and is now also being picked up by regional and sectoral players. Rather than focusing upon the constituent actors within the system, the strength of the national systems of innovation (NSI) approach is said to lay its emphasis upon the relationships and linkages between the actors. If we accept the Mode 2 thesis, this emphasis on linkages and networks is important. Thus, an NSI marked by actors that are not "particularly strong, but where the links between them are well developed, may operate more effectively (in terms of learning and in generating innovations) than another system in which the actors are stronger but the links between them are weak" (Martin, 2001).

This brings us to perhaps the most commonly cited rationale for TF today—that of correcting "system failures". The foresight process itself is said to enhance communication between actors within a system, providing a means of coordination and generating commitment to action. As Martin and Johnston (1999) contend, "Technology foresight offers a means of 'wiring up' and strengthening the connections within the national innovation system so that knowledge can flow more freely among the constituent actors, and the system as a whole can become more effective at learning and innovating."

Knowledge flows and system-wide learning are important to emphasize here. For instance, knowledge of other actors' strategies and positioning vis-à-vis a given issue (e.g. through foresight) can reduce uncertainties, thereby enhancing a system's innovative capacity. The potential for system-wide learning, which is also said to enhance a system's capacity for innovating, is related to the level of interdependence between the various system actors. The degree of interdependence is, in turn, dependent upon processes that stimulate, nurture, encourage, and strengthen interactions between actors so that they become more permanent—processes such as TF (Martin, 2001).

Other drivers can also explain the wide adoption of foresight:

Emergence of new styles of policy-making—it could be argued that the 1990s have witnessed the emergence of a new, more inclusive style of policy-making, partly in an effort to bridge the perceived "implementation gaps" associated with previous era policy interventions. This development is also being driven by a growing realization that, as the world grows more dynamically complex, it is impossible for any one organzation to know everything that is needed for successful policy intervention. In other words, many governments have recognized that the requisite knowledge for successful policy intervention is distributed across a wide and varied landscape of actors, and that this landscape has a role to play in policy formulation and implementation. This is sometimes described as a shift from top-down government to a more distributed "governance" model. Foresight exercises, with their inclusiveness and emphasis on processes, would seem to be part of this shifting trend.

Increasing desire for anticipatory intelligence—an oft-cited rationale for conducting foresight, especially at the sectoral and regional levels, concerns the development of anticipatory intelligence amongst system actors. This is a common rationale found in foresight exercises associated with industry cluster development, or with the competitiveness of Small and Medium sized Enterprises (SMEs), though it tends to be implicitly assumed in virtually all foresight exercises. It refers to the objective of widening perspectives, both spatially (e.g. to cover unexplored domain areas, untapped potential markets, etc.) and temporally (e.g. to encourage longer-term thinking than might normally be the case). These new perspectives offer insights into possible opportunities and threats that might otherwise remain invisible. Armed with this strategic knowledge, system actors, be they companies, or policy makers, or others, are believed to be better placed to implement flexible and robust strategies that have the responsiveness and agility to deal with multiple futures. In other words, and to use the common jargon, foresight allows companies and bureaucrats to be better "future-proofed" against a whole range of future eventualities.

Building advocacy coalitions—an often overlooked but increasingly important rationale for conducting foresight is its ability to mobilize disparate groups of actors around a particular vision. For example, if a particular issue is believed already to be strategically important, foresight can be used not only to raise awareness of its importance, but also to mobilize the key stakeholders into taking strategic collective action. Collectivity is important here—to be taken seriously and to attract resources, actors usually need to coalesce within more or less organized coalitions in order to better argue for (or advocate) support of their particular area. Indeed, as history has demonstrated time and again, those who are organized tend to rule, whilst those who are disorganized tend to be ruled. With this in mind, foresight is often used to organize advocacy coalitions around issues of particular strategic importance, since such groupings are better placed to enact strategic change than the lone academic, entrepreneur, or bureaucrat. In some instances, foresight has even been used in this way to broaden the coalition of interests that advocate a central role for research and innovation in the wider political-economy.

Bandwagon effects—as one country has undertaken a foresight exercise, "competitor" countries have felt the need to follow suit. The same phenomenon can be seen in sub-national regions. Foresight "promoters" have told good stories and these have proven to be irresistible to those who do not want to be "left behind". In addition, the activities of international organizations, such as UNIDO (e.g. in Latin America and the former Soviet Republics) and the EU (e.g. in Eastern Europe), have played no small part in this diffusion process.

The "Millennium effect"—governments all over the world have sought at least to appear to be preparing for the new opportunities and challenges that lie ahead in the twenty-first century. This could explain an explosion in futures-type studies in the run up to the new Millennium but probably cannot fully account for foresight's continuing popularity in the post-Millennium era.

5. CHALLENGES FOR TRANSITION COUNTRIES

Issues for transition countries

The countries in transition went through significant changes during the 1990s. This process influenced both the demand and supply sides of innovation and technology development. The framework conditions, the social and business environment, and their interrelations changed so dramatically, that both old and new actors faced the challenge of how to adjust to this new situation. The rapid privatization and the management of deep social and macroeconomic crises resulted in short-termism in all these countries. Some of the main symptoms of such policies are:

- Sharp cuts in both public and private R&D spending, and serious reduction of the traditional science base (cuts in the number of institutions and scientist). Havas (2003) calls it "planned, policy-assisted destruction".
- Lack of strategic and long-term thinking and a negative attitude to any kind of planning activities (considering them as a typical practice of socialism).
- Little attention to issues, which have longer-term impacts (environment, health, human resources development, corruption, etc.).
- Less developed capital market (low interest and experience in financing projects with high risk), poor links between academy and industry.
- Few, if any, long-term planning documents at both government and ministry level (papers titled as "strategic" or "policy" usually did not meet even the minimal requirements for such documents by Western European standards).
- Underdeveloped social frameworks for permanent communication among the interested communities. "In less developed countries typically the link between science and society is weaker and public policies are less rationalized" (Tavares, 2002).
- The autonomy of scientific research is over-emphasized. There is a strong resistance against prioritizing R&D. The role of governments in this process is interpreted by the academic communities in a narrow way ("give support, and leave us to set the rules and allocate the resources alone").

Based on historic experiences the most serious danger the catching-up economies face now is copying techniques and procedures of innovation policy formulation without any criticism. Tools, which work effectively in one country, do not necessarily function automatically well in another. It is important to study the exercises of other countries, but in launching a policy formulation process every government should combine its knowledge on the local situation, the views of the society on its potential futures, and the values, limits and relevance of the application of different policy tools. This knowledge may form a strong base for deciding what methodology and tools should be selected in preparing policy decisions. The best practices learned internationally have their own value, but when they are applied somewhere else they always need to be adjusted to the local environment. Automatic copying as a strategy brings unnecessary challenges and usually leads to failure.

There is another danger accession countries may face. Parallel with the growing activism of the EU in the fields of R&D and innovation (the ERA concept, the coordination of the relevant national policies, increasing funding sources for the R&D framework programmes, etc.), the countries during their preparation period for membership are extremely motivated to follow the Commission's policies. The importance of the framework programmes in their total R&D funding is much higher than in most of the member States. These factors put an emphasis on simplifying the R&D and innovation policy formulation. Many experts think, that the framework programmes set national priorities as well, so there is no need to run complex and sometimes politically complicated exercises, like foresight at a national level.

Copying the EU is the usual "lazy" reaction of politics, which prefers to avoid conflicts (no matter whether it is necessary or not) and aims at solving challenges with the lowest cost (no matter what is the real social cost in the longer term). But this strategy is obviously not appropriate and not effective.

Recommendations for emerging economies

Public administrations play a significant role in any foresight exercises. The culture of governing, how public bodies and administration work, how they form an integrated system and how they formulate and implement policies are factors which directly influence the follow-up process of foresight programmes. These factors should be taken into consideration during the programme. The recommendations and other outcomes of foresight should fit into the later action-capabilities and capacities. Otherwise, the final documents will remain only papers and no efforts will be mobilized in order to give life to the written statements.

"The cooperative culture" in the public administration in most of the CEE countries "is very poor, the tasks and functions of individual organizations are not well defined, the system itself is not transparent enough. The organizational learning and innovative capabilities are weak. Technical and managerial competence, creativity and strategic thinking are not highly valued, loyalty is much higher prioritized as a requirement for employment than professional knowledge and expertise" (Nyiri, 2002).

Government offices in these parts of the continent do not consider, that accountability, working under defined rules and in a transparent way, delegating tasks and responsibility into an optimal, usually lower level inside the vertically organized hierarchy are high priorities in their daily operation. Coordination and cooperation among different ministries and government agencies is difficult.

Some challenges foresight promoters face in launching a programme in less developed countries:

- The time horizon of foresight is always far beyond the interest of the decision makers (both in the administration and in the political life).
- There are different understandings inside the stakeholder groups and the policy makers about the process of innovation and the links between innovation, economic performance, quality of life and competition. It is much easier to follow the linear model of innovation. The very complex approach of new innovation theories is hard to sell. That is the reason why it is extremely important to find appropriate language in formulating the final recommendations.
- The public administration dealing with R&D and innovation is under constant restructuring in most of the European countries, including the CEE region. In addi-

tion, the ministries responsible for R&D and innovation are not considered as "hard ministries" (like defence, finance, foreign affairs or trade and industry), their position is rather weak inside the governments. These two factors make difficulties for foresight promoters in creating the necessary coalition behind a foresight exercise.

Foresight is a complex process, with a large number of interrelations, a high level of communication in both quantity and quality, and with a strong multidisciplinary and interactive character. The local environment may determine the success of the process. The aims of the exercise, the applied methodology and tools should be selected after intense study of this environment. One of the success factors of foresight programmes is how the process will have changed this local social environment. (In many cases the major target of foresight programmes is to improve networking and communication among all the stakeholders.)

One of the most important parameters, which should be taken into consideration before starting the design of a foresight programme, is the actual *decision-making culture* around the programme. In the practice of the post-industrialist countries reflexivity is a very important element of the decision-making process. Reflexivity means a regular and systematic collection of data in order to measure the outcomes of any actions. This data serves the analysis, with the aim of further improving the performance of an organzation. It is a key element of the learning process. Both monitoring the outcomes and evaluating the performance are integral parts of such a decision-making culture. Political decisions are based on expert knowledge and the process needs to involve all the stakeholders.

The less developed countries have a big deficit in this area. Social input into the decision-making process is weak and it is not based on the broad participation of stakeholders. Performance indicators are usually not applied as tools for learning (their use is not an organic part of policy programming). The concept of reflexivity is poorly understood. Political programmes are usually declaratory, and priorities are either not set or set without practical implications for budgeting. The importance of public servants and governmental politicians is overemphasized. Data collection does not support analytical purposes, but is used as a way of arguing for decisions already made. This culture does not favour a foresight approach, but foresight may have a positive and effective impact on changing this culture.

The *social infrastructure* in the less developed countries is also much weaker and less supportive of foresight than in post-industrialist countries. All social systems in Central and Eastern Europe "appear to be highly localised and particularized. The different parts of the system have started to operate independently of the rest which among other features is characterized by restricted/non-existent flow of information between the parts, lack of cooperation and, in some cases, excessively high levels of competition" (PREST/FhG ISI, 2000). These societies are traditionally vertically structured, the civil societies are weak, the groups of different stakeholders are badly organized and the public administrations, as bureaucracies are rather strong. Platforms for social dialogue are missing or under-developed. The social infrastructure in these countries is fragmented and poorly networked. This situation may limit the efficiency of a foresight exercise, which by its nature does not tolerate rigid structures and hierarchical thinking.

Another important aspect, linked directly to the social infrastructure, is the well-balanced *participation of major stakeholders*. It is an issue, which should also be given special attention in the new democracies. These countries are in transition in both an economic and a social sense. There is a danger, that foresight exercises in these countries are dominated by the academic community and lack a critical mass of globally thinking and future-oriented business participants. At this early phase of a market economy the number of such business leaders is limited. That is why the strong involvement of industry in such policy-formulation procedures should be given high priority and special attention through the whole process.

Communication is a key element in all foresight programmes (sometimes it is one of the targets). It has many functions. Communication does not mean only the flow of information, but a real dialogue among different stakeholders, as well. It creates a new language, which is equally spoken by all the participants. It makes possible the formulation of new networks and improves the relationships among them. Last, but not least it serves one of the most important tasks of foresight, the consensus building process. The communication culture of a country, where technology foresight is launched, should be carefully studied before starting the exercise. It is one of the most important tasks of the preparation phase.

In the accession countries, especially in the new market economies, foresight may play a special, significant social function in this regard. It may improve the communication among different stakeholders, who otherwise do not speak the same language; it may create a new tool for further social debates; and finally it may develop the internal linkages of the national system of innovation. The importance of such benefits cannot be over-estimated in economies, where the innovation system is highly fragmented and the links between the actors are poor or non-existent.

6. EVALUATION OF FORESIGHT

Since foresight is a policy instrument consuming time and resources, it is reasonable to expect that it should be subject to evaluation of a comparable rigour to other tools. In a generalized evaluation framework, three basic tests could be applied:

- Accountability—with questions such as whether the activity was efficiently conducted and proper use made of public funds.
- Justification—with questions such as whether the effects or foresight justify its continuation and extension.
- Learning—asking how can foresight be done better in particular circumstances.

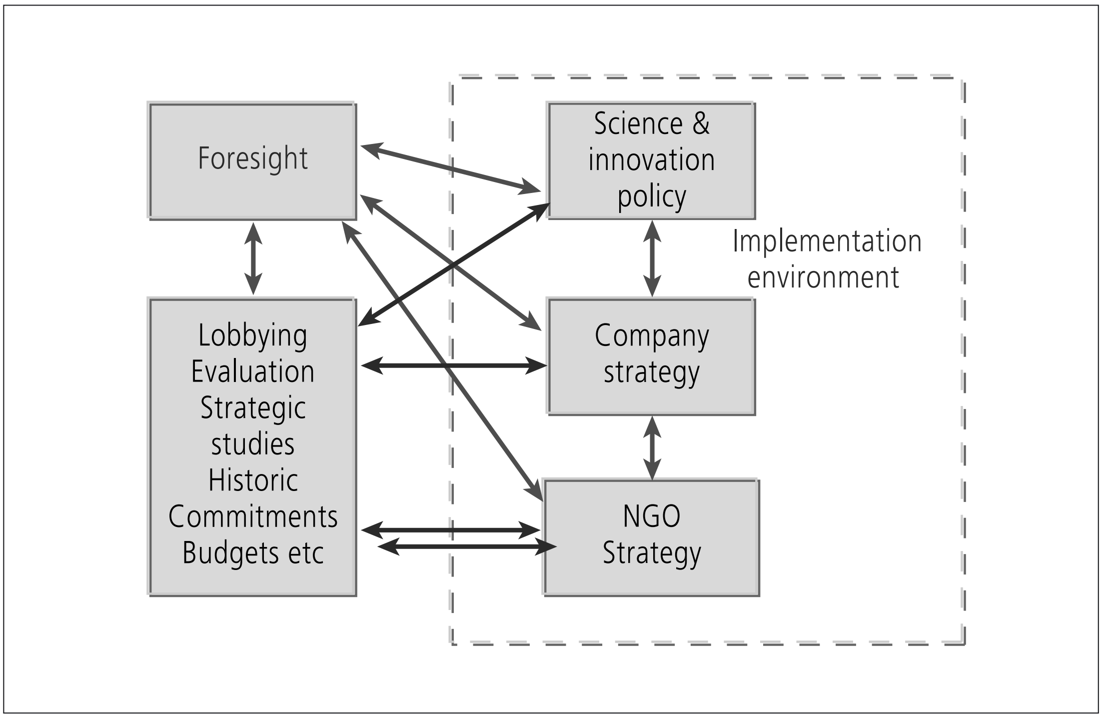
In a standard evaluation approach, it is important to define the scope and purpose of what is being evaluated at an early stage. The variety of forms of foresight has been discussed in the previous section. Another dimension in which foresight has to be delineated is that of location in time. The key question is where does a foresight activity begin and where does it end. In a first national effort, the beginning is usually clear as the process is initiated with a decision to commit resources and often to establish some sort of secretariat. The end is frequently much less clearly delineated. Where the aim is a report or list of priorities, publication and launch marks some kind of termination though dissemination and other implementation activities may well follow, The launch of networking activities is far less likely to offer a clean break as these are likely to persist for some time after the foresight activity has ended. An arbitrary decision may need to be made on when to demarcate the cut-off point when foresight outputs cease to provide a distinct or influential voice in policy discourse. Furthermore, to understand the context in which foresight is operating it is necessary to locate it in a broader strategic and policy context. The evaluation will have to explore the period in which foresight emerged and its interaction with other elements of the system.

The timing issue is also linked to the type of question being asked. If a linear or sequential view of foresight is taken, process issues are best pursued while the activity is still under way. However, many outputs and outcomes will not be clearly visible at this time and will need to be investigated ex post. Here the problem becomes one of attributing effects. If accuracy of the future visions is an issue the ex post delay corresponds to the foresight period. This may not be a problem with short horizon five-year critical technology exercises, but it requires a remarkable stable system if the issue is to be usefully pursued for foresight on, say, a 15-year timescale. Only the STA/NISTEP forecasts have been properly assessed on this basis.

Process evaluation covers topics such as organization and management, and would for example ask: Were the right people involved? Did expert panels receive adequate support? Was the exercise adequately linked to decision-making centres? It may also address the question of the appropriateness and efficiency of methods used, for example: Should a Delphi have been used? Were scenario workshops properly facilitated? As noted above it should be conducted in real-time or immediately after an activity is complete to ensure that the findings arc not distorted by hindsight or obscured by loss of data.

With regard to outputs and outcomes, probably the most important observation is that outputs measure only activity and not its significance. Hence it is useful to know the numbers participating in meetings or surveys, reports disseminated, meetings held, website hits, and so on, but none or these measure the effects of these contacts or their contribution to outcomes. Numbers may even be misleading: the number of “new networks” formed disguises variation in their novelty, size, significance, durability, etc.

Figure II. Foresights in a non-linear relationship with its implementation environment



Source: Georghiou, L. "The UK Technology Foresight Programme." *Futures,* vol. 28(4), (1966).

Attribution—a non-linear view

Figure II is intended to show that assessing the effects of foresight requires an understanding that it is only one of several influences upon public policy or the strategy of firms. Furthermore, once a foresight output enters the implementation environment the question may be asked how is it different from other policy information. Possibly the answer lies in a longer timescale, creativity or commitment, but all of these elements can also come from other sources. The implication is that evaluation of foresight must include understanding of the interaction of foresight output with the strategic behaviour of policy and economic actors.

There are also some normative issues involved. Foresight is not always tuned to the needs of recipients and hence, to extend the analogy, the signal may be obscured by noise and not picked up. Information needs to be presented in such a way that policy/strategy mechanisms can receive and absorb it. One moderating factor is that of timing. This needs to synchronize with policy and strategic cycles. Furthermore, the level of recommendations needs to match available funding or capacity for reform, however, foresight cannot always work within the status quo and occasionally it is the policy/strategy structure that needs to change in the light of foresight information.

A key question in the evaluation of any public policy intervention is that of additionality—the extent to which the activity would have taken place without a public intervention. In this framework, the questions that should be asked about a foresight activity are:

- Would foresight have happened without the policy intervention?
- Is foresight done differently/better because of the policy intervention?
- Are the resulting actions better because of foresight?
- Have persistent changes been achieved (e.g. Foresight culture)?

Within the field of evaluation, recent thinking has moved away from treating additionally as a binary stop-go item. Within a system of innovation framework, temporary financial interventions are seen as less important than efforts to change the innovation system for the better in a lasting way. If it is accepted that foresight is correcting an inherent tendency to have excessively short-term horizons and a difficulty on forming new networks around technologically and socially innovative activities, then foresight may be best evaluated ultimately in terms of its ability to change values and behaviour in these directions.

The evaluation of foresight should also beware of potential traps. Traditionally foresight is seen as a process of building commitment among stakeholders—an important element for example in Martin's "5Cs". However, from an evaluation perspective this also creates risks when trying to assess the additionality of foresight. One risk is that of a self-fulfilling prophecy when the "owner" of a foresight activity (for example, a sponsor ministry) also controls the distribution of resources at the implementation phase. There may be a tendency in this situation to cause foresight priorities to have a stronger influence in the implementation environment than may be justified in terms of the rigour and merit of the exercise. At a more methodological level, stakeholding and consensus may be seen to some extent as a trade-off with creativity and insight. It may be somewhat easier to get "buy-in" to a set of views that are already commonly held than for a really novel or disruptive idea.

Some evaluation experiences

Figure III. Evaluation of national foresight activities

Country	Evaluation effort
Austria	Internal assessment by Science Ministry
Netherlands	Self-evaluation, PhD study, Master's thesis, evaluation by Advisory Council for Science and Technology (AWT)
Sweden	Process (and not the impacts) evaluated continuously by an Evaluation Committee
Japan	Assessment of realization of results some 15-20 years after identification in STA forecasts
Germany	Delphi 98 evaluation questionnaire; FUTUR evaluated during 2002
United Kingdom	Grand plans that degenerated into piecemeal efforts; some limited external (and independent) scrutiny, e.g. by (Parliament, a PhD study, etc.)

Source: Georghiou, L. *PREST* (2003).

Figure III shows some recent, experiences of foresight evaluation, and serves mainly to emphasize that a consistent and comparable approach has not emerged. Two of the countries mentioned are discussed further as case studies.

Case I: UK foresight evaluation experiences

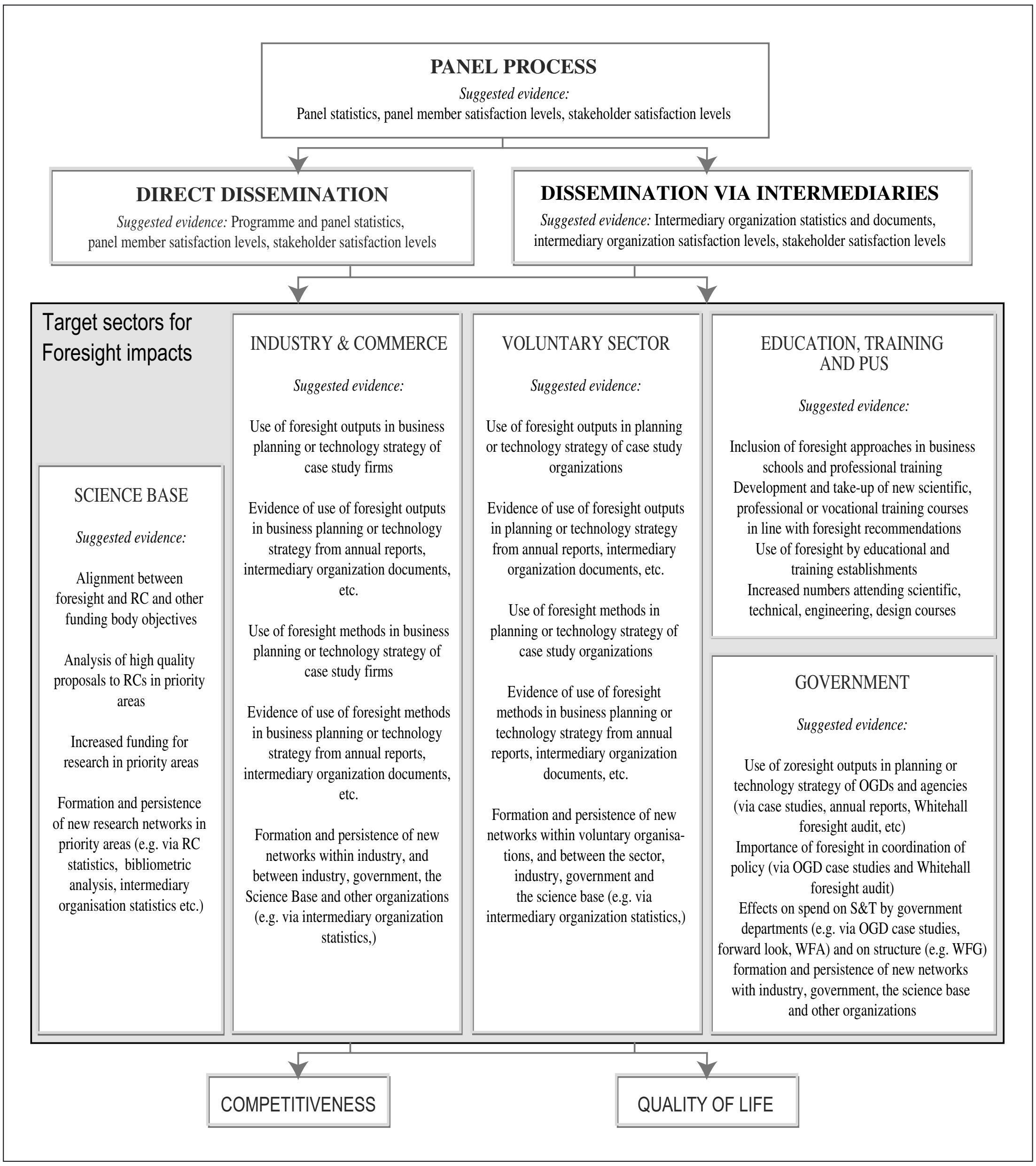
(See figure IV for an idealized approach that was not carried through.)

- Office of Science and Technology/PREST conducted survey of panelists (1995).
- Office of Science and Technology drafted more comprehensive evaluation proposals (1995).
- PhD CASE studentship at PREST (1995-1999).
- Panels asked to draft performance indicators (1996).
- Research councils and other government departments asked to account for implementation (1996-1998).
- Royal Academy of Engineering did some case study and questionnaire work (1997).
- Parliamentary Office of Science and Technology produced a review of foresight and its impacts (1997).
- Academic work at York and Brunel universities (1997-2000).
- Office of Science and Technology Consultation about lessons from first round.
- Segal Quince Wickstead contacted to develop impact indicators (1998).
- PREST/Wise Guys/SPRU contracted to develop an evaluation framework for 2nd foresight cycle (2000) (see figure IV).
- Chief scientist's review.

The first case, that of the UK, illustrates that without a consistent, credible central approach to evaluation, the likely result is a proliferation of activity. Much of the work in the list above was at a sub-critical level or else relied very heavily on anecdotal and potentially prejudiced evidence. It may be seen that the operating Ministry for foresight, the Office of Science and Technology was the main driver of activity but, despite commissioning a number of methodological studies and some fieldwork, it never allowed these to be compiled as an authoritative evaluation, Other interested bodies such as the Parliamentary Office of Science and Technology were able to put forward more critical and insightful views, but lacked the resources to follow up in terms of extensive collection of evidence. A parallel theme was growing government enthusiasm for performance indicators in all aspects of public sector activity. Notwithstanding the comments made above about the limitations of output indicators the constant pressure was to capture the effects of foresight in terms of key indicators. During the second cycle some experts were asked to develop an indicator-driven evaluation framework. A particular difficulty with this accountability-style of approach is that foresight depends heavily upon the unpaid involvement of panellists and other contributors who do not take kindly to being monitored. A “softer” evaluation approach was adopted that relied upon participants to collect and analyse a significant part of the data, while other items would be compiled centrally. The organizing principle was to separate process from impact and in the latter case to identify the five main stakeholder groups: the science base, industry and commerce, the voluntary sector, government, and education, training and public understanding of science. From the framework a set of key indicators was derived (figure IV).

Evaluation framework for second UK foresight process

Figure IV. UK second cycle evaluation framework



Source: Georghiou, L. *PREST* (2003).

In the event this framework was overtaken by events as growing dissatisfaction with this cycle of the programme led to the final activity in the list to be instituted. The chief scientists review was an internally conducted evaluation based on soliciting views from stakeholders but without any attempt to codify a systematic approach or to present detailed evidence The conclusions however were powerful and resulted in a major change of direction. There are many reasons underpinning the changes that took place but one source of explanation was that the foresight machinery in government had been constructed to optimize implementation (for example, by shifting panel membership towards representatives of industry, scientific and consumer associations). When this machinery was then turned towards creating new foresight visions it was simply not equipped for the job.

Case 2: Evaluation of German FUTUR initiative

The second case concerns a recent evaluation, that of the German FUTUR initiative. This was commissioned by the responsible ministry, BMBF, and was largely a process evaluation, focusing upon:

- The objectives of FUTUR, which are assumed to summarize the central assumptions upon which the exercise is based.
- The different instruments and methods with regard to their effectiveness, efficiency and interplay.
- The process in general.

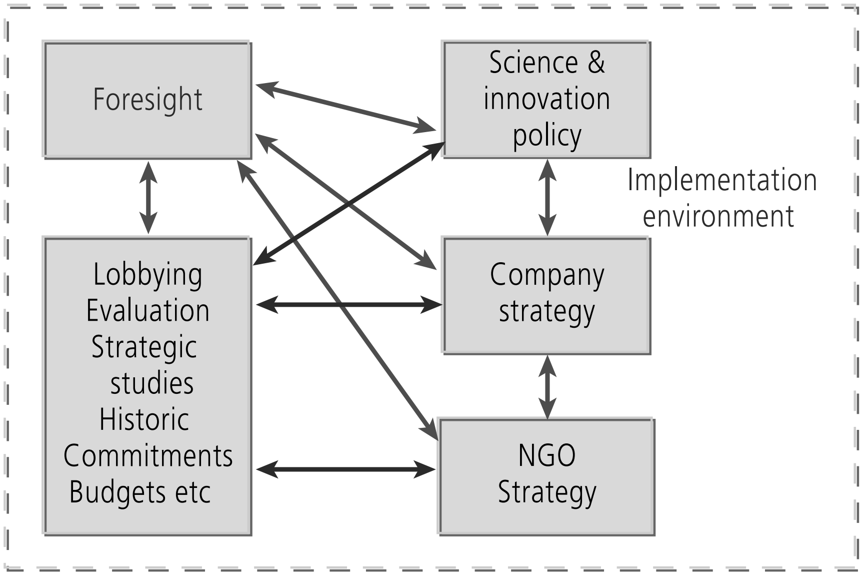
The evaluation approach was developed by ISI-Fraunhofer and involved formulating the underlying assumptions and hypotheses that underpin the ideals and conduct of FUTUR. These hypotheses were then "tested" through their operationalization into questions that could be detailed in surveys and inter-view protocols. Following a survey of participants a document was constructed to support an International Panel of Foresight Evaluation Experts. This panel held a one day hearing with interviews and the Chair consulted with the Ministry as a user at the most senior level before producing the evaluation report. The limitations of this exercise were too little time and resources available and the fact that the exercise was conducted too early to pick up outcomes. However, several process-related recommendations were made and an impetus was gained for the continuation and improvement of the activity. A key finding was that the participants felt disconnected from the implementation process and to a lesser extent the programme managers responsible for implementation lacked a sense of ownership of FUTUR.

Emerging lessons—policy tool and the fourth generation

If we return to the definition of foresight (stated earlier) and combine these with the considerations about foresight evaluation, then it can be argued that the common space and joint ownership elements in the foresight definition imply that foresight not be in a linear relationship with implementation but rather that foresight should move into the implementation space. Figure II can be redrawn as figure V to emphasize that foresight needs to take place inside the implementation environment, but also that foresight and implementation are interactive activities.

Foresight inside the implementation space

Figure V. Foresight inside the implementation space



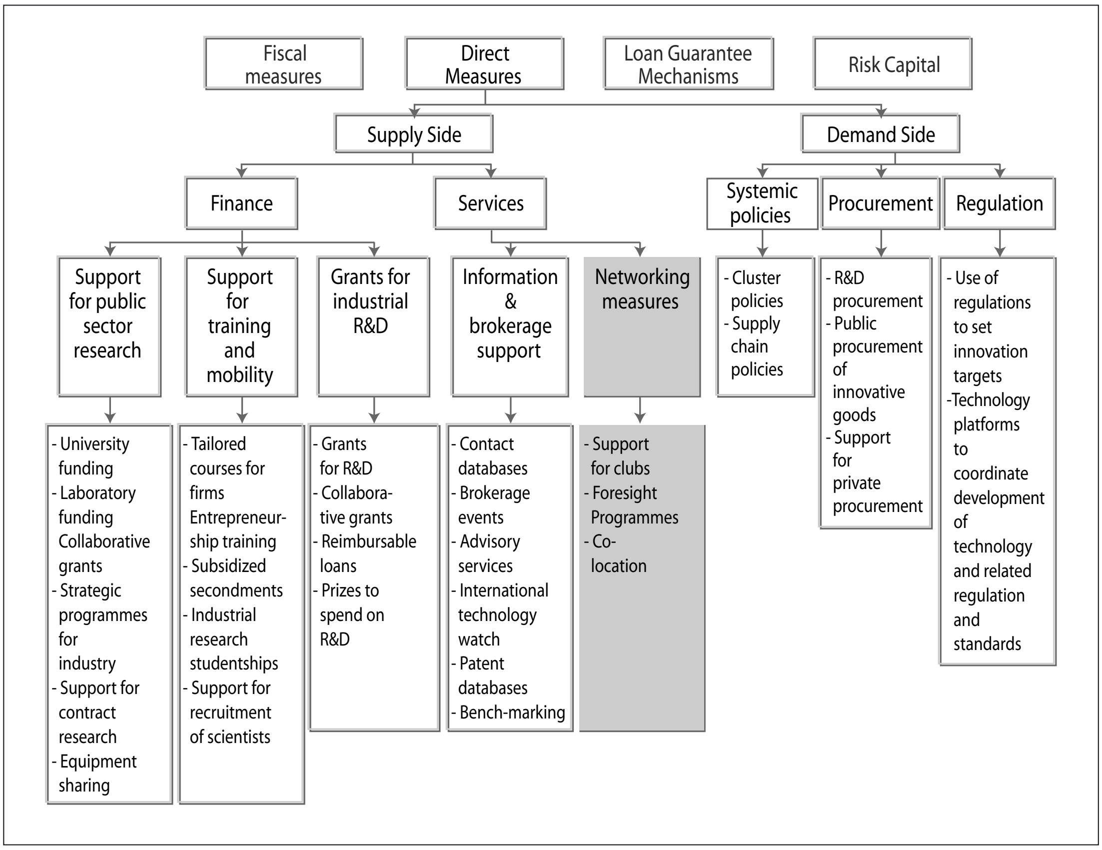
Source: Georghiou, L. *PREST* (2003).

In this mature stage foresight can be examined as an innovation policy instrument. There is a need to strengthen and be strengthened by combinations with other policies. Figure VI, from a current European policy exercise, illustrates how foresight sits in the array of available instruments but does not show how it can be used to enhance a range of other measures when used in combination. Particular opportunities exist on the right of the chart that depicts demand-oriented innovation policies. These are effectively packages of policies. Hence grants and other measures can be used to incentivize the formation of new clusters or technology platforms. In each of these cases the building of a specific common vision shared by the potential participants would be an important step. The same applies to the use of procurement policy driven by public sector.

In the light of the considerations discussed above one can begin to see what the emerging fourth generation of foresight might look like. Those engaged in foresight are well aware of the dangers of extrapolation and this is salient here. The signs are that the next generation is changing not in its methods or basic rationale but rather in its situation. As already mentioned, technology foresight as an instrument of national policy is approaching maturity. What we are now beginning to see is a trend towards a distributed model of foresight in which the activity becomes embedded at multiple levels with-

Framework conditions: Science base—contract research—human resources IPR—state aid regulation

Figure VI. Improving the effectiveness of direct public support measures to stimulate private investment



Source: Georghiou, L. *PREST (*2003).

in the system. This distributed model of foresight in some ways reflects the increasingly distributed nature of the innovation system in which knowledge acquisition by firms is as much about their ability to scan and draw upon outside sources of technology and to manage partnerships as it is about, internal R&D. The fourth generation seeks to play a linking role in the networked economy through development of a common vision around which networks can coalesce. This role was anticipated in second-generation foresight and also is implicit in the foresight definition. However, the driver now is more likely to be self-organizing and bottom-up rather than part of a centralized plan.

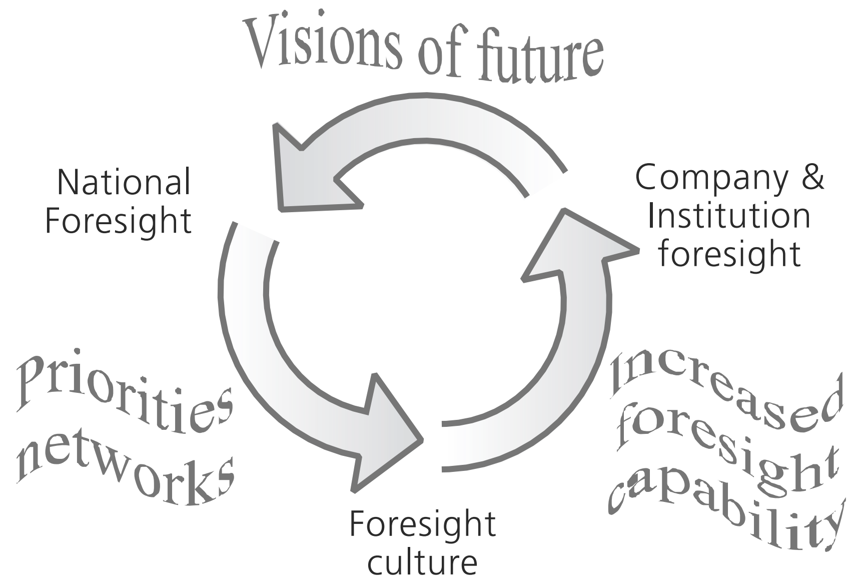
Broadly speaking, Europe operates under a system of multi-level governance that reflects the layers of government, with measures originating from local, regional, national and supranational levels and interacting with one another intentionally or otherwise. Each of these provides a potential setting for foresight, at present manifested most strongly in the regional foresight movement but not confined to it. As with the innovation actors above, foresight is now more likely to be originated by non-national levels than to be diffused to them. The motive for these actors is as much about diversity and competition as it is about coordination and complementarity.

Within the research system we also now see many foresight activities; in part this a rebranding of the natural tendency of research support, agencies and the communities of scientists to identify emergent themes and sub-fields and to formalize them as an agenda against which projects may be selected and funded. However, there is also a realization in these communities that their science needs to engage with socio-economic issues and public attitudes so the focus may be broader. Even at the national level, the UK has moved from a comprehensive or "holistic" approach of panels reflecting most sectors and latterly thematic issues, to one of selecting two focused themes each year and exploring these over a two-year period. Miles describes this as a move from a single "mountain" to a landscape with many "foothills of foresight". This strategy is, not new as it has always characterized the activities of the Netherlands, allows a focusing of resources but effectively abandons goals concerned with setting national priorities for research. Any prioritization takes place before the foresight begins in the phase of topic selection.

The European research area offers the possibility of a new setting for foresight. The new instruments of the sixth framework programme, the Networks of Excellence (NOEs) and Integrated Projects (IPs), are delegating a degree of financial and strategic autonomy to those parts of the community that they support. As self-organized units projects funded under both of these instruments they will require a vision of where their areas of activity are going. From personal experience it is clear that even preparing an application for an NOE requires a considerable degree of foresight in order to construct a research agenda that could engage some 200 people over four years. Integrated projects, with clear exploitation objectives also require a vision of where their context for application is going. Since both types of measure are expected to persist beyond the initial funding period it is to be expected that these visions will need to be updated and renewed from time to time. A more formalized approach to foresight embedded within the project may provide an appropriate means to do this.

What role for large national or supranational foresight? Revisit the virtuous circle of foresight?

Figure VII. The virtuous circle of foresight



Source: Georghiou, L. *PREST* (2003).

If analysis of the emergence of a fourth generation of foresight is correct, where does this leave the large national or supranational programme? It could be argued that these programmes have served their purpose and contributed to creating the conditions that have allowed distributed foresight to prosper, in this sense the “virtuous circle of foresight” model (figure VII) has been attained. However, that model also presumed that the increase in capability would sustain a new cycle of national activity. Some countries, Sweden for example, are proceeding to a new cycle at full national level. The answer to the question is probably that the integrated national or supranational programmes will re-emerge when there is a clear policy need for them. Foresight is associated with managing change in the research system, be it induced by technological opportunity, financial constraints (or growth), economic reform, the emergence of new structures and new alignments. All of these were characteristic of the 1990s. The present decade will bring its own challenges and the foresight community will have to be well-prepared to contribute to meeting these. Without wishing to engage in foresight it seems clear that innovation in public services (health, transport, security, water, energy) is a major challenge and one where no vision with a technological content is presently guiding policy. Foresight can be targeted on these challenges but it will need to be “innovation foresight” rather than “technology foresight”. This might be the first glimpse of the fifth generation! However, to succeed, an integrated role for foresight in policy and strategy is needed if it is not to be marginalized and treated as an academic exercise. The lessons from evaluation suggest that the process and implementation of foresight must both be constructed in the light of the government and company strategic processes it seeks to influence. Following from this, for foresight to improve it must be subject to rigorous evaluation and the evaluation must feed back into new design. Strengthened in this way, foresight can take its place in the array of conceptual and practical instruments available to the enlightened decision-maker.

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This module is based upon papers presented at a series of events arranged by UNIDO as part of a programme for Central and Eastern Europe and the Newly Independent States. Each paper is available in full on the UNIDO web site http://www.unido.org. The papers are:

1. *Technology foresight in a rapidly globalizing economy*, given by Ben Martin at the Regional Conference on Technology Foresight for Central and Eastern Europe and the Newly Independent States, Vienna, April 2001.
2. *Technology foresight: An Introduction,* by Michael Keenan at the Technology Foresight for Organizers Training Course, Ankara, December 2003.
3. *Foresight as a policy making tool* by Lajos Nyiri at the Technology Foresight for Organizers Training Course, Ankara, December 2003.
4. *Foresight: Concept and Practice as a Tool for Decision Making,* by Luke Georghiou, at the shaping our future: Technology Foresight Summit, Budapest, March 2003

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REVIEW QUESTIONS

1. What is your definition of foresight?
2. What are the main developments in foresight since 1990?
3. What do you think are the main lessons to be drawn from the history of foresight?
4. Why do you think different focuses of TF are important?
5. What are the major influences that have made foresight an important policy tool.
6. How might foresight be used to assist development in your country?
7. What do you think are the main difficulties encountered in evaluating foresight?
8. How you would approach the evaluation of a foresight programme?

Review question 3

- TF developed slowly at first in a few countries, notably Japan, but became much more popular in the 1990s.
- There are a variety of approaches.
- The process is often considered as important as the results.
- Several different methods that have been used by different countries.
- Foresight is an evolving idea.
- Developing a foresight culture may be most important.

Review question 4

- Because science and technology do not exist in a vacuum but within a wider context to which foresight is also relevant.

Review question 7

- Timing, particularly in longer term exercises.
- Should the focus be on output or process, or both?
- Differentiating the impact of foresight from that of other influences.
- Additionality, or whether the same results would have occurred without foresight.
- Whether the impact was affected by other things such as the relationship of the exercise to the policy cycle.
- Were the findings essentially self-fulfilling because of their relationship with the sponsoring organization?

Module 2

ORGANIZING A TECHNOLOGY FORESIGHT EXERCISE

This module provides guidance to assist you in organizing a TF programme. At the completion of the module you should have:

- An understanding of the issues that need to be considered in organizing a TF exercise.
- Ideas about how to approach these issues.
- An understanding of the use of expert panels in TF exercises.
- How to use them.

Before starting the module you should make a list of the issues that you think would be important to consider before embarking on a TF programme.

Contents

Figures

1. INTRODUCTION

The increasing number of foresight programmes suggests that it can be a useful policy tool in rather different national innovation systems. Emerging economies—faced with a number of challenges when trying to find their new role in the changing international settings, while still characterized by their own distinct level of socio-economic development, set of institutions, culture and norms—can also benefit significantly from conducting foresight programmes. Foresight has now reached a point at which different approaches can be compared to highlight "good practices': what has worked in certain circumstances (level of development, challenges and hence policy aims), and thus what set of tools and approaches are likely to be useful in different environments. In other words, foresight should be used in the context of adequate policy needs—actually, it can also contribute to identify/reformulate those needs. Its focus (e.g. purely technological, techno-economic or broad socio-economic orientation) is therefore largely determined by the perceived socio-economic and developmental needs. Further, its focus, broad objectives, geographical scope (level), themes, time horizon, methods and participation are closely interrelated, and thus a careful project design is needed to assure coherence among these constituents.

Consideration of the methods associated with organizing and managing a TF exercise is often hidden and forgotten yet these are crucial to the success of foresight. For example, how are participants identified and engaged in a TF exercise? Who decides on the areas to be covered and how is this done? And what methods should be used to do what? Such questions are largely addressed at the outset of a TF exercise in a process known as "scoping". In this module the process of scoping and its constituent elements will be explained. Accordingly, the module is divided into three main parts. The first deals with the process of scoping TF—why it is necessary, how it is done, and who to involve. The second section is more extensive, presenting a set of elements against which a TF exercise can be scoped. Twelve elements are presented in all, ranging from the starting point of an exercise through to consideration of policy intervention. Throughout, interdependencies between elements are discussed in order to show that choices made have consequences for other parts of an exercise. The intention is to provide a strategic framework (platform) that will allow the reader to construct coherent TF options.

In the final section, panels, as one of the methods used by many foresight studies, will be examined. It is included in this module rather than in the methods module because it is the organization and management of the use of panels which is critical. Panels frequently use other foresight methods in their deliberations; the use of panels may therefore be considered a meta-method in which more specific methods are incorporated as required.

2. THE SCOPING PROCESS

Deciding on what you want to achieve from TF, on who should be involved, on the areas that should be covered, on the methods to be used, etc. are matters for debate and negotiation within a process called "scoping".

What does "scoping" mean?

The term "scoping" refers to those processes of research and deliberation that contribute to the shape and timing of a given TF activity. TF can come in many shapes and sizes, and can be conducted over a long or shorter time period. Deciding on an appropriate design requires research into what others have done, consulting people on what could work in a given setting, and elaborating options (or scenarios) for the conduct of the TF exercise. The manner in which these tasks are carried out depends, to some extent, on the local circumstances. Nevertheless, it is possible to provide guidelines on the conduct and content of any scoping exercise.

Why is scoping necessary?

Scoping is important for several reasons:

- To review and perhaps pilot foresight options—there are many different ways to conduct foresight and setting out some of these options can be useful. In some instances, for example, where foresight has not been used before, it may be worth piloting some of the possible methods.
- To assess current and past arrangements—what is done already and what are its strengths and shortcomings?
- To assess requirements against capabilities—foresight exercises can sometimes be resource-intensive, in terms of human, social and financial capital. Not all foresight approaches are suited to all situations. Therefore, it is necessary to formulate a foresight approach that takes account of existing opportunities and limitations.
- To establish the need for any new structures or arrangements that will have to be put in place—existing structures and/or routines may not be readily adapted to the participatory and creative environments demanded by foresight. In such circumstances, new arrangements may need to be put in place.
- To generate a flexible (and responsive) blueprint for the exercise that uses the most appropriate methods—it is important for scoping to lead to an exercise plan that is responsive to changing conditions. Indeed, scoping should broaden options rather than constrain them, and should engender an understanding of interdependencies between strategic choices.
- To make the case for foresight—a well-written report that demonstrates an understanding of foresight and sets out the various options can be a powerful tool for

convincing others of the merits (and limitations) of undertaking an exercise. Moreover, because scoping is a process, it has the potential to accommodate participation from the outset, thereby engendering ownership of foresight early on.

How is scoping carried out?

Scoping TF involves three main tasks:

- Gathering background information—TF should not be undertaken without research into past and ongoing activities of a similar nature. Organizers may also have in mind a particular methodological approach, which again should be researched. Research typically takes the form of literature reviews through books, journals, reports, and web sites.
- Eliciting views and advice—more often than not, expert consultation is also relied upon—for instance, advice is often sought from practitioners involved in other similar TF exercises, some of who may come from abroad. But the target audience of a TF exercise, including those who might be expected to participate in the process and/or to act upon the results, will also need to be consulted. This may be done through scoping workshops and even open conferences, but more often than not, it first involves private bilateral discussions with key stakeholders. The aim is to gather ideas, obtain commitment of future support and participation, and to begin the process of securing buy-in to the results of the exercise.
- Articulating and presenting options—once background information has been gathered and views elicited, options for TF should be set out in some sort of report. This may be openly published, for example, as a consultation document, or may remain a private document to be circulated only amongst sponsors and key stakeholders. It should set the background and rationale for TF, highlight examples from other countries, regions, organizations, etc. (whichever is most comparable), and describe a set of possible options for TF. The scoping elements described in the last section provide one possible framework for constructing these different options. It could be recommended that three or four different exercise "blueprints" be generated using these scoping elements and used in further discussions with sponsors and key stakeholders.

When should scoping be carried out?

Some initial scoping will be carried out normally by TF "champions", mostly in the form of reading about exercises in other places but also through conversations with others who may share a similar interest. In other words, informal scoping occurs right at the outset of an exercise.

The formal scoping process, of which the informal is a part, involves gathering data, eliciting the views of stakeholders, and preparing options for foresight. It is usually done before any foresight activities get underway. Since some commitment of human and financial resources will be required to conduct a scoping process, the political decision to initiate an exercise may already have been taken, although this is not frequently the case. Instead, scoping often constitutes a sort of intelligence gathering to see whether TF is appropriate. The decision may be taken not to proceed with a TF exercise, and indeed, this option should in any case be considered in the scoping process.

Once a "blueprint" has been agreed upon, an exercise can be initiated. However, this "blueprint" will need to be responsive to its environment, i.e. adaptable to unfolding events during the course of an exercise. Thus, some sort of informal scoping process tends to be continuously operating during the conduct of an exercise. In some instances, this may even be formalized into periodic reviews that set the future course of an exercise at key stages.

Who is normally involved in scoping?

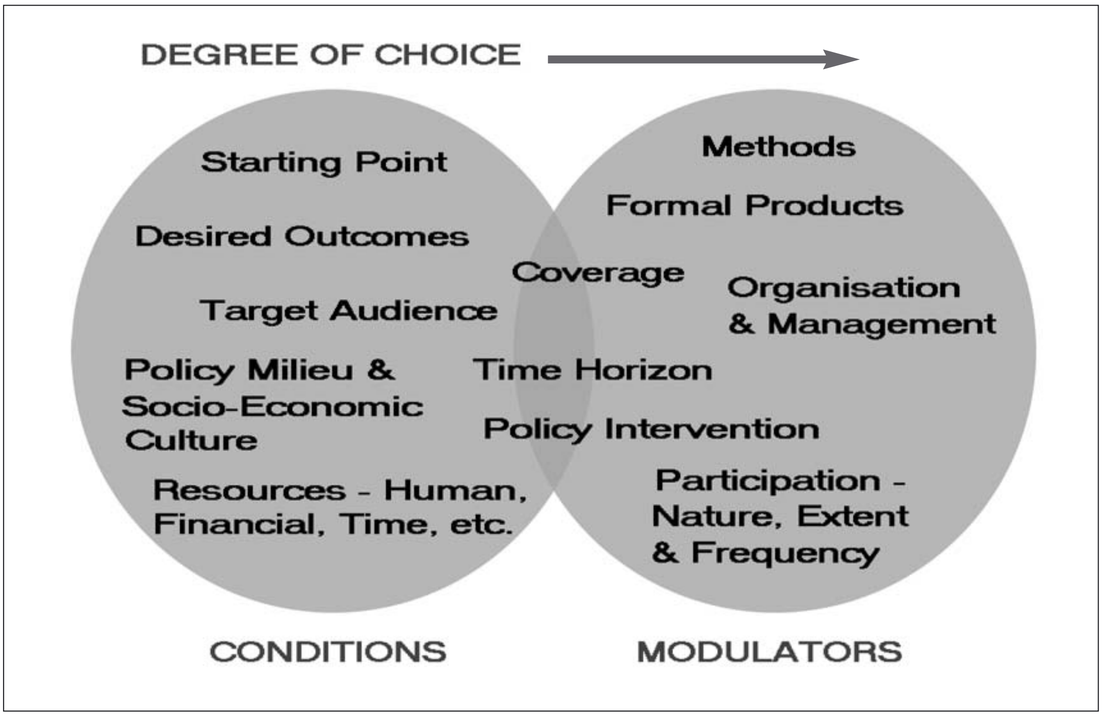
Whether the aim is to set up a process-based or a product-based foresight activity, one of the main features of foresight activities must be the active involvement of the various stakeholders from initiation and throughout all the stages of the activity. This is a core factor differentiating foresight from more narrow futures and planning approaches, and is an important determining factor in foresight's organization and management. This means that key stakeholders should be consulted as part of the scoping process.

As to who orchestrates the scoping process, this might be done by prospective sponsors and/or foresight "champions". However, it is not uncommon for consultants or academics to be drafted in to lead the scoping process, not least since they tend to be viewed as neutral players (although they may not be!).

3. THE SCOPING ELEMENTS

Below, 12 elements around which foresight can be scoped are presented. Most of these elements provide opportunities for strategic choice in foresight, although some of them will offer more or less room for manoeuvre than others, as shown in figure I. The elements on the left, the so-called "conditioners", are usually (though not always) predetermined and largely non-negotiable. These include the starting point of an exercise (national, supranational, sub-national, company, etc.), its desired outcomes (usually politically determined), and the available resources for conducting the exercise. They represent the conditions under which the TF exercise is to be conducted. On the right are the "modulators". These (usually) offer much greater scope for variation and include the methods to be used, the degree of participation, and the organizational structure of the exercise. Each of these elements is discussed in detail below.

Figure I. The 12 scoping elements of TF



Source: Keenan, Miles, (2003)

Starting point

Given the pervasiveness of technology in all our lives and the impacts of technological change on our cultures and societies, TF can be undertaken at almost any location of decision-making. Until now, it has been most prominent at the national level, with national governments in many parts of the world organizing wide-ranging exercises that cover several technologies. Such exercises are typically located in science ministries, research councils and/or academies of science. TF has also been used by international organizations, such as the European Commission (EC), e.g. the FAST programme during the 1980s and early 1990s, followed by the activities of the IPTS since the mid-1990s; and UNIDO since the late-1990s, e.g. the support for TF activities in Latin America. More recently, the subnational level has seen an increased interest in foresight processes, though much of this is not focused primarily on technology but on other issues such as business cluster development and democratic renewal. Subnational regions where TF exercises have taken place include the Basque region (Spain), Bordeaux Aquitaine (France), Lombardy (Italy), and Liege (Belgium). Non-governmental actors, such as professional associations and industry federations, have also been active in TF, with exercises on areas such as agriculture, the automotive industry, and aerospace having taken place since the late-1990s.

The starting point for TF tends to be largely determined from the outset by the institutional setting of any given exercise. All institutions are defined by the "levels" of governance at which they operate and the domain areas they cover. These defining factors institutionally "position" the TF process, and have a determining impact on the territorial levels and domain areas to be addressed. Nevertheless, even within these confines, there is normally considerable room for choice in an exercise's focus. To take a national health ministry as an example—it may decide to use TF as a policy-making tool, but could focus upon any one of hundreds of disease groups, or upon sites of a particular service delivery, or upon the implications of certain technological developments, e.g. nanotechnology. It may also decide to collaborate with other health agencies in its own country or even internationally. So, whilst the institutional positioning of TF has a large effect on its scope and shape, even here there is considerable room for choice.

Policy milieu and socio-economic culture

TF does not take place in a political, techno, or socio-economic vacuum. Rather, as noted above, it is positioned within an institutional setting. The term "institution" in everyday language refers to distinct bounded organizations that are easily identified. But such institutions themselves are situated in wider policy milieu and socio-economic cultures (themselves termed "institutions" in some political and sociological academic writings). These settings will need to be taken into account when designing a TF exercise. For example, it may be that a particular economic sector or policy area is characterized by extensive conflict between stakeholders—what implications does this have for TF in such an area? Similarly, other areas may be characterized by cosy relations amongst key stakeholders that might breed a certain degree of complacency. Again, what are the implications for TF in such a situation? To give a brief answer, in areas of conflict, TF should have the objective of *(a)* stretching perspectives into the future (if possible, beyond the reach of current disputes), *(b)* developing mutual understanding of and respect for different positions, and *(c)* laying the foundations for continuous long-term strategic conversations. By contrast, in areas of complacency, emphasis should be placed upon *(a)* introducing new perspectives and/or data that call into question current assumptions, and *(b)* instilling a sense of urgency (or even crisis) that demands immediate collective action.

Other issues that might be considered when scoping TF include:

- Cultures of collaboration;
- The presence or otherwise of a forward-looking tradition; and
- The presence of other policies and programmes that profess to take a strategic view of future developments and actions.

The latter can be especially important—a stand-alone TF exercise may not be an appropriate choice if there already exists such strategic programmes. Instead, it might be better to introduce foresight into these existing strategic processes.

Particular features of emerging economies may make foresight a useful tool in creating change

Quite a few pressures—especially the need to change attitudes and norms, develop new skills, facilitate cooperation, balance budgets—are even stronger in emerging economies than in advanced countries. Moreover, most of these countries also have to cope with additional challenges: the need to find new markets; fragile international competitiveness; relatively poor quality of life; brain drain. These all point to the need to devise a sound, appropriate innovation policy, and even more importantly, to strengthen their respective systems of innovation. Foresight can be an effective tool to embark upon these interrelated issues, too, if used deliberately in this broader context.

Foresight can also contribute to tackle yet another challenge of emerging economies: most of them are struggling with "burning" short-term issues—such as pressures on various public services, e.g. health care, education, pensions and thus severe budget deficit; imbalances in current accounts and foreign trade; unemployment; etc.—while faced with a compelling need for fundamental organizational and institutional changes. In other words, short- and long-term issues compete for various resources: capabilities (intellectual resources for problem-solving); attention of politicians and policy-makers who decide on the allocation of financial funds; and attention of opinion-leaders who can set the agenda (and thus influence discussions and decisions on the allocation of funds). These intellectual and financial resources are always limited, thus choices have to be made. A thorough, well-designed foresight process can help identify priorities, also in terms of striking a balance between short- and long-term issues.

Further, foresight can offer additional "process benefits". By debating the various strengths, weaknesses, threats and opportunities of a country posed by the catching-up process, and the role of universities and research institutes in replying to those challenges, the process itself is likely to contribute to realign the S&T system (including the higher education sector) to the new situation. An intense, high-profile discussion—in other words, a wide consultation process involving the major stakeholders—can also be used as a means to raise the profile of S&T and innovation issues in politics and formulating economic policies.

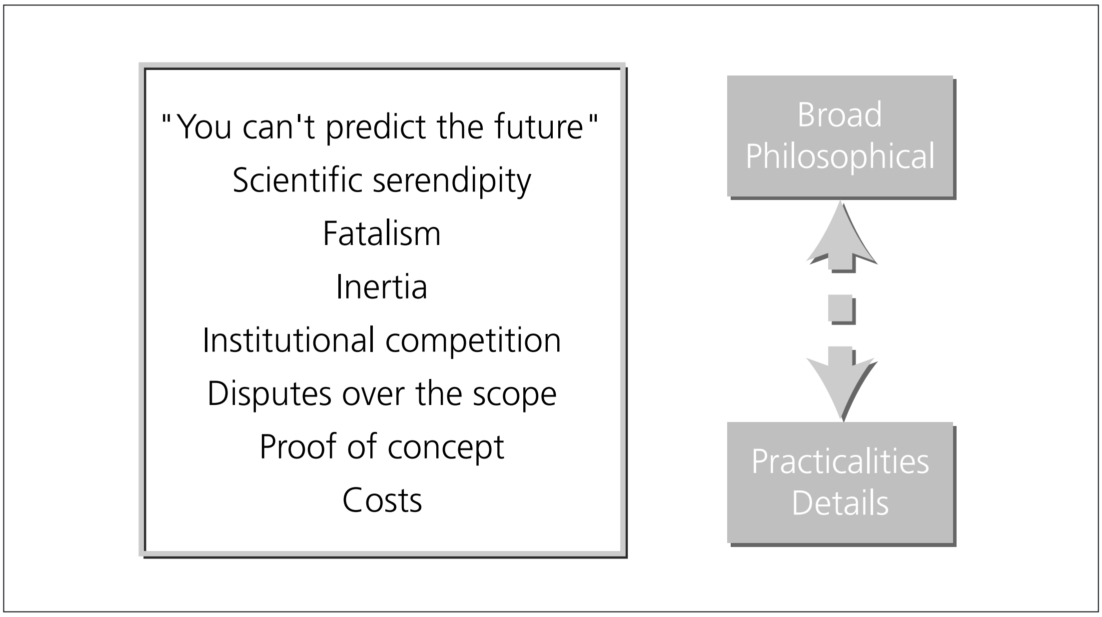
Barriers to foresight

A number of objections may be raised to foresight which may need to be dealt with during the preparation of an exercise.

Several barriers to initiating TF might be anticipated, as shown in figure II. These range from broad philosophical objections to more practical and down-to-earth difficulties.

The first objection, "you can't predict the future", results from a misunderstanding of foresight, which is not about predicting the future. Rather, foresight is concerned with anticipating a variety of possible futures. It is also about creating desirable futures through the actions we choose to take today.

Figure II. Some of the barriers facing TF



Source: Keenan, Miles, (2003)

The second objection is centred on scientific serendipity and is somewhat related to the first. Here, it is argued that we should not try to direct the course of science since we can never know in advance what benefits might accrue to society from scientific discoveries further down the line. Lasers are often cited as a technology discovered decades ago with few initial applications but that are now widely used in thousands of products and processes, from consumer electronics to military hardware. As in the first objection regarding prediction, this argument against using TF is also flawed:

- TF has never been used to prioritize all of the scientific enterprise of a country. Rather, it has been used to identify emerging (often interdisciplinary) areas of research that hold promise for socio-economic and scientific developments. Such areas of research are often overlooked by the traditional disciplinary organizations of science.
- Most science is funded through public taxation or shareholder profits and should be accountable, just like other areas of expenditure. In other words, science should be able to at least demonstrate promise, if not immediate worth.
- Something that is often missed by proponents of the serendipity argument is the fact that TF can help science and technology better connect to the socio-economic goals of public and private actors. This can be especially important under conditions of severe fiscal constraint when science budgets may come under threat.
- Finally, who is to say that the science supported as a result of priorities emerging from a TF exercise will not result in similar widespread applications as the laser? The real issue underlying the serendipity argument could be one of control—who sets the direction of what scientists do, the scientists themselves or society? In fact, TF does not force us into such stark choices. Rather, it provides an additional forum

where scientists can discover new ideas and opportunities from other scientists and other social actors.

The third objection to foresight is informed by a fatalistic view of the world that basically equates to a hopelessness for intended action to make any difference. Many countries, regions, and communities exist under appalling conditions of dependency upon those who are stronger. For example, the strong set the terms of global trade, often at a disadvantage to the weak. Although these structural impediments to self-determinacy are real enough, they can also lead to a semi-mythical helplessness that seeps into the consciousness of individuals and the routines of bureaucracies, which in turn breed inaction and even corruption. Under such conditions, a collective social activity like foresight may appear irrelevant and difficult to initiate. But foresight could be a first (admittedly tentative) step in better understanding dependencies, in initiating strategic conversations between key actors within society, and in agreeing and acting upon collective solutions. The role of foresight "champions" with authority and vision could prove decisive in whether foresight is initiated and effectively implemented. Alone, foresight is unlikely to have much impact, but when organized in tandem with other broadly-based emancipatory policies, it could make a real difference.

Linked to a fatalistic view of the world is the view that things will carry on as they always have without the possibility for enacting change—a sort of state of inertia. Here, political systems (in the widest sense of the word, to include, for example, national science regimes) are believed to have a certain (often bureaucratic) logic of their own that defy change and reform. There are undoubtedly elements of this in all political and administrative systems, whether in the public or private sectors. However, such challenges can be particularly acute in autocratic systems with little operational transparency. Again, there are no easy solutions here—the role of foresight "champions" is likely to prove decisive, and there will be a strong need for foresight to introduce a sense of crisis within such systems. The latter can be achieved in part through benchmarking with competitors, trend extrapolation, and the use of scenarios.

The fifth barrier to TF—institutional competition—has been observed in countries and regions in Europe and Latin America, and even within the European Commission. This is where institutions compete to be the "authority" on and location of TF. Such competition can lead to open conflict and eventually to nothing being done, as has happened in one Central European country over the last three to four years. It is difficult to advise on such situations in a generalized way, but it is something that proponents of TF need to be aware of. The problem seems to be most acute under conditions of financial resource constraint where there may be competition to be the "owner" of foresight. Where finance is not a problem, there is nothing preventing several institutions from organizing their own foresight exercises, a situation commonly found in north-west European States, e.g. Denmark, Finland, and the Netherlands.

Linked to institutional competition is the sixth barrier—disputes over the scope of TF. The scoping process may generate intractable disagreements that could prevent or delay an exercise being launched. In such instances, the temptation might be to limit access to the scoping process, but this has the significant danger of excluding stakeholders who may prove to be key to an exercise's successful implementation. Again, it is difficult to provide generalist advice on such disputes, which will be specific to the given political situation. But it will be near-impossible to satisfy everyone, so disappointment and complaints should be expected.

The seventh objection centres on TF's "proof of concept". This refers to the evidence base that demonstrates the effectiveness of TF. Little evaluation of TF has been conducted that demonstrates its effectiveness. Moreover, the processes of TF remain poorly understood. Evidence of foresight's worth is therefore largely anecdotal and focuses mostly upon apparent success stories in other countries or regions.

The final objection—cost—is also dealt with more fully below. Just to say here that there were some planned TF exercises that were either scaled back or postponed due to the unavailability of necessary financial resources. When scoping TF, it is possible to generate project plans that demand different levels of funding. However, the limitations of cut-price exercises and the benefits of more extensive programmes should be made plain to prospective sponsors.

Target audience

Since TF should be a participatory process involving time and commitment from stakeholder representatives, activities must carry a stamp of approval strong enough to assure participants that they are engaged in a worthwhile endeavour. Such endorsement can be obtained in part by involving leading figures from science, industry and government. The foresight process should also be clearly explained, transparent and involve the key stakeholders. Moreover, there should be a commitment from the outset to follow-up and act upon foresight findings and outputs, otherwise stakeholders are unlikely to give the exercise a second chance. Similarly, care must be taken not to promise too much to too many players.

Communication is a key activity in TF. Arguments for a foresight activity, instructions on how to participate effectively, and dissemination and implementation of results—all of these involve communication to potential supporters, participants and users. Various tools can be used to promote widespread appreciation of, and participation in, foresight activities, including:

- Publications and traditional communications tools (databases, newsletters, etc.) aimed at widespread promotion of the activities to be carried out and, thus, identification of players interested in participating.
- A remote communications forum designed to disseminate information and promote the activities carried out and completed by foresight. Websites are being used to increasingly good effect in foresight activities, and can provide an important way of reaching people remotely.
- Initiatives aimed at encouraging participation, such as conferences, workshops, and other meetings. These may be mainly oriented toward dissemination of decisions already taken and preliminary results, or they may constitute more active consul-

tation as to the aims and activities of TF. They may be tied to the actual work of foresight in terms of generating visions and gathering knowledge. It is often helpful to work together with specific intermediaries and sectors of activity (academies of science, trades unions, research centres, industry associations, government ministries, etc.), whose aim is to encourage participation and promote a more active and knowledgeable involvement among their members or clients.

- Illustration of foresight "success stories" in organizations and/or areas characterized by similar problems and objectives.

The communication tools used will depend upon the target audience for the TF exercise, but most of those listed above are likely to be useful in any instance.

Desired outcomes

What are the arguments for conducting foresight? These will be dependent upon the organizations (especially the sponsor) and communities involved. Rationales for TF will tend to emphasize how things can be done better with the help of foresight. They may also point to other places or areas where foresight has been successfully deployed as exemplars.

A sense of social or political crisis, or the anticipation that break points are undermining established trends, often gives rise to demands for foresight (and/or similar strategic futures activities). It can be helpful to interpret the situation in terms of challenges, and to identify the critical challenges that should set the main thematic orientation of the foresight exercise. But there must be a good measure of shared agreement as to the nature of these challenges established at an early stage in the foresight activity. Once the challenges have been identified in broad terms, then it is important to consider the extent to which the organizations involved in foresight, be they public or private, are able to influence or respond to such challenges:

- Some issues are best addressed by the private sector. But this does not preclude public administration from leading or facilitating a foresight exercise, for example as a forum helping private businesses reach consensus on what actions they might need to take around particular technological developments.

- Other issues will have a global reach and therefore the crux will be to identify the appropriate perspective to take, and to consider how foresight considerations might be linked to these broader plains.

- The challenges to address may be highly pertinent to a particular organization, country, etc.—but the political competence to deal with the issues may or may not reside in that organization or the state, and other players will have to be brought on board very early on if the chances of connecting to critical users are to be maximized.

These are just a few of the considerations to bear in mind. However, the underlying questions of competence, prerogative and authority, are absolutely vital, and should inform the objectives of a TF exercise.

Objectives tend to exist at several levels—for instance, an immediate objective of those managing a foresight exercise is its smooth execution. But there will also be higher level objectives that relate to the rationales offered for conducting foresight, so formal objectives tend to be dictated by the organizations and communities involved. Of course, objectives may shift over time and it is not unusual for different actors to hold different objectives for a foresight exercise. Nevertheless, it is good programme practice to set verifiable objectives, i.e. objectives where it is possible to verify whether they have been met. All too often, this is not done, mostly because TF is new to many exercise sponsors and managers and they are unsure of what to expect.

Foresight processes have different objectives; but since foresight cannot meet them all specific targets have to be set. In the context of policy-making, the most important are:

- To enlarge the choice of opportunities, to set priorities and to assess impacts and chances.
- To prospect the impacts of current research and technology policy.
- To ascertain new needs, new demands and new possibilities as well as new ideas.
- To focus selectively on economic, technological, social and ecological areas as well as to start monitoring and detailed research in these fields.
- To define desirable and undesirable futures.
- To start and stimulate continuous discussion processes.

Of course, a single foresight activity or programme cannot meet all the objectives at once (although some make the mistake to try). There must be a clear focus on the objective of the specific process, and in most regional and national foresight cases, the major target is to identify the most promising issues in science, technology and education. These issues are identified to assess the priorities which get additional support from the regional or national governments or companies in which they are identified and selected.

Setting priorities does not only mean selecting the winners but also identifying "losers", those issues which decrease in importance and therefore will be less supported than others. When planning a foresight exercise, one has to be aware of the resistance of those persons committed to the "loser" subjects.

There are on the one hand foresight activities that are more result-oriented, here we often find the priority-setting question. Others are more process-oriented, trying to make people aware of certain developments. These are on the other hand often less result-oriented, therefore, we find less priority setting in these cases.

One warning: setting priorities is not easy. In only a few cases, can pure statistics be used. A mixture of clear methodology and policy-decisions are the reality. Thus, even if the outcome of a structured foresight is a clear list of priorities, that does not mean the proposals are adapted by the policy-makers. This can sometimes be confusing—even disappointing for the managers of such processes.

Resources

The resources needed for TF are often equated with finance, yet this misses the whole picture. Besides financial resources, the scope of a foresight exercise will be dependent upon other resource factors, such as time, political support, human resources, institutional infrastructure, and the culture in which the exercise is embedded.

- *Financial resources*—the cost of a TF exercise depends primarily upon the nature and scale of involvement of participants and its duration. Obviously, the shorter the exercise and the fewer people involved, the cheaper it is likely to be. The financial burden of foresight activities are typically borne by a wide range of players, not least by the participants themselves, who usually provide their thoughts and time for free. "Official" sponsors can be from the public or private sectors, as well as from the "third" sector (e.g. trade unions, voluntary groups, etc.). It is not unheard of for foresight to be co-sponsored by all three (figure III). As for costs, little indicative financial data exists on foresight exercises in general. Core, and usually centralized financial costs are most likely to result from such elements as:

  (a) The running of a project management team;
  (b) The organization of meetings and events, travel and subsistence of at least some of the participants (some participants may even have to be paid to give up their time for the foresight exercise—this is uncommon, but in some places, it might be necessary);
  (c) The production and dissemination of publicity material;
  (d) The operation of extensive consultation processes (e.g. questionnaire surveys); and
  (e) Other activities, both routine and one-off, associated with an exercise.

Figure III. Examples of sponsors of national TF exercises

Exercise	Sponsor
Delphi Report Austria	Federal Ministry of Science and Transport
Norway 2030	Ministry of Labour and Govt Administration
French Key Technologies 2005 exercise	Ministry of Industry
German FUTUR project	Federal Ministry of Education and Research
Dutch Biology Foresight	Royal Netherlands Academy of Arts and Sciences
Portuguese Engenharia e Technologia 2000	Three sponsors from business, science and engineering
Swedish Teknisk Framsyn	Three sponsors from industry and strategic research bodies

Source: Keenan, Miles, (2003)

- *Time*—this is nearly always a resource in short supply in TF. Whether a public or private sector exercise, the results of foresight are usually required by a particular date to feed into policy and/or investment decisions. Typically, national TF exercises take one to two years to complete, depending upon financial resources and political imperatives. Private sector exercises are normally shorter, mostly on account of being more focused. Clearly, the available time for an exercise will have major implications for its organizational structure and the overall methodology. Foresight can also become a "continuous" activity, perhaps in the form of a continuous horizon scanning activity or as a "rolling" programme of mini-foresight exercises focused upon targeted areas.

- *Political support*—without the support of those in authority, TF is unlikely to get off the ground, let. al.one make a difference. It is therefore essential that foresight receives political commitment throughout the lifetime of an exercise and, importantly, is seen to receive such commitment. Political commitment can be demonstrated in a number of ways, for example, through institutionally locating an exercise at the heart of power (e.g. in the Prime Minister's office, within Parliament, etc.). More modestly, it can be helpful if someone in position of authority (e.g. a government minister or company CEO) opens and attends workshops and conferences.

- *Human resources*—TF requires domain expertise in the areas under consideration, as well as expertise in the use of foresight methods. Dealing with the latter first, in almost every country on earth, some expertise in using some foresight methods is present. Much of this expertise can be found in state planning departments and universities. However, it is more than likely that these methods have been used in forecasting, which is a rather technocratic practice, as opposed to foresight or strategic futures, which are more participative processes. The implications of these different settings should not be under-estimated, since forecasting experts often fail to understand the differences with foresight and may not see the value of participation and public deliberation. It is therefore typical for less experienced actors to become involved in facilitating foresight, and these tend to gain their expertise through trial and error, as well as through international learning (e.g. through the use of international advisors). Moving on to domain expertise, TF should be informed by the best available experts. In some countries, regions, or companies, this may mean looking outside for such experts. But if such expertise is unavailable, then the focus of the TF should be reviewed.

- *Infrastructural resources*—these refer to the existing institutional landscape around a given area, such as research councils, academies of science, universities, science ministries, professional associations, industry federations, consumer groups, banks, etc. In other words, infrastructural resources refer to the organization and network capacity of potential stakeholder groups in a given area. In virtually all countries, there will be an institutional "thickness" in some areas but less in others. In a general way, the implications of such "thickness" are unpredictable. For instance, a rich institutional landscape can greatly smooth the way for foresight, providing useful data inputs, knowledgeable participants, and forums for dissemination and implementation of foresight's findings. But institutional "thickness" can also act as a barrier to foresight—institutional rivalry is not uncommon whilst institutional worldviews may be rather static and difficult to openly question. Moreover, an exercise is far more likely to be subject to intensive lobbying by well-organized groups of interests. Appropriate strategies for dealing with such opportunities and threats will have to be informed by a deep understanding of those areas to be covered by the foresight exercise. The foresight exercise should then be designed in such a way as to be responsive to different institutional landscapes.

- *Cultural resources*—these refer to a rather ill-defined and broad set of conditions that are likely to have an important impact on the conduct of TF. They include the propensity to take risks, the extent and degree of collaboration between industry and academia (as well as between competitors), and the extent to which actors already understand and position themselves vis-à-vis the long-term. It would seem that some countries and some industrial sectors are endowed with more favourable cultural resources than others. The same may also be said of some areas of science and technology. Again, the implications for TF are rather difficult to spell out in a generalist way. But where such resources are largely absent, foresight should aim to begin the process of building them.

Coverage

It must be recognized from the outset that it is impractical to set out to cover all possible themes and/or sectors in any given TF exercise. This means that some sort of selection is inevitable. Yet how such selection has been made in existing foresight activities is rarely made explicit. Methods ranging from "recycling" existing strategic priorities to undertaking SWOT analyses have played an important part. Even fads and fashions probably play a role here, as in many other organizational decisions. Lobbying by interest groups is another influence. A review of national TF exercises conducted in the last decade show a commonality in the areas covered, with ICTs, transport technology, biotechnology (primarily applied to healthcare and agriculture), nanotechnology, and energy ttechnology featuring in almost all such exercises.

The definition of areas to cover should be a process where consultation of key regional players is likely to pay dividends, both in identifying themes of concern and through increasing the likelihood of commitment to later stages in the exercise. Nonetheless, difficult decisions will perhaps have to be taken when there is demand for more themes and/or sectors to be addressed than resources or time will allow.

Time horizon

Foresight is centrally concerned with increasing the time horizon of planning activities. This is not just a matter of "stretching" existing horizons, extending familiar planning and intelligence-gathering into a longer-term future. A major point about the longer term is that it brings into relief trends, countertrends, and possible events that are of limited concern in the short term. Such developments may well not be crucially important to one's immediate prospects—but if they are not taken into account until the problems start to be highly manifest, then it may be too late to adapt effectively, or the costs of coping with change may be higher than they would be otherwise. Consider, for example, the question of developing a base of skills to cope with economic or technological change: this is often a matter that will require years to put into place.

Figure IV. Time horizons used in a selection of national foresight exercises

Time Horizon	National Foresight Exercises
5 Years	French Key Technologies
10 Years	Netherlands Technology Radar, Czech Foresight
15 Years	Belgium, German FUTUR, Ireland, Spain (OPTI)
20 Years	Portugal, Sweden, UK, Hungary
> 20 Years	Delphi Austria, Norway 2030, German Delphi studies

Source: Keenan, Miles, (2003)

In practice, the time horizon of foresight activities will differ considerably, since what is thought of as the "long-term" varies considerably across different issues and different cultures. The average time horizon for national and regional foresight exercises seems to be around 10 to 15 years, although it may be as long as 30+ or as short as 5 years (figure IV). There is some evidence that the time horizons adopted tend to be related to foresight's objectives and orientation. In other words, time horizon tends to depend upon the uses to which foresight is to be put. An apparent paradox of foresight is that whilst a long time horizon provides the opportunity to develop a broad vision, most players" expectations are for short-term policy and/or investment responses. In fact, there is no paradox here—foresight should be instigated in order to think about possible futures, with a view to changing what we do today for the better. Foresight is therefore about readjustment, in the present, to create more agile organizations, cultures, etc. for the future.

Methods

As some of the main methods used in TF exercises are summarized in module 3, they will not be covered here. Instead, how methods can be used together, both in parallel and in sequence, to constitute a coherent exercise, will be considered. To do this effectively, it is important to:

(a) Outline the key steps in a TF process, and
(b) Understand the requisite inputs, processes, and outputs associated with leading foresight methods.

The temptation with *(b)* is to classify methods according to some envisaged function (e.g. Graham May's foreseeing, managing and creating futures methods typology), or according to the sorts of outputs generated (e.g. quantitative and qualitative data, or explorative and normative futures), or according to their preferred time horizon. However, such typologies are often problematic, since many foresight methods are rather flexible and defy easy classification. Therefore some of the key steps in TF will be set out and possible methods that might prove useful will be suggested.

To begin, it is worth noting that consideration of foresight methodology should not be confined to approaches for thinking about the future, e.g. Delphi, scenarios, etc. Rather, foresight methodology is far broader, taking into account the important tasks of coalition building, project scoping, organization and management, implementation, etc.

When starting to think about the future, we need to achieve an understanding of the past and the present. This can be achieved through examining datasets, conducting literature reviews, benchmarking performance against that of other countries, regions, companies, etc., and eliciting the views of experts and other commentators (e.g. through surveys, interviews, and expert panels). This information can be analysed, synthesized, and consolidated into a baseline report of "where we are now and how we got here".

Quantitative datasets and qualitative trends can then be extrapolated into the future. Cross-impact analysis might also be used to better understand the interactions between key trends and issues. Wild cards and anticipated discontinuities can be introduced at this stage to generate multiple views of the future (scenarios). These may be informed by weak signal analysis, which in turn is dependent upon some form of environmental scanning and issues management. Where there is extensive uncertainty on future developments, as there is in much foresight work, methods such as Delphi, which rely upon the views of a cohort of experts, can be used to elicit expert judgement. Alternatively, causal models can be developed that explain some aspect of the world. Using such models, future time series simulations can be run (usually on a computer) to assess the impact of alternative developments in key variables.

Extrapolation of futures, as described above, is nearly always accompanied by normative approaches to thinking about the future. The focus here is on identifying and deliberating upon desirable futures. Common techniques include brainstorming, visioning exercises, creative imagery, scenarios, and futures workshops. Normative approaches tend to be more open to widespread participation, although by no means exclusively so. Attention to the visualization and presentation of results is also especially important at this stage.

Once anticipated and/or desirable futures have been visualized, strategies of avoidance and/or realization are typically developed using techniques such as backcasting and technology road-mapping. These methods tend to be highly participatory since the aim is to secure buy-in to the conclusions and recommendation of the TF by as many groups as possible.

To reiterate, many of the aforementioned methods can be used in a variety of ways. Selection of methods will depend upon several factors, most notably available time and financial resources, although increasing use of ICTs in these methods has the potential to lower time and monetary thresholds.

Participation

Who participates in a TF is a central concern of exercise managers, not least because of a perceived need to produce results that are widely considered to be legitimate, robust, and relevant, although the need to implement these results is also an important consideration, given the process benefits associated with foresight. Who participates depends upon other elements of foresight's scope, including objectives, orientation, the themes/sectors covered, and the intended audience. Some exercises are quite limited in their breadth of participation, both in terms of actual numbers and the types of actors engaged. Others, on the other hand, have set out to directly involve widely disparate groups, including citizens.

"Stakeholder analysis" has been developed as a tool for participatory planning, and involves listing stakeholders and attempting to identify their interests in the activity. One may attempt to infer from experience or available evidence, or to find out via interviews or even surveys, answers to such questions as:

- What stakeholders specifically expect of the activity? Are these realistic and well informed?
- What benefits might they experience, and how might these be affected by participating in the activity rather than leaving it up to others?
- How can this be communicated?
- What resources could or should stakeholders contribute?
- Do they have interests or objectives that might conflict with the activity?
- What are their attitudes to each other—are there conflicts to resolve or manage?

Broad classes of stakeholders should first be identified—a simple starting point is to consider the roles of scientist, governmental, non-governmental organization (NGO), industry, other professional, and citizen groups. It is important not to be too restrictive in identifying, for example, the sort of government department or firm that should play a role. Different levels (national, regional) and sizes of organization might be required. What is important is to recruit gifted individuals who are prepared to learn and share, and not just present their organization's official positions.

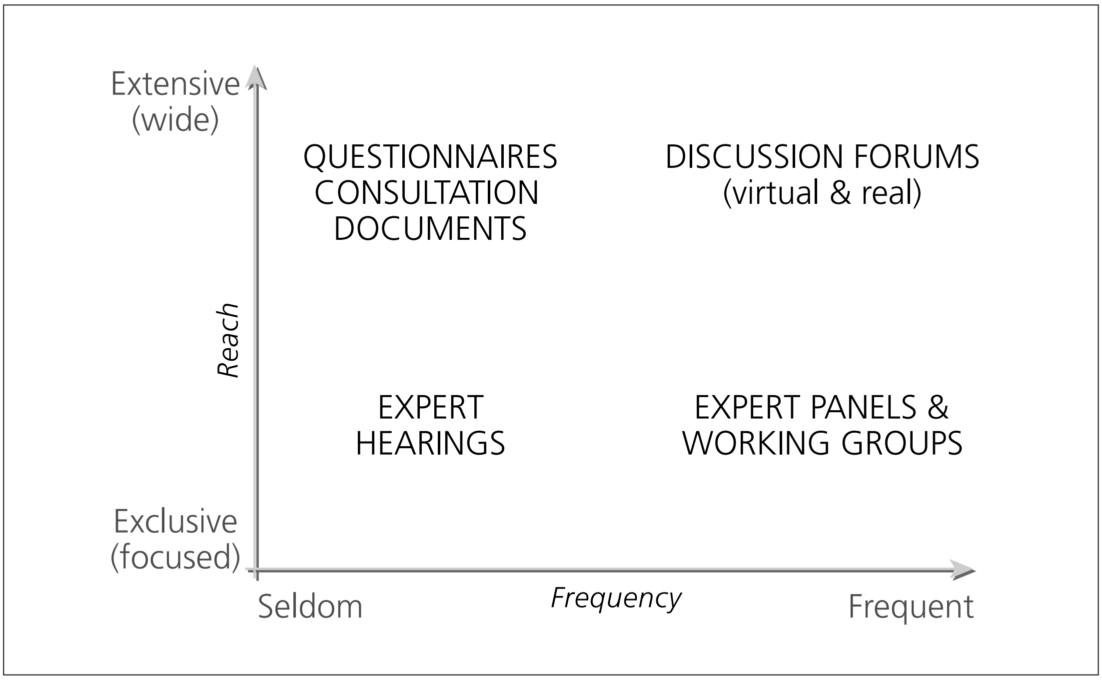
Methods for locating such individuals involve a search through databases and web resources, or seeking advice from other informed people. Representative approaches can involve asking scholarly, professional and industry organizations for names—but here it has to be stressed that the people sought are not to act solely as representatives of their bodies, rather they are being recruited to give a representative sample of opinion. Reputational approaches, for example, questionnaires asking informed sources to nominate particularly knowledgeable people in required areas of expertise (snowball surveys and co-nomination methods are particular versions of these) are also commonly used in foresight.

The more formal methods are important for reaching beyond the "usual suspects", but approaches such as co-nomination are time-consuming. Any methods can be limited by the choice of initial informed sources, so it is important to cast the net widely here. If the area under consideration is large, many new names may be generated by such approaches. In smaller areas, there may already be little to learn, since most players are likely to be already well-networked. It may be important to ensure representation of women (gender balance is often highly skewed in such activities) and ethnic minorities, people from regions, etc.

Identifying participants is, of course, only part of the picture—how they are actually engaged in the foresight exercise is of paramount importance. Such engagement can be thought about along two dimensions: the "frequency" of participation and its "reach" (figure V). Considering "frequency" first, an exercise might be largely desk-based with wider views of stakeholders elicited only seldomly at discrete points in the process. Alternatively, an exercise might largely constitute an ongoing dialogue or "strategic conversation" between stakeholders, with panels and working groups set up for an indefinite period of time to deliberate on the future of an area.

Moreover, it is often thought that the issue of participation is associated with only the elicitation of expert/stakeholder views on the future, for example, through Delphi or scenario workshops. However, there are a number of points in a foresight exercise where views might be elicited—for example, during the scoping process, during deliberation on the implications of foresight's results, etc. These can often be the most significant (yet often forgotten) consultation points, since they allow participants to make strategic choices about an exercise, which, in theory, should engender greater ownership of the process and its outputs.

Figure V. Methods of different styles of participation



Source: Keenan, Miles, (2003)

Who is to be consulted at each round of consultation is covered by our second dimension—"reach". A total pool of participants may be identified, but it is likely that different stakeholders will be engaged at different points of the process. In this respect, reach can be considered to be either "extensive" or "exclusive", with different methods typically used for different situations. Although there are no hard and fast rules for selecting any particular consultation approach, the choices made have implications for the credibility of the outcome of a foresight exercise, for the time needed for its completion, and for its eventual cost.

In terms of "how" to ensure wide and in-depth consultation, promotional activities, such as those suggested previously, offer opportunities to elicit views on the conduct of foresight. Moreover, many of the methods used in foresight require inputs (e.g. data, visions, etc.) from participants. In other words, foresight activities "naturally" offer a number of opportunities to consult stakeholders—it is up to project managers to decide how to take full advantage of these.

Organization and management

A structure for any foresight activity needs to be thought through, including the assignment of roles to working groups, panels, committees, sponsoring agencies, trainers, etc. The tasks assigned to such parties are linked to the type of foresight planned. Common characteristics include, for example, the vital initial step of establishing a steering committee and management team. Many activities also make use of "expert" groups or panels that focus on particular issues. Thus, common organizational elements include:

- A steering committee that will tend to approve the objectives, the focus, the methodology, the work programme, validate the strategy and tools for communication, and help to promote the results. It will define/adjust the assessment criteria and review the deliverables. It will monitor the quality assurance process for the whole project. The steering committee can also be a key actor to raise awareness, mobilize experts, and to nominate them to various panels.

- A project team that will manage the project on a daily basis, with tasks such as:

  — Leading the project on a daily basis.
  — Maintaining regular contacts with the stakeholders and the steering commit tee to ensure that the project direction is maintained.
  — Keeping accurate records of costs, resources and time scales for the project.
  — Ensuring integration of Management Reports and their presentation to the Steering Committee.
  — Checking that the project maintains its technical objectives.
  — Ensuring that the project maintains its relevance to wider activities, initiatives and policies.

- Securing high political support early on, which demonstrates that the exercise is taken seriously. If key people are first targeted and won over, a momentum can be established. It would be helpful if "champions" or "ambassadors" could be enlisted early on to put forward the arguments for foresight. Such figures are vital to seeing projects through difficult times; but there are sometimes risks of rivalry (e.g. between agencies), or of divergent expectations.

- Expert work, which is more often than not organized around expert panels/working groups. Expert work is highly significant in terms of:

- — Gathering of relevant information and knowledge.
- — Stimulation of new insights and creative views and strategies for the future, as well as new networks.
- — Diffusion of the foresight process and results to much wider constituencies.
- — Overall impact of foresight in terms of follow-up action.

The mechanics of setting up these groups need to be thought through very carefully, since their membership will influence the whole exercise. Moreover, the management style of these elements will need to be defined—for example, will working groups be given the freedom to make many of the decisions associated with methodology for themselves? (This is a definite possibility if the exercise is to be sponsored by more than one organization.) Alternatively, a central project team or steering committee might define the terms of conduct to be followed (this is more common). Tasks and responsibilities will have to be assigned to the different groups appointed.

Setting up simple tools that allow the project team to monitor the foresight exercise constitutes what is now considered good practice in project management. Monitoring consists of continuously observing and ensuring that the resources foreseen for each step are used effectively as defined in a project blueprint; that work schedules are respected; and that outputs actually materialize. It will help the project team to control and focus the implementation of the project. On-going monitoring involves:

- Observing the activities undertaken during the implementation of each step in the project in order to compare them, in real time, against the targets set.
- Continuously adapting the project plan to its environment. As new knowledge is gained and stakeholders are activated, the vision or process of the foresight exercise may need to be altered: TF projects are not expected to be rigid.

The monitoring methodology should involve a set of selected indicators that are designed to provide relevant actors with specific and topical data that allow them to follow the course of the project.

Formal products (including processes)

Many commentators have noted a fundamental distinction between contemporary TF exercises in that national programmes may stress products or processes, or seek to synthesize the two. Product-oriented approaches are generally oriented toward achieving tangible outputs, such as reports embodying a scenario; a “critical list” hierarchy of priorities (e.g. areas for R&D expenditure) or of key technologies, a Delphi report, etc. Such approaches often involve small expert groups, and/or highly formalized methodologies for eliciting and combining expert opinion (most notably, Delphi). French and German national exercises have taken this form, for example. Tangible outputs are often what some people refer to as “codified” knowledge, in that the knowledge generated through the process has been turned into information that can be circulated widely, without necessarily requiring face-to-face interaction.

Process-oriented approaches are more focused on achieving better networking and exchange of opinions among actors. The idea is that a shared focus on longer-term developments will help those involved to identify emerging issues and the carriers of relevant knowledge about these issues, to share understanding about each others' expectations and the strategies that are liable to be pursued, and to forge enduring networks for collaboration. The Dutch and the second UK exercises are examples. (There are also some regional level activities—for example in the UK's north-east—that focus almost exclusively on developing capabilities and institutional support for regional actors to undertake their own foresight, without the felt need for a central programme producing codified outputs.) Such "soft" outputs are more difficult to grasp, because these typically take the form of knowledge embodied in people's practices and approaches to issues. Though these may be harder to identify and quantify than documentation, they represent a very important aspect of the benefits of TF.

Mixed approaches attempt a deliberate synthesis of the above. The creation of products is seen, in practical terms, as a helpful device to encourage people to work together and network effectively. It also provides, more politically, a legitimating tool to convince auditors that money is being spent well. Furthermore, networking provides a wider range of inputs and this wider participation itself gives social legitimacy to the process. The first UK exercise is generally seen as a good example of such a mixed approach.

Figure VI. Some types of output from foresight

	Formal outputs	**Informal outputs**
Material for long-term reference and dissemination activities beyond those organizations directly involved in the foresight	Reports, books, electronic records (videos, web resources).	Networking with foresight activities and actors in other settings, etc.
Dissemination within those organizations directly involved	Workshops, newsletters, press articles, web sites.	Visions developed in workshops, results and evaluation circulating within networks.
Networking	Institutionalization of networks e.g. through formation of permanent organizations and meeting places.	Development of new networks or new links established within existing ones.
Strategic process	Formal incorporation of results within strategic processes, e.g. through use of lists of key priorities as a framework for assessing projects and plans.	Informal incorporation of results and knowledge of networks and key sources of knowledge, within strategic processes.

Source: Keenan, Miles, (2003)

Figure VI outlines some of the types of outputs that can be expected. In general, the outcomes of foresight activities are likely to address different audiences. In starting a foresight exercise, project managers need to be able to define who the interested groups are that might benefit from the outputs. Thus, and to reiterate, it is a useful (and essential) thing to involve members of various user groups in the foresight process. Members of user groups can help to define the targeted outcomes that should be foreseen for the various user groups.

How to set priorities

There are different structured and less structured methods of setting priorities. Some are listed below:

- Rankings from (Delphi) surveys.
- Analyses from surveys, simulations, extrapolations and other futures' studies votings (postal, fax, electronic: online, offline, etc.).
- Listings according to a set of criteria (group work, panels, expert consultations, interviews etc.).
- Consultation of single experts (open interviews etc.).
- Panel sessions with discussions.
- Workshops with different stakeholder groups.
- Structured interviews.

Among the methods for priority-setting are two types: the first type is based on more or less structured data, the second on person workshops and discussions. Although the manager of a foresight process often assumes that with a clear input from a data set, a clear list can be derived and therefore clear priorities can be set, the reality is a mixture.

To make rankings from surveys is relatively simple, but they have to be adapted for implementation. If the different actors who are supposed to be active do not accept the list, these rankings are useless. Therefore, in most cases, the actors are already involved in the process as such. In other cases, some actors make their own decisions on priorities based on these lists: the list is the start of the decision-making process, but not all of the "priorities" of the list (the high ranks) are taken up.

In all cases, to provide a certain transparency of the process, a clear set of criteria has to be developed. In surveys, these are formulated as questions; in Delphi studies they are inherent in the questionnaire design. There are many possibilities of formulating the criteria. They all derive from the objectives of the foresight exercise. Figures VII and VIII show some different examples.

The criteria can be applied in a voting procedure during a workshop (e.g. by giving points to the issues to be selected), by just discussing or in a more formal voting procedure like a survey or (online and offline) voting. The criteria can even be weighted, e.g. for a specific objective and purpose, one criteria is weighted higher than another one.

Figure VII. List of criteria applied in the "Technologies at the Beginning of the 21st Century"

- R&D infrastructure
- Scientific and technological constraints on implementation
- Human capital
- Innovation expenditures
- Interest of enterprises
- National competitive position (status quo ante)
- Public interest
- International division of labour

Source: Cuhls, (2003).

Figure VIII. Criteria applied in the German "FUTUR", phase I

- Societal demand
- Focus potential
- Interdisciplinarity
- Relevance for research

Source: Cuhls, (2003).

As an illustration, in the German FUTUR, the criteria were even applied in different ways and at different steps of the process. One selection step took place in autumn 2001, when the focus groups were selected: 25 theme profiles were generated from the first FUTUR conference. Most of the groups and themes met the criteria mentioned above. As it was only possible to continue the discussion of 12 themes, a broad selection process was organized to select 12 profiles for a continuation of the discussion. For the selection, the following procedures were taken into account.

Voting of the participants: an online-voting was organized in the internal workspace asking for the opinion of the inner and outer circle members. Out of about 680 persons addressed, 154 participated in the process. The participants were informed via e-mail and entered into the workspace with a personal password. Each participant was able to vote only once. For the voting, an online-form had been prepared. The participants were asked:

- To select themes, which they considered most important for future research.
- To judge these themes by given criteria on a five-point scale.
- To vote on all of the 25 theme profiles, these should be further integrated into the process.

A workshop of BMBF divisions was organized with division and division heads as well as the project managing agency representatives. They voted on the similar criteria as the participants by giving “points” according to the criteria (stickers were put on the wall at the name of the field). Then, the Innovation Council was informed and gave a short statement on the themes. In a session with the consortium, BMBF division Z22, responsible for FUTUR, decided on 12 groups, taking into account the votes from the participants and divisions, as well as the opinion of their own representatives. On the basis of the different votings, the background information and the suggestions by Z22, the final decision was taken by the minister.

The second round of selection was necessary to reduce the number of the themes to be developed further from 12 to 5. As in the first selection round, the second selection was based on a variety of votes on the respective themes:

- Online-voting was set up in the workspace to ask the participants of FUTUR about their priorities and opinion. Some 332 people participated. The results were a Top-5-Theme-Ranking, a judgement on the importance of the themes as lead visions and an evaluation of the individual themes according to the criteria of “research perspective” and “societal demand”.
- The project managing agencies and specialist divisions of BMBF ranked the themes according to their opinion of relevance of research, the societal demand, the status of maturity of the themes and the possibility of political usability.
- The Innovation Council discussed the innovativeness and quality of the focus themes. As a result, the Council came up with the suggestion to structure the lead visions in a broad political context and frame them in “roofs” (resuming the strategic orientation of the research policy in a wider context, e.g. living better, healthier and longer) and “columns” (conceptualizable focal points which emphasize the societal demand and include a concrete objective and a new quality in the problem-solution process for which interdisciplinary actors are necessary due to the complexity).

BMBF, with support of the consortium, reviewed the different statements with regard to the FUTUR criteria. The final decision of the five favourite focus themes was again taken by the minister. Some selection decisions of the themes were accompanied by requirements, stimulating the group to emphasize their further discussion on certain focal points. In addition to the five favourite themes, it was decided to recover the theme “understanding thought processes”, which had been discarded during the open-space conference due to the lack of interested participants. But the topic was thought to be “very interesting” by BMBF, the project managing agencies, the Innovation Council and the consortium, so they established an additional expert group.

The lead visions were debated by the Innovation Council. It accepted four out of the presented five themes (Network World, Prevention, Understanding Thought Processes, Access to Learning) and recommended the theme "Intelligent Products" as a cross-sectional theme to the respective BMBF divisions. The theme "Understanding Thought Processes", which had been taken up parallel to the selected themes, was also approved as lead vision.

Who sets priorities?

There are different kinds of priorities. As explained in the previous section, there are different actors involved in different steps of priority-setting. In some cases, expert panels discuss priorities (e.g. in key technologies approaches), in others, the priorities are indirectly set by different participants in a survey directly. In most cases, a steering committee or the sponsor (company or policy-makers) has the last word.

The example of FUTUR is therefore very illustrating: Although there is participation in the development of the lead visions and the online-voting on the subjects, in the end, the Innovation Council and the minister herself have the last say, because the ministry is the major target group of the process and has to implement the results. In FUTUR, there was little discrepancy between the online-voting and the assessments of BMBF, and this therefore, this was not a critical point. But when power structures are involved, this can be very critical. Often, it results in methodological criticism—although the powerful parties just dislike the results. Therefore one should be careful to apply an explicable methodology.

In most current foresight activities, participants stem from different backgrounds ("participation" principle) to bring in new ideas and set different priorities. But it has to be clearly stated, where their power ends in order not to disappoint these people by evoking too many expectations. It has to be clearly stated and communicated who selects what, when, and with which criteria. Laymen can then accept that in the end a minister or a CEO of a company has the last word.

Even in processes with laymen and different participants, one has to be very careful of lobbying. In open discussion processes they are sometimes obvious, but not always. In policy-oriented processes, lobbies occur quickly on the spot. In less result- or less implementation-oriented processes, there are fewer lobbies. Delphi processes and other surveys try to avoid these lobbies by giving all participants the same weight when voting. This has other disadvantages, but makes people more equal. Dominant group leaders who emerge in physical open groups can be avoided. On the other hand, votings with uncontrolled samples (Internet polling, online-voting, etc.) can be dominated by lobbies when they mobilize and vote as often as possible.

The conclusion here is that the actors who set the priorities can be very different and range from policy-makers to laymen. Even their number is unlimited. If a survey with many participants is conducted and in the end, their vote is taken up directly, this is as much priority-setting as the single decision of a man in power. It is very important that the procedure of selecting the priorities is clear and can be communicated. One could even imagine leaving setting priorities to a machine (as seen in some science fictions), but then, it is totally unknown what is assessed in which way, and fortunately, foresight processes are based on people.

Various levels of priority-setting in foresight

It is also important to think of the level, the priorities are set for and at which they will be used. In a regional or communal context, people often know each other, and it may be easier to decide openly because there are not too many persons who could be involved. On the other hand, there are as many power games going on as at larger levels of decision-making. In cross-border regions the different administrative structures might be expected to play a role.

On a national level, this is more difficult: Here are many interest groups who have more power than ordinary people, therefore, it is more difficult to create "trust" in the decision and to get acceptance for it. What is also interesting are comparisons of the priorities set in different national contexts. Although the first impression is that all high technology countries set the same priorities, in detail that varies. Cultural aspects add to this differentiation.

If there is a sector or thematically limited foresight, there are also different levels: already established communities, who know the different opinions among each other agree more or less easily on the priorities. There are themes, in which no agreement can be expected at all (e.g. the field "energy" in Germany) and there are others which are internationally agreed upon (e.g. ICT developments).

Policy intervention

How are the results of foresight to be followed-up with action? This tends to be a neglected consideration, with project managers often overly preoccupied with getting the foresight process "right". Getting the process "right" can indeed increase the chances of successful follow-up action, but political awareness of the possibilities for follow-up action should ideally be considered from the outset. In most instances, successful implementation involves follow-up action by actors who may not have been directly involved in an exercise. This is particularly challenging, and it is probably wise to ensure that these actors have some sort of involvement in the process at some stage.

Action plans are common outputs from foresight exercises. These are simply lists of actions that should follow from the identification of problems and possible solutions through foresight. Action plans should not be "wish lists", nor should they simply specify end points and objectives. They should indicate actions and responsible agents ways of monitoring progress, and indicators with which to assess the degree of success attained ("verifiable objectives").

Considerable skill and inside knowledge may be required to formulate these in terms that can be accepted by decision-makers. Yet it is important to link actions to the people responsible for executing them, but at the same time avoiding setting goals that are unrealistic (either because of being too ambitious, or due to an absence of either political will or effective sanctions on the part of those responsible). Of course, successfully linking decision-makers with actions is more likely to be achieved if they have been involved in the foresight process.

Rather than (or in addition to) providing a list of numerous actions, it may be possible to incorporate a number of actions in a demonstrator project. This can be a highly visible instance of the application of foresight, and may arguably be particularly effective where technology or infrastructure issues are concerned. However, the time taken to establish a demonstrator, and for its impacts to become visible, may mean that the success of the demonstrator in increasing the visibility of foresight may be limited. There are also dangers of putting "all the eggs into one basket", as well as having people associate the foresight activity with only the demonstrator (this happened in the first UK national foresight exercise, where a competition for demonstrator projects distracted attention away from other important dissemination and implementation initiatives).

The outcomes desired from foresight may vary across actors—some may hope for a focus on certain types of work, others on particular sectors of the economy or on certain social groups, and so on. Some expectations as to outcomes can be unrealistic, in that they will be informed by too optimistic a view as to how great an emphasis will be placed on certain issues, how far decision-makers are liable to heed the inputs from foresight in dealing with such issues, and how rapidly to expect change.

For these reasons, it is helpful to have a clear notion of the sorts of benefit that can reasonably be expected. This needs to be conveyed as part of the foresight activity. It needs to be communicated by capturing relevant information, and putting it into a form suitable for stakeholders to examine. As the foresight activity proceeds and better understanding is gained as to what it can and cannot hope to accomplish, there may also need to be some modification of these expectations.

Arrangements should be put in place to obtain some measure of whether the exercise has met its objectives—a process known as summative evaluation. But the novelty of foresight, especially as applied to the areas of living conditions, working conditions, and industrial relations, means that some formative evaluation may also be useful. The latter is not so concerned with outputs and outcomes as it is with processes—a better understanding of these can be used to improve the conduct of future exercises.

Gaps in implementation can be very discouraging. These may occur where recommendations have been prepared, but there has been no mechanism to check on their follow-up; and where networks that were working productively have been allowed to dissolve. This is why this paper has stressed the need to link foresight to action: foresight is not a matter of free-floating visions. It is a participatory process for constructing better understanding of what desirable and feasible futures could be, and how different socio-economic partners need to work together to create them. This is a demanding task, and it cannot be achieved without serious inputs of time and effort from many parties. Perhaps the most crucial message in managing expectations is the following: foresight is not a quick fix.

Examples of how the results of the German Delphi '98 survey was used

When the Delphi '98 survey was finished, no strategic plans for implementation existed, although this was regarded as necessary. Money for "marketing" was not available. From the political aspect, it was mentioned that this "practical application" should be planned. Unfortunately, the report was published in pre-election times for the German Bundestag (parliament). This meant that political exploitation of such studies was extremely dangerous as many of the current problems and their effects always become obvious when looking into the future (e.g. the lack of personnel in the IT area, demographic consequences, problems in the health sector, the consequences of the unpopularity of expensive big science projects especially in the nuclear power field, and many others).

The election passed, and the new government this time was really a new one—representing different parties, persons, and opinions. It took time until the new BMBF was able to decide on follow-up activities in foresight. It was decided to start a new foresight process, FUTUR. Nevertheless, the work on Delphi '98 was not in vain. There were many different users of the data. Many were even unknown, as they worked more or less anonymously. It is not known who made what use of the two volume edition (around 10,000 were sold), the downloads from the Internet and the eight newsletters that dealt with special topics, themes or fields and were provided by BMBF to all interested persons, especially in schools.

The major users of the Delphi '98 were companies. Most of them selected those topics and fields in which they were active. They analysed these topics in detail and used the information for different strategic planning purposes, often with a more long-term perspective than usually applied. Some had working groups to analyse and discuss the data or even made further Mini-Delphi studies to gain more in-depth knowledge of the field. Others developed their own strategic high technology lists. For most of them, it was very interesting to know how others (companies or experts from the different kinds of institutions) rated their field. Did all agree? Or was there no consensus? Did the own company overlook certain problems? Where was the conflict potential?

It was especially interesting for companies to learn about fields at the borders of their own activities. They knew their own fields pretty well, but what if other products coming from different areas replaced their technologies? What happened if interdisciplinary research was conducted? What about technology combinations or fusions, or even the combination of production and services? What other frame conditions would change for the companies? For companies, these were the most interesting questions to be answered.

Research institutions and associations used the data similarly: for priority-setting, orientation and strategic planning. They also developed high technology lists for themselves, which were added to the traditional world market indicators. The associations sometimes provided their members with the results of their activities.

Summary

This section has sought to introduce some key elements in organizing a TF that can be used at national, regional or company/organization levels. These elements have already been employed widely in foresight exercises across Europe and underpin recent European guidelines on the use of foresight. It has also sought to raise awareness of foresight's limitations, arguing that expectations should be realistic. Planned appropriately, and with sufficient political support, TF can be a real force for good. But foresight is never easy, and those who wish to pursue the use of such policy instruments need to be prepared for the long haul.

TF should not be used if there is no possibility to act on the results that it will generate. "Wishful thinking" is not enough to sustain a foresight exercise: those involved are likely to feel that their expectations have been raised unduly, and their time wasted. A minimal degree of political, economic or cultural leverage is required—even if it is recognized that the foresight activity is likely to have to battle with entrenched opposition to achieve any significant impacts.

Nor is "me too" a good basis for TF. The simple imitation of issues and methods (not to mention the uncritical "borrowing" of results) from elsewhere is liable to be counter-productive. For example, a predominantly rural agricultural region or state cannot "foresight" its way to becoming a high-tech nanotechnology or even biotechnology hub. Neither can a foresight activity that has been designed for a region or state that is accustomed to wide public participatory debates necessarily be (immediately) deployed in one which public opinion is handled through more traditional routes—surveys, press, political party representation, etc.

If there is no possibility for careful preparation and tailoring of foresight to specific national or regional characteristics, then it probably should not be implemented. We should be explicit in acknowledging that foresight cannot solve all of the social, economic or political problems that beset a state, region or organization. Foresight can generate visions. Ideally, large elements of these will be shared visions, and ones that are well-founded on knowledge of the relevant developments in social or technological affairs. This ideal is not as utopian as it may at first seem: some national and regional exercises have succeeded in achieving quite widespread consensus behind their results.

But foresight is not a "magic wand" with which to impose consensus in situations where there are profound disagreements. Political discretion also needs to be exercised in cases where conflict is inevitable between certain sectors on highly contentious issues. Skills at mediating conflictual discussions are liable to be required! In some situations, unfortunately, there is a strong probability that the conflict-resolution powers of foresight methods will be insufficient, and that conflict may even be exacerbated by embarking upon foresight at this moment. In such cases, foresight should not be undertaken, or at least taken up in a very cautious way. Foresight may help find areas of agreement shared between opposing factions, but it can become mired in disputes between entrenched antagonists, especially when the focus of foresight is on topics that divide these groups—which will often involve issues of social welfare, governance, and the like.

Furthermore, and to reiterate, foresight should not be seen as a "quick fix". A foresight exercise may provide the information (e.g. a priority list) needed for a particular policy to be implemented. But the sorts of longer-term analyses that foresight involves, and the new networks and capabilities that it can forge cannot be expected to achieve results overnight. Often the processes of interacting around ideas of what opportunities might be seized, how particular challenges might be confronted, etc. will take a long time to result in widely-accepted notions of the way forward. The problems we wish to address have often matured over many years—effecting significant change is often going to require long preparation, and considerable groundwork to prepare people for the change.

4. USING EXPERT AND STAKEHOLDER PANELS IN TF—PRINCIPLES AND PRACTICE

Any review of TF exercises conducted over the last decade or so will show the almost universal usage of "expert" and/or "stakeholder" panels. These are typically collections of between 12 and 20 individuals who are given 3 to 18 months to deliberate upon the future of a given topic area, whether it be a technology (e.g. nanotechnology), an application area (e.g. health), or an economic sector (e.g. pharmaceuticals). Despite their ubiquity, there is surprisingly little in the foresight literature on the use of expert panels. Instead, the literature focuses upon the use of more esoteric methods such as Delphi and scenarios, presumably because the organization and management of expert panels is considered to be routine and unproblematic. Yet, years of advising TF programme managers in many parts of the world has demonstrated that the organization and management of expert panels is far from routine and unproblematic (Keenan, 2003). For example, practical and conceptual issues surrounding panel composition and the conduct of panel work are regularly raised. Therefore, it seems timely that some guidelines be set down on the use of expert and stakeholder panels in TF.

What are expert and stakeholder panels?

Expert and stakeholder panels come in many shapes and sizes. The common conception is of a "Bunch Of Guys Sat Around a Table" (BOGSAT), reflecting experiences in Europe and North America, where such panels are typically composed of white, middle-aged, middle-class, professional males who are considered to be "experts" in a given field. Such a panel normally consists of from 12 to 15 individuals and is mandated (usually by public authority) to use its collective expertise in addressing a particular problem or set of issues. Experts meet face-to-face, normally in private session, at regular intervals over a fixed time period. During this time, they use their judgement in interpreting available evidence. They report their findings, usually through a written report that is later disseminated and, in ideal situations, acted upon.

This is the "typical" model of a panel, but there are many deviations. For example, "expert" panels may include "lay persons". In fact, panels may not be "expert" at all (at least not in the traditional, professional sense of the word). Instead, such panels may be composed of "stakeholders", i.e. individuals (sometimes representing an organization) with a stake in the outcomes of the panel process. The practical life experiences of such individuals are typically taken as criteria for membership. Another deviation concerns the interaction of panel members, which need not be face-to-face. Indeed, some panels never meet at all. In such cases, interaction may be through the Internet or through a survey process, e.g. a Delphi. This also means that panel numbers need not be limited to between 12 and 15 members but can be much larger. Panels can also meet in public sessions, although this tends to be reserved for those instances where panels wish to consult with a wider public. Finally, panels can, in some instances, be constituted for an indefinite period of time. This often occurs where the desire is to establish an "independent" authority for dealing with long-standing challenges, e.g. global warming. Such panels report periodically, often on a specific topic or theme.

In TF exercises conducted over the last decade or so, "expert" panels have tended to be the norm, although there is now a discernible shift towards incorporating more stakeholder-type panels. This reflects a move away from science and technology oriented panels to ones that are focused upon business sectors, e.g. automotive industries, and policy challenges, e.g. ageing society. Panels have often been given very tight briefs, e.g. to arrive at *n* number of Delphi topic statements within *t* months. Once the brief has been completed, they are usually disbanded. Foresight panels typically meet face-to-face, although the Internet has been used in some cases. Sessions tend to be in private, with meeting minutes and background documentation often published. In many cases, panels produce their own published reports. Whether this happens or not largely depends upon the overall methodological design of the TF exercise.

Why use panels in TF?

TF is, by definition, a participative, discursive activity that should be based upon the best available evidence and judgement. These conditions make the use of (expert) panels a natural choice in the foresight practitioner's methods toolbox. Panels not only open up the foresight process to potentially hundreds of individuals, they are also ideal forums for in-depth discussions and debate. For these reasons, panels are the "process centres" in many foresight exercises.

The benefits of using panels in TF are manifold and widely acknowledged, as evidenced by their extensive use in foresight exercises. Some of these benefits include:

- Availability of expert judgement "on tap" at the centre of an exercise, which can be particularly important when dealing with the uncertainties associated with the future.
- In-depth and meaningful interaction and networking between different scientific disciplines and areas of expertise that would otherwise be difficult to organize.
- The ease with which panels can complement other methods used in TF. Indeed, with some methods, panels are a near necessity for the generation of inputs, the interpretation of outputs, and/or the overall conduct of the method.

- Credibility and authority lent to the TF exercise through the profile of panel members and the visibility of expert/stakeholder panels.
- The moulding of influential individuals (panel members) into foresight ambassadors and change agents in support of panel findings.

There are of course other well known “tried and tested” means of eliciting expert and stakeholder views, including the use of interviews/witness hearings and questionnaire surveys. Whilst these are likely to be cheaper to deploy and may take less time, they lack many of the benefits associated with the panels listed above.

Defining a panel’s mandate

Expert and stakeholder panels are commonly important components in the design of a foresight exercise, conducting specific tasks within a given time-frame. What these tasks are, how they should be done and by when needs to be specified, not least so that panel members understand what is expected of them. In addition, panels can be held to account against such specifications, thereby providing some leverage on their activities. However, before the mandate of a panel can be set, the rationale and objectives of the foresight exercise must be clearly understood and agreed upon. To achieve this, careful consultation with key stakeholders is necessary through a process of foresight scoping. The mandate and composition of expert or stakeholder panels should naturally reflect the scope of the foresight exercise in question. In this respect, the preparation of two documents can be foreseen:

- Proposals covering what the panel will do, why they will do it, and who (which experts/stakeholders) should be involved.
- Terms of Reference for the panels, setting out what they should do, how it should be done, and when it should be completed.

The proposal should be derived from the foresight scoping process. It should begin by covering the rationale for using a panel in the foresight exercise and should state the kinds of products and process benefits that are expected. Essentially, the proposal should include all relevant information that will allow sponsors, key stakeholders, and the project management team to see the technical approach, the plan of action, and the time (including milestones) and resources required to complete the work. It should also indicate the sorts of expertise that will need to be represented. In other words, the proposal should constitute a blueprint for executing the panel work.

The panel’s terms of reference document should draw heavily on the proposal, but will be directed at guiding the panel in its tasks. An example of the terms of reference used in the first UK TF Programme in 1994 is provided as annex A at the end of this module. It is a short and succinct document that is divided into four parts:

- Background, which provides some background on the UK TF Programme and the purpose of the terms of reference document.

- Description of each of the three phases of the programme, setting out *(a)* what needs to be achieved, *(b)* how the panel should go about its work, and *(c)* a series of milestones.
- Description of the way in which the panels' work fits into the overall programme.
- Account of the human, infrastructural (including training) and financial resources available to the panels in support of their work.

This document was distributed to all panel members in the programme and was used by the sponsor and project management team to monitor progress of the panel. Similar terms of reference have been used in other TF exercises.

Assembling a panel

Once the panel remit has been formulated, the task of assembling members can begin. The first step is to develop a profile of the panel, i.e. to identify the sorts of expertise and/or stakeholders that should be represented in light of the panel's remit. There are two interrelated considerations to take into account when profiling a panel:

- Composition—what mix of knowledge is required to address the panel's remit?
- Balance—what mix of views/positions/value judgements/scientific disciplines should be represented on the panel to ensure even-handed analysis and conclusions?

These are major concerns in TF, since panels must be perceived to be technically qualified and even-handed if the exercise is to achieve authority, credibility and legitimacy. It must, however, be acknowledged that panel members will bring their own interests and biases to the table and to pretend otherwise is unrealistic. Indeed, expertise in a given area normally means that an individual has some sort of stake, whether financial, professional, political, etc. in that area. With stakeholder panels, this link is typically even more obvious. Interestingly, there is little or no reporting of the effects of conflicts of interest or bias in TF panels in the literature. This is perhaps because very little research has been carried out on foresight panels. But it can also be attributed to the safeguards that are typically put in place in TF to prevent undue influence by vested interests, e.g. the requirement of verification of panel findings through wider consultation processes and the use of reference panels; transparency in the foresight process itself; and methodological design, which should encourage people to think "out of the box" and to leave organizational and/or professional affiliations out of the frame.

Nevertheless, some good advice on achieving balance is offered by the Royal Society of Canada in its manual on expert panels:

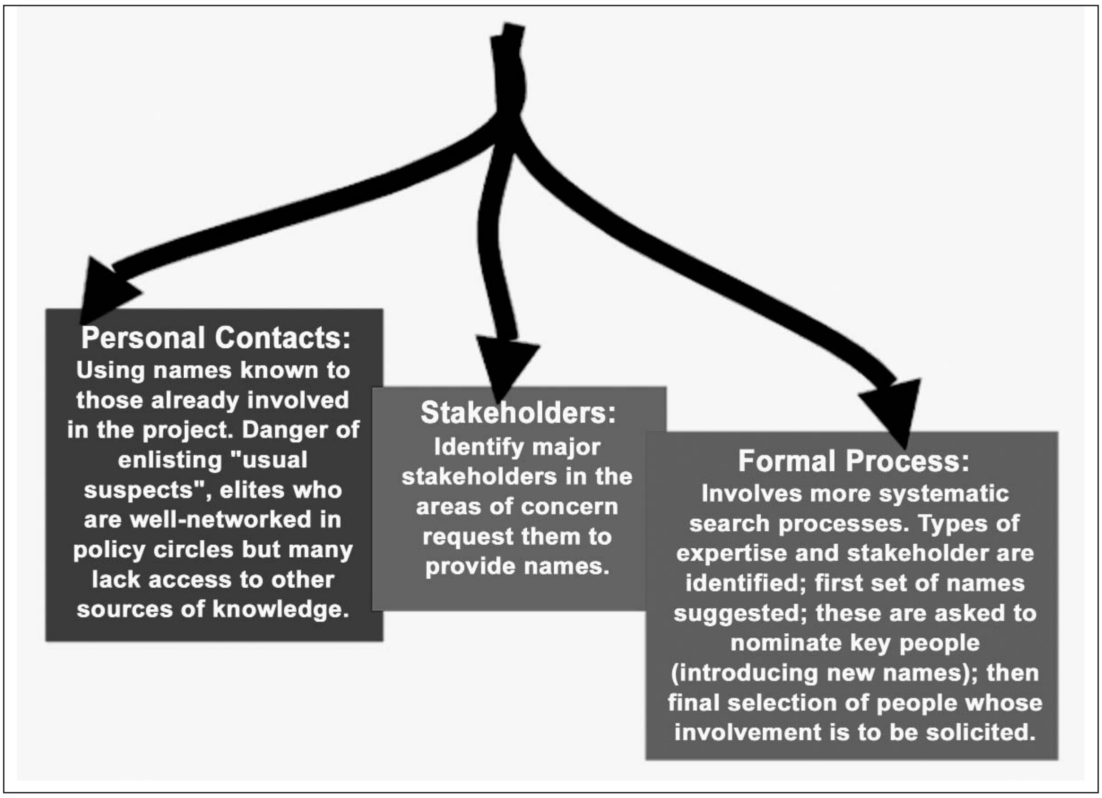
> "Sometimes balance can be achieved by having opposing views represented in the panel membership. In other circumstances, particularly when the opposing views are strongly held and not subject to a factual test, it can be better to seek members who are not strong proponents of the contending perspectives. The panel

> profile in such cases should aim for more balance in each member and rely on briefings, workshop presentations, etc., to bring forward the best evidence and arguments from the strongly opposed sides."

On a practical level, there are a number of approaches for actually identifying individual participants. In figure IX, these have been divided into "personal contacts", "stakeholder involvement" and "formal processes" (e.g. co-nomination, which is a form of snowball sampling). All three should be investigated for their suitability. It is likely that several approaches will be drawn upon when identifying possible panel members.

The initial aim is to generate a long list of candidates for panel membership. This list will then need to be cut down to a short list of primary nominees and alternates. As already mentioned, key stakeholders typically contribute to the composition and procedural design of expert panels, which helps ensure that those stakeholders will find panel results credible. Stakeholders include sponsors of the foresight exercise as well as those organizations that might be expected to act in light of the exercise's findings. But this panel shaping by stakeholders and sponsors may extend to the power of veto over panel membership, particularly over the key role of chairmanship. This is what happened in the UK National TF Programme, where the sponsor and a small number of interested ministries and research councils were essentially given the right of veto over panel membership lists.

Figure IX. Three ways of recruiting members and participants



Source: Keenan, (2003).

Clearly, having people on panels who are acceptable to organizations responsible for implementing foresight findings is important for policy impacts. On the other hand, some care needs to be taken to avoid situations where panels are composed solely of an elite of "usual suspects". TF should be about interaction between different communities, disciplines, and ideas. This aim is seldom best served by filling a panel solely with nominees from, for example, a sponsoring ministry. This is why many national TF exercises have used co-nomination approaches to broaden the knowledge base, by bringing new faces into the foresight process.

The co-nomination approach

The UK TF Programme in 1993 was the first to use co-nomination. Around 600 people were first identified through traditional nomination methods and their contact details entered into a database. A mailshot questionnaire was then distributed to this group, inviting them to *(a)* describe their own areas of expertise, and *(b)* nominate up to six other names who could provide relevant expertise to the foresight exercise. The new names nominated were then entered into the database and the same questionnaire sent out again. An average response rate of 40 per cent was achieved across the two iterations of the questionnaire, with 1,400 returned forms generating an additional 5,200 new names for the exercise. Of these, 17 per cent were nominated more than once, with multiple nominations an important (though not exclusive) criterion for the identification of panel members. Although the Programme Steering Group ultimately selected the Panel Chairs and Vice-Chairs, in 13 out of the 15 panels, at least one of these had been identified through the co-nomination exercise. Since the successful British use of co-nomination, similar surveys have been used in support of foresight exercises in many countries, including Austria, Czech Republic, Hungary, and South Africa.

When the shortlist is agreed upon, nominated individuals must be sounded out on their willingness to serve on a foresight panel. Such approaches are typically done by the project manager through a telephone call. During this initial contact, the exercise should be described to the nominee, explaining clearly why it is being carried out. The remit of the panel should then be summarized, indicating the key tasks and, most importantly, the time and effort needed. Evidence from past foresight exercises suggests that most people are flattered to be asked to serve on such panels and typically accept the invitation, especially if the exercise has a high profile and political backing. Those individuals that are unable to accept or those that are not approached to serve as panel members may be used in other parts of the exercise, for example, as recipients of questionnaires and consultation documents and/or invitees to workshops and other consultation forums.

A special mention should be given to the choice of panel chairperson. Two main criteria are typically used for selecting such people in TF—their profile and standing, and their time commitment. Having someone who is well-known and (more importantly) well respected in a given community (or even nationally) will provide an invaluable boost to a panel's work, lending it authority and legitimacy. People will be more inclined to respond to surveys and to read a panel report if the chair is well respected.

Unfortunately, many of the really good people are too busy to chair a TF panel, which requires probably at least twice as much commitment in time than being simply a panel member. However, it is not impossible to attract really good people but it does require a lot of effort on the part of project managers. Further considerations on the suitability of an individual to serve as panel chair (in addition to the ones already mentioned for panel members more generally):

- Is an ability to lead a team.
- Good project management skills (especially given the time constraints given to most TF exercises).
- Political skills for dealing with sponsor and stakeholder organizations.

A further concern when organizing TF exercise centres on the number of panels to appoint. There is no fixed rule here—some exercises appoint a relatively small number of panels—perhaps only six to eight to cover the whole S&T base—whilst others may appoint 15 to 20 for the same purpose. The decision on the number of panels to appoint has resource implications, e.g. financial costs, exercise management tasks, etc. The fewer the panels, the lower the costs, although this calculation depends upon what a smaller number of panels are expected to do. A larger number of panels allows for more focus and in-depth consideration of issues but suffers the risk of fragmenting an exercise to the point where communication between different foci may become difficult.

Figure X. Number of panels in a selection of European national S&T foresight exercises

Exercise	No.	Orientation
Austria	7	Society/Technology
French KT 2005	9	Society/Sector/Technology
German Delphi 93	15	Sector/Technology
Hungarian TEP	7	Sector/Technology/Society
Ireland	8	Sector/Technology
Portugal	23	Sector
Spain	8	Sector
Sweden	8	Society/Sector
UK 1 (1995)	15	Sector/Technology
UK 2 (2000)	15	Sector/Society

Source: Keenan, (2003).

A related issue concerns the number of panel members to appoint to each panel. Most foresight exercises have opted for 12 to 25 individuals per panel, with the average number being around 15. Typically, a small number of individuals are absent from each panel meeting, and this needs to be taken into account when deciding on the final number.

Financial and coordination costs must be taken into account when appointing panels. Time is needed for assembling the panel and any support staff, holding meetings, using methods such as Delphi or scenarios, preparing reports, and disseminating the final results. Financial costs include the following possibilities:

- Honoraria may be paid to panel members and/or the panel chair. This has not been common practice in TF up until now—the prestige associated with being a panel member in a high profile exercise has usually proved to be sufficient reward. A notable exception is the Czech TF exercise (2001) where honoraria were paid to panel chairs and panel members. The amount paid represented a token of appreciation rather than a payment for services at normal professional consulting rates. But it did seem to encourage a great amount of commitment from panel members and is an issue that probably deserves closer attention.

- Panels tend not to run themselves but are typically supported with facilitators and/or secretaries. Secretarial support, for instance, minute taking and document preparation, may be provided by staff from the sponsor or the organization awarded the contract for running the exercise. Facilitation of meetings is largely carried out by the panel chair, but additional specialist facilitation is also often required in TF, e.g. for the running of scenario sessions, the writing of Delphi topic statements, etc. Such skills may reside in the organization managing the exercise, although this is not often the case and other contractors must be brought in.

- Research and technical services will probably be needed to support the work of the panel. Some of this can often be prepared before the panels start their series of meetings, but other research and technical assistance demands are likely to emerge as the panels undertake their work. Research and technical services can often be provided “in-house”, for example, by the sponsor or the project management team. In other instances, however, it will be necessary to bring in outside expertise to write specialist reports, collect and analyse data, etc.

- Travel costs and other communications (telephone, document courier, etc.) also need to be factored in. In some countries, most expertise resides in the capital city and meetings are held there. But even in such situations, some people will have to be brought in from elsewhere, though costs are likely to be quite low. In many foresight exercises, expertise or stakeholders are more geographically dispersed, e.g. in Germany and the UK. Here, meetings may be held in many different locations with perhaps most panel members having to travel. Some countries have two dominant centres between which meetings may be split. South Africa (Cape Town and Johannesburg) and Turkey (Ankara and Istanbul) are two examples where national TF panel meetings were largely distributed across two centres.

- Rental of facilities may also be necessary, especially if panel meetings move about. It is normal for the sponsor to make its premises available for meetings. Sometimes panel members’ own organizations may offer similar facilities for free (this happened extensively in the UK national programme, but it should not be taken for granted). If meetings stretch over a day or more, it may also be necessary to pay for hotel accommodation.

- If panels are to carry out questionnaire surveys and/or organize workshops, materials will need to be provided. Moreover, reports will have to be published and disseminated.

Realistic estimates must be made of the time and costs required to complete these tasks. This can prove difficult at the outset, and it is common to underestimate, especially with respect to the time needed. Indeed, it is not uncommon for TF exercises to overrun—usually by only a few months, but sometimes it can be longer.

Getting started

Once the panel chair and other panel members have been appointed, they will need further detailed briefing on the task at hand. This can be done face-to-face at the first panel meeting. But face-to-face briefing may also be supported by the prior distribution to panel members of more detailed project plans, summaries of the methods to be deployed, and brief résumés of the other panel members. This means that panel members will have reasonable knowledge of the exercise by the time they arrive at the first panel meeting. Many national TF exercises have also used training workshops to acquaint panel members with working practices and the methods they will be using. This is strongly advised if panels will be using unfamiliar futures or forecasting techniques. Training sessions should be run by experienced trainers/facilitators.

It is imperative that the panel gets off to a good start, necessitating special attention be paid to the first panel meeting. A suggested architecture for the first panel meeting is shown below. After brief introductions, the panel chair and/or project manager should lead discussion of the foresight exercise's scope and the panel's remit within it. This might be followed by discussions with the sponsor, although this often does not happen—instead, the project manager may articulate the views and expectations of the sponsor. Discussion could then be widened to include consideration of the expectations of a wider group of stakeholders, especially of those who might be expected to act in light of foresight findings.

Typical first meeting architecture (adapted from Royal Society of Canada)

1. Discussion of the origin, background, task statement, and objectives of the terms of reference, led by the chair or the project manager involved in preparing the original exercise proposals.
2. Discussion with sponsor(s) of the terms of reference, and their views on origins, context, schedule imperatives, objectives, and so forth (optional).
3. Expectations of other important audiences, especially key stakeholders who might be expected to act in light of foresight's findings.
4. Discussion of panel composition and balance. Full presentation by each panel member and project management team of her/his background as it relates to the study.

5. Initial immersion in the subject matter of the foresight study, often through briefings by sponsors and others on subjects of major importance to the study and/or through brainstorming amongst panel members.

6. Discussion among the panel and project management team of the study approach and plan, resulting in an agreed-upon approach and plan.

Some further time will need to be spent on fuller introductions, where panel members spend a few minutes setting out their interests and experiences in more detail. At this point, panel members may decide that there is a need to appoint additional members to cover anticipated knowledge gaps. Generally speaking, this should not be encouraged—eliciting views of the necessary experts can usually fill knowledge gaps without the disruption of introducing new panel members. However, if it is deemed necessary, then new members will need to be appointed by the time of the second meeting.

All of these procedural tasks are likely to take up two to three hours of a whole day meeting. But it will also be important to get panel members to start to think about the issues they will need to consider in their work. This can be done through presentations and panel brainstorming sessions. Whilst the process and content of sessions will depend on the remit of the panel, likely outcomes of panel discussions will probably include formulation of preliminary questions and issues for further discussion. Issues surrounding data access and the panel's research needs may also begin to emerge at this early stage.

Finally, two to three hours will need to be set aside to formulate the overall approach to the task. In many TF exercises, panels are given quite tight terms of reference that clearly specify the methods to be used and the types of outputs to be produced by certain fixed dates. In other instances, panels have a greater degree of freedom in how they go about their work and in what they produce, although even here, milestones are likely to be established. The sorts of things that will need to be discussed and decided upon include:

- Working practices and panel structure—for example, will the panel work as a whole or through sub-groups? Will particular panel members be assigned to lead on specific areas?

- What methods will be used? What are the data and research requirements in using these methods? How will data be collected and analysed? Who will conduct research (project team, consultants, panel members, etc.)? What wider consultation will be carried out? What facilitation will be required for specialist methodology? Panels will need experienced foresight practitioner help to be able to answer these questions effectively.

- What will be the schedule of panel meetings? This includes the total number of meetings and their frequency. These can vary widely between panels, even within the same TF exercise. The panel (or project team) may also decide to prescribe the topic for each meeting—for example, "meeting no. 3" might be scheduled to deal with SWOT analysis or the like.

- What will be the schedule of panel outputs, including the final report? In order to track and monitor progress, an agreed-upon milestone chart will need to be formulated (if not already specified a priori in the terms of reference).

Conducting foresight work

The purpose for and manner in which TF can be undertaken is rather variable, as is the role of expert and/or stakeholder panels in such exercises. It is therefore difficult to be precise on panel methodology in this section. In some cases, panels are the main process centres ('hubs') of a TF exercise, gathering and analysing data and community opinions, employing a wide variety of foresight methods, such as scenarios, and formulating priorities and recommendations for action. In other cases, they are given very specific tasks within a much wider process, for example, commenting upon weak signals picked up in environmental scanning or formulating Delphi topic statements. However, some general principles are worth highlighting or even reiterating.

First amongst these is the challenge of getting panels to think creatively about

- The future; and
- The means of getting there.

People seem to find this difficult, partly due to the unfamiliarity of thinking in this way—our faster worlds tend to dictate short-termism and a reactive positioning to unfolding events. It is therefore imperative to ensure that panels take sufficient account of:

- The long-term (short-termism is a common weakness in panels and workshops); and
- A wide variety of perspectives on any given topic.

Creativity courses and handbooks, as well as tips from several creativity Internet sites, can help project managers to encourage out-of-the-box thinking within panels. Inspirational or even controversial speakers can be brought into some meetings to stir things up. Provocative "think-pieces" (e.g. essays) can also be prepared for panels to read. Some of the major foresight methods, borrowed from the worlds of forecasting and futures studies, are also useful in encouraging creativity. A number of these methods are described in the methods module so will not be covered here. But popular approaches in expert panels include brainstorming and scenario-writing. A panel composed of members from diverse backgrounds should also help, particularly for encouraging consideration of different perspectives. As a general rule, panel members are expected to behave as individuals rather than advocates of the "corporate" views held by their particular organization.

At the same time, panels should not stray into the realms of wishful thinking—their analyses and recommendations need to be based upon sound data of the past and present, as well projections of those trends that can be projected with reasonable confidence of accuracy, e.g. demographic change. SWOT analyses, reviews, and trend analyses are therefore commonly used. Much of this information can usually be readily found if one knows where to look. However, some further research and data analysis is usually required, which can be carried out by members of the project team, external consultants, or even panel members. But careful considerations needs to be given to the commitment required from panel members to deal with such data. Foresight panels are usually composed of volunteers who tend to be extremely busy people with little time for collecting and analysing data. Much of this work will need to be out-sourced to project managers and/or technical consultants, with analyses written-up in attractive formats for panel members to digest easily.

A further general principle that should be highlighted is the necessity and benefits of wide consultation. The temptation might be for panels to settle for internal discussion—things tend to get done more quickly, and greater control over the scope and direction of deliberations is possible. But panels that talk only amongst themselves risk missing important information and perspectives, even when members come from diverse backgrounds. Moreover, consultation lends a panel visibility, which can be important if findings are to be effectively disseminated. And stakeholder commitment to a panel's results, garnered through direct involvement, should not be underestimated. Of course, consultation should not be done for its own sake—it should have a clear purpose in the overall methodological approach used by a panel. Neither should it be confined just to those communities served by the panel. A foresight exercise should provide space for interactions with other communities, most obviously through developing linkages between the various panels set up within a foresight exercise. In general, consultation can be conducted through a wide array of mechanisms, including workshops, questionnaire surveys, expert hearings, Delphi, consultation documents, Internet mail groups, etc.

It has already been mentioned that panels can carry out their work through various organizational configurations, and a popular approach makes use of sub-groups within panels. These might focus upon a particular topic or task, with their small size (typically two to five members) allowing for more concentrated effort through the assignment of specific roles to individual panel members. However, to reiterate an earlier point, consideration will need to be given to the time requirements of such work, since panel members tend to be busy people.

The overall governance of volunteer panels is relatively straightforward when tightly specified terms of reference are provided. Panels meet a fixed number of times within a well-defined framework to carry out a particular task. But many panels in TF exercises are given wider remits whereby they have the freedom and relative autonomy to decide on their own approach and the substance of their reports. In these instances, the role of the chair and her/his relationship with the project manager are crucial. For instance, prior to all panel meetings, the chair should discuss the meeting agenda and any documents or analyses to be presented with the project management team. It is important that the chair and project manager come to an understanding on all meeting items so that they can be mutually supportive in the panel meeting. This is not to say that the chair should stifle debate—on the contrary, the chair should encourage expression and discussion of diverse viewpoints. Fairness and flexibility should be employed toward the goal of achieving a group consensus view where possible. But panels work within budget and time constraints and the chair must ensure that the panel effectively meets its remit within these constraints.

Increasingly important considerations for panels and other public committees are accountability and transparency. In this regard, the substance of discussions within closed panel meetings may be publicly reported, although the norm is to keep these confidential. In this way, panel members have the relative freedom to express opinions without having to publicly account for them. Meetings should be transcribed and minutes prepared—the latter could be made publicly available on a web site if personal opinions are sufficiently anonymized. Panel members should also respect this confidentiality and should not brief the media or other groups without the expressed permission of project managers and/or the panel chair. Indeed, relations with the media should be carefully managed and an information dissemination strategy developed. The panel chair should act as the official spokesperson for the panel and its reports in dealing with the media, sponsors, and audiences.

Project managers should publish brief progress reports at regular intervals—perhaps every four to six months, depending upon the duration of an exercise—whilst analyses prepared for or by the panels, e.g. SWOT analyses, literature reviews, etc. could also be made publicly available. In this way, the evidence base (and assumptions) upon which a panel is working can be scrutinized. Such reporting may also be used as an opportunity to consult with wider communities of actors. Thus, in many TF exercises, interim reports containing preliminary analyses and findings are published and feedback invited.

Reaching consensus and identifying priorities

One of the chief aims of appointing panels in TF is to nurture deliberation amongst a group of recognized experts and/or stakeholders around a set of issues with a view to generating enlightenment and policy advice. Analyses and discursive debates, whether within a panel or across a wider community, are good at generating enlightenment. But policy advice is usually requested in "neater packages" than this, for example, as priorities and recommendations. These clearly set out what needs to be done and why, and in the case of recommendations, suggest who should take action.

In some TF exercises, panels may not be required to reach consensus or to identify priorities, let. al.one outline recommendations for policy and investment. Their tasks might be confined to analysis and comment (although it should be acknowledged that the focus and framing of such activities implies agreement on certain choices and assumptions somewhere down the line). But where priorities are requested, these should be determined in a transparent and systematic manner if they are to be credible. For a panel to arrive at priorities, it must reach some level of consensus and closure. This is usually achieved through the power of analysis and panel debate. If serious disagreements between panel members remain, these should be highlighted rather than obfuscated. Where panels must prioritize large lists of topics, for example, in critical technology exercises, voting procedures are commonly used. Voting is nowadays done online, as in the Czech TF Programme (2001), and can in theory be opened up to invited individuals from outside the panel.

It is one thing to identify priority areas but quite another to formulate recommendations for action. Recommendations set out actions that need to be taken in light of the priorities identified by a panel and tend to be directed at named organizations. This means that they are highly political in nature. For this reason, many TF exercises choose either not to make any recommendations at all or they at least clearly separate panel analysis and priority-setting activities from the task of setting recommendations. In such situations, panels do not get involved in formulating recommendations. If recommendations are to be set, special forums of stakeholders are organized to consider the implications of panels' analyses and priorities.

There are TF exercises where panels do make policy and investment recommendations. There are, however, risks with this approach, since the potential for upsetting organizations is great. To minimize such risks, a panel might first consult named actors in order to gauge their response to being highlighted in a panel recommendation. There is then always the danger that panels find themselves engaged in political negotiations, acting almost as lobbyists for policy change. This situation can be somewhat avoided if a panel opts instead to list the various policy options that are available to decision makers and then, without endorsing a single choice, identify and explain the policy implications of each option. In this way, panel reports remain explicitly politically relevant but also relatively "neutral".

Reporting on the panel process and findings

Panels will need to report on their findings, both at the end of their work and in interim. The main rationale for reporting is to disseminate analyses and findings and to present priorities and recommendations for further action. Reports should therefore be tailored to their intended audiences. Reports are also used to demonstrate that panels conducted their work with integrity, drawing upon the best available evidence to support their findings.

Report preparation should be given early and careful attention and not just left to the end of a panel's tenure. It is advisable to define the report architecture early on, no matter how tentatively, and to refine this later. This tends to be easier to do when panels are given very specific tasks, but can be more difficult when panels have greater scope and freedom. Annex B shows the final report template given to sector panels in the first UK foresight programme (1994). This was distributed to panels somewhat later than it should have been (about six months after panel work had started and only two months before draft reports had to be delivered to the sponsor). It indicates the need to include:

- An Executive Summary.
- Background material—a description of the topic area being covered, and an account of the panel's approach to its task.
- Foundations—benchmarking data on the relative strengths and weaknesses of the topic area, and a review of trends and assumptions on where the topic area is likely to be heading in the next 10 to 15 years.
- Topics—an account of the topics deliberated on by the panel, a description of barriers and opportunities, and the presentation of a set of well-founded priorities.
- Recommendations—outline of practical steps to be taken in response to priorities.
- Summary conclusions that reflect upon the foresight exercise and its future.

Panel members can take responsibility for writing the final report themselves, but it is more usual for the panel secretary (who will be part of the project management team) to lead on this and to consult panel members in the process. More often than not, the panel chair plays a pivotal role in report drafting. The Royal Society of Canada, in its manual on expert panels, makes the following observation in this regard:

> "The chair should review all drafts of the report and ensure that the report as a whole is consistent, well reasoned, and coherent. The chair's intellectual leadership should be exercised through analysis, constructive criticism of the contributions of others, and recommendations for improvement, rather than by overruling objections or seizing control over the report's message. Whether the chair should take responsibility for initial drafts of major sections or stay with the role of assessing, revising, and integrating drafts prepared by others will depend on several project specific factors. Tieing up the chair's time as initial drafter may diminish her or his ability to act as architect and integrator of the entire report. On the other hand, if a chair brings special expertise to the panel, she or he may be the best choice for initial writer on those topics."

The project management team might also decide to assign a technical writer to draft the report, not only to ensure one consistent style but also to present the panels findings in an attractive way as possible. Before being published, panel reports should be peer reviewed to check for:

- Factual or analytical errors.
- Coherence in analysis that shows convincingly how priorities and recommendations were arrived at, and
- Overall readability and visual appearance of the report.

The criteria used by reviewers to assess the panel reports in the first UK foresight programme are shown in figure XI. Draft reports are also normally sent to the sponsor for review.

Figure XI. The criteria used to assess the panel reports in the first UK foresight programme

Criteria for assessing UK foresight panel reports (1995)

Sectoral context:

Does the report explain the significance of the sector to the UK (and global?) economy? Is its relationship to other sectors in the economy clear?

The story:

Is there a coherent account of how the panel approached its task and developed its vision(s) of the future? Has an adequate range of social, technological, economic, environmental and political factors been assessed?

Prioritization:

Have the priorities criteria (economic and social benefits, technological opportunities, industrial capability and science base strengths) been *(a)* adequately considered, and *(b)* sensibly applied in deriving priority recommendations?

Recommendations:

(1) Do the recommendations flow naturally from the priorities?

(2) Are there clear and actionable messages to funding and policy customers, i.e. Research Councils, Higher Education Funding Councils, other Government Departments, EC Framework Programme managers, the private sector, charities, etc.?

(3) Are the recommendations on a reasonable scale and is there a sense of a timetable embedded in the report (urgent actions, medium term rolling programme, independent initiatives over the long term)?

Network futures:

Does the report have a clear vision of how the sectoral networks will function in the future?

Supporting material:

Is there adequate supplementary material annexed (or provision for companion papers)?

Source: Keenan, Miles, (2003)

Dissemination of panel findings

All too often, consideration of a dissemination strategy for a panel's findings is left to near the end of a foresight exercise. This is not advisable—dissemination and implementation should be considered from the outset and the panel's approach designed with this in mind. Dissemination should also be budgeted for, both in terms of time and costs, particularly as it is likely to involve at least some panel members (especially the panel chair) in further activities. As the sponsor is likely to play a significant role in dissemination activity, the panel chair should consult them in their strategy for diffusing the messages contained within the panel report. In instances where panels have been assembled to carry out a specific task as part of a wider process, there may not be a panel report produced that is suited for wide dissemination. Instead, the sponsor alone may take full responsibility for disseminating the findings of the whole exercise later on.

On their publication, panel reports are typically announced in a press release. The panel chair normally promotes the report and addresses any questions or queries on substance, at least in the first instance. After some time, the sponsor may become the chief spokesperson for the panel's findings. Report summaries may be produced that are targeted at the media and/or high-level decision makers who may not have the time to read the whole report. Every panel report has its own audience depending on the topic area being covered and the recommendations made (if any). The panel report should be interesting to its audience and clear on the message it wants to convey. But this may not be enough in itself, and it is quite common for panel reports to be formally presented at meetings and conferences and for recommendations and implications to be discussed and debated at workshops. Panels may even be retained after their reports have been published in order to promote dissemination of their findings and implementation of their recommendations. This is, however, quite rare, with the UK foresight programmes being the notable example.

Summary

This section has sought to explicate some of the issues surrounding the use of expert and stakeholder panels in TF. Implicitly, it has mostly focused upon using traditional expert panels and has not sought to discuss the peculiarities associated with panel variations, such as web-based forums, learning circles, citizen juries and the like. Specifically, the section has dealt with the rationales for using panels, arguing that they have key advantages over other approaches such as interviews and questionnaire surveys. It has set out procedures for assembling panel members and for organizing the first panel meeting. It has also provided advice on how to get panels thinking "out-of-the-box" and has recommended an evidence-based approach complemented by consultation with the wider community. The pros and cons of identifying priorities and recommendations for action have also been discussed, as have procedures for reporting and disseminating a panel's findings. Whilst the section has been unable to address all issues associated with the use of expert panels in TF, it does provide the prospective project manager and panel member with useful pointers for getting started.

ANNEX A

Terms of reference for sector panels in the first UK Technology Foresight Programme

(Issued to panels by the exercise sponsor, the Office of Science and Technology, April 1994)

Background

1. On 28 February 1994 the Chancellor of the Duchy of Lancaster [the science minister] announced the 15 sector panels which will carry forward the main work of the TF Programme. The programme has three phases. These are:

(a) initial foresight work (April-August 1994);
(b) wider consultation about the results of this initial work (September-December 1994); and
(c) in the light of *(a)* and *(b)* an assessment of priorities within and between sectors, taking account of relative strengths and weaknesses in the UK industrial and science and engineering base (benchmarking) (January-March 1995).

2. The purpose of this note is:

(a) to make clear what work sector panels need to undertake and on what timescale; and
(b) to clarify how the work of panels fits into the programme as a whole, including in particular their relationship with the Chief Scientific Adviser, Office of Science and Technology (OST), and the TF Steering Group.

Phase 1: Initial Foresight Work (April to August 1994)

3. Each panel will wish to start considering at the outset of its work:-

(a) how best to access and make use of work already undertaken in its sector (e.g. databases on markets and technologies, other relevant foresight work); including work of the research councils and professional bodies in its area;
(b) key economic and social trends likely to affect market developments in its sector over the next 10 to 20 years;
(c) what new products, processes and services might emerge over the next 10-20 years;
(d) what developments in science and technology will be needed to enable the UK to remain at the forefront of technological innovation in its area; and
(e) technological possibilities within the sector.

4. Each panel should prepare a brief progress report to the OST and the Steering Group on the work above by the end of May 1994. The Steering Group and the OST will liaise with the panels on how best to take forward work during the remainder of phase one.

5. The aim of this first phase is for each sector panel to produce by the end of August 1994 a preliminary report about possible market and technological developments in its sector over the next 10 to 20 years. This report will be submitted to the Steering Group and the OST. Once the Steering Group and the OST have commented, these reports will then serve as the basis for the formal consultation that each panel will undertake in phase 2 of the Programme (September-December 1994).

Working methods of the panel during phase 1

6. It will be for each panel to decide how it carries out the tasks above and it will be given flexibility, under the chairman, on how it takes the process forward. In some cases much work will have been done already. In others, the panels will be starting more or less from scratch. Each panel might wish to consult a sample (say 30 to 50 representation) of the wider pool of experts (i.e. experts in that sector not selected for panel membership), relevant trade associations, professional institutions, government departments and Research Councils, Research and Technology Organizations OST and networks identified during the co-nomination process.

7. Panels may wish to establish working groups on specific tasks or commission studies on particular issues. Each panel will wish to establish arrangements to exchange views with panels in related or overlapping sectors.

8. To aid discussion across panels, panels may wish to follow similar formats when drawing up questions and issues to be addressed during the consultative phase of the Programme. A template survey form will have been introduced to chairmen and panel members during March/April. Panels can then adapt this template to the individual circumstances of their sectors.

Phase Two: Wider Consulatation Phase (September To December 1994)

9. In the light of comments by the Steering Group and the OST, each panel should submit its preliminary report to wider consultation through the Delphi process and regional workshops. Using the Delphi process, which the OST will manage on behalf of the panels, the findings of the preliminary report will be put to experts from all the sector panels to make sure that all cross-sectoral aspects are properly considered. Sector panels will undertake consultation through the regional workshops.

10. This wider consultation should be undertaken according to the following timetable:

- *(a)* each panel receives initial responses from consultees in the Delphi process by the end of September;
- *(b)* each panel should complete their series of regional workshops by the end of October;

(c) each panel should have received the second round of responses from consultees in the Delphi process by the end of October; and
(d) each panel should summarise the results of this wider consultation phase and submit a report to the Chairman of the Steering Group by the end of 1994.

Phase three: assessment of prorities (January To March 1995)

11. In the light of comments from the Steering Group and the OST on the report submitted by the panel during December, each panel should deliver to the chairman of the Steering Group by the end-January 1995 a final report covering:

(a) the factors it considers important in future markets, including some assessment of their relative importance;
(b) an assessment of the most promising opportunities for matching new technological advances to future markets; and
(c) the panel's perceptions of the strengths and weaknesses of the UK industrial, scientific and technological base as identified during Phase 2 and as identified in the benchmarking work of the OST's foresight team.

How the work of the panels fits into the foresight programme as a whole

12. Chairmen and members of sector panels are appointed by the Chief Scientific Adviser and Head of the OST, taking account into of advice from the TF Steering Group, the results of the co-nomination process, and other representations.

13. The main point of contact between each panel and the OST on day-to-day matters will be the technical secretary (see paragraph 16 (i) below). In addition, the OST central foresight team will keep in touch with the chairman of each panel.

14. Each panel has assigned to it one or more members of the foresight Steering Group who will serve as assessors and who will act as a point of contact between the sector panel and the Steering Group. Relevant government departments will also have an observer on each panel.

15. When panel reports are at the draft stage, the OST central foresight team will arrange for them to be circulated to other panels, to Steering Group members, and to relevant government Ddepartments. Final reports should be delivered to Professor W. D. P. Stewart as Head of the OST and Chairman of the Steering Group.

Resources available to panels

16. Panels will have a Chairman and a Vice-Chairman, and:

(a) a technical secretary who will provide executive support to the work of the panel (for example the panel's meetings, drafting and circulating papers, taking forward action outside meetings in consultation with the Chairman;
(b) a facilitator, hired by the OST on a consultancy basis, with some knowledge of the particular sector. The facilitator will be available to panels to provide

advice on foresight methods appropriate to work in their sector during Phase 1 of the programme;

(c) one or more assessors from the Steering Group.

17. Additionally, the OST will provide each panel with information about foresight work that has been carried out previously in its sectoral area, if any. The OST will also make available to each panel a small budget (£10,000 approximately) to enable the panel to commission consultancy assistance.

The OST will stage a series of foresight information days during March and April to give panel members a working knowledge of how their work will fit into the foresight programme as a whole and to provide suggestions on how panels might wish to organize their work.

ANNEX B

Framework for final reports from TF sector panels

(OST, October 1994)

Guidance on length and style

- Executive summary: [1 page].
- Main text: 25-30 pages (preferably 25 pages).
- Minimal technical jargon.
- Appendices and Annexes no restriction on length or style.
- Descriptive summary (published separately for wide distribution): 3-4 pages.

Structure of final report

1. Executive summary

2. Introduction

2.1 Description of the sector and its characteristics

Including, for example, size, traditional relationships with the science base and Government, potential for creating wealth and improving the quality of life, user or supplier of technology, part of the technological or commercial infrastructure, etc.

2.2 The panel and its programme of work

Including, for example, working techniques, consultation methods (including Delphi questionnaires, regional workshops and written submissions), relationship with other sectors, drawing other expertise into the programme, etc.

3. Foundations

3.1 Benchmarking

For example, describing the relative size and strength of different parts of the sector. Describing the strengths and weaknesses of the sector relative to other sectors in the UK.

Describing the strengths and weaknesses of the sector in the UK to similar sectors in other countries.

This section may be supplemented by an appendix.

3.2 Scenarios

Working assumptions, scenarios and predictions about the future and how they underpin and inform the recommendations. Also cover major driving forces which shape the future.

This section may be supplemented by an appendix.

4. Topics

4.1 Priority market, technology or product opportunities.

Identify and describe the priority opportunities, relating them to benchmarking and scenarios where possible.

4.2 Priority setting

The approach and criteria used.

4.3 Barriers to progress

Identify and describe threats and barriers to progress that might stand in the way of the opportunities already identified. This might include areas of current activity which could be scaled down to make way for new initiatives.

4.4 Key priorities

A small number [about 6] of priority opportunities or barriers to progress which deserve particular attention because of their high level of impact.

5. Recommendations for implementation

5.1 Practical steps which should be taken in response to the priorities and key priorities already identified.

This might include, for example, a description of the administrative framework which could be used to take forward a recommendation.

5.2 Key recommendations

5.3 The future of technology forsight in the XYZ sector

6. Conclusions

Brief observations about the TF programme, the priorities and recommendations.

References, list of appendices and list of separate publications.

REFERENCES

This module is based on papers presented at a series of events arranged by UNIDO as part of a programme for Central and Eastern Europe and the Newly Independent States. Each paper is available in full on the UNIDO website http://www.unido.org. The papers are:

Organizing a Technology Foresight Exercise, by Michael Keenan and Ian Miles at the Technology Foresight for Organizers Training Course in Ankara in December 2003

Socio-economic and Development Needs: Focus of foresight programme, by Attila Havas at the Technology Foresight for Organizers Training Course, Ankara, December 2003

Setting Priorities, by Kirsten Cuhls at the Technology Foresight for Organizers Training Course, Ankara, December 2003

Using Expert and Stakeholder Panels in Technology Foresight—Principles and Practice, by Michael Keenan at the Technology Foresight for Organizers Training Course, Ankara, December 2003

REVIEW QUESTIONS

1. The scoping process (what it is, why it is important, how it should be carried out, when it should be done, who should be involved)?
2. How would you deal with the barriers to foresight?
3. Who is likely to be the target audience in your situation?
4. What objectives would you suggest for a foresight exercise in your own country?
5. What resources would be needed to mount any foresight exercise that you may be involved in? How could they be mobilized?
6. What methods would you use to set priorities for a foresight exercise?
7. What time horizon do you think would be most appropriate for any exercise in which you were involved? How would you justify it?
8. How would you go about selecting participants for a foresight exercise?
9. What are the main issues to be taken into consideration in organizing a foresight exercise?
10. What are expert and stakeholder panels and why might you use them in a TF exercise?
11. How would you go about assembling a panel and what issues need to be considered in organizing their work?
12. What is it important to think about in preparing for the first meeting of a foresight panel?

13. Outline the issues to be considered in running a foresight panel

14. What outputs do you think would be appropriate for a foresight exercise in which you may be involved? How would you disseminate them?

Review question 1

What

- Designing the process.

Why

- To select the means for the exercise.
- To see what has been done already.
- To compare the requirements with the capabilities.
- To assess the need for new structures.
- To plan the exercise.
- To make the case for foresight.

How

- Gather background information.
- Get views and advice.
- Examine options.

When

- At the start of the exercise.

Who

- Key stakeholders.

Review question 2

Can't predict

- foresight is not about prediction but anticipating possible futures

Should not try to plan the unknown

- Concerned to identify potential.
- Need accountability of publicly funded research.
- Link technology and socio-economic needs.
- Questions of control.

Fatalism

- Actions have consequences.

Inertia

- Need to deal with change.

Institutional competition

- Need to include key stakeholders.

Scope

- Need to resolve any disputes.

Proof of value

- Evidence of foresight exercises.

Cost

- Costs of not doing foresight.

Review question 3

Key stakeholders

Communication is vital

Review question 4

Could include

- To enlarge the choice of opportunities, to set priorities and to assess impacts and chances.
- To prospect the impacts of current research and technology policy.
- To ascertain new needs, new demands and new possibilities as well as new ideas.
- To focus selectively on economic, technological, social and ecological areas as well as to start monitoring and detailed research in these fields.
- To define desirable and undesirable futures.
- To start and stimulate continuous discussion processes.

Review question 5

Finance

Time

Political support

Expertise

Infrastructural support

Cultural resources

Review question 6

Involve key people

Use a clear process

Establish criteria

Review question 7

Will depend on aims of exercise

Relate to the objectives of the exercise

Review question 8

Clarify objectives
Search relevant lists
Contact organizations
Contact individuals
Co-nomination or other formal procedure

Review question 9

Target audience
Desired outcomes
Resources
Coverage
Priorities
Time-horizon
Methods
Participants
Management
Products
Impact

Review question 10

Real or virtual groups of individuals (experts) recruited to advise process
Expertise
Networking
Complement other methods
Credibility and authority
Ambassadors for foresight

Review question 11

Personal contacts
Stakeholders
Co-nomination
Payment
Secretarial support
Research and technical support
Costs
Facilities
Materials

Review question 12

Clear statement of purpose
How panel will operate
Methods to be used
Schedule of meetings
Outputs required

Review question 13

Getting them to think about the future
Training in methods
Making the best use of the time of busy people
Wide consultation
Do you need sub-groups?
Operating guidelines
Confidentiality, accountability, transparency
Progress reports

Review question 14

Seeking consensus
Identification of priorities
Format of report

Module 3

TECHNOLOGY FORESIGHT METHODS

This module provides both an overview of the range of methods available for foresight and details of some of the most common.

When you have completed the module you should have:

- An understanding of the range of methods available for use in foresight programmes.
- Detailed knowledge of the following methods.
  - Delphi.
  - Scenario building.
  - Brainstorming.
  - Critical Technologies.
  - Roadmapping.
- An introductory knowledge of:
  - SWOT.
  - STEEP (V).

Contents

Figures

1. INTRODUCTION

"Foresight is simply the act of looking forward" **Denis Loveridge**

Looking forward in terms of time implies that the central concern of foresight is the future. This module, then, focuses on how we can look forward into the future and reviews some of the methods that have been used in foresight programmes to do so.

"Futurists borrow techniques from other disciplines. They are not distinctive to futures studies. What determines their relevance to the futures field is their substantive content and the purpose of their use (e.g. making assertions about possible, probable and preferable futures) rather than their methodological characteristics alone." (Wendell Bell, 1997)

A wide range of methods are available, some are specifically designed for futures work while others are borrowed from management and planning. Some may not be specifically related to the future but are used to provide the basis for foresight. Some methods, like Delphi and Scenarios, which were developed by futurists have since been borrowed by others. From the range available it is important that the chosen methods are selected as suitable for the purpose for which they are to be used. Exploring possible, probable and preferable futures relies on assumptions about the future and how we relate to it, which in turn will influence the choice of methods.

It has been made clear in module 1, Introduction to Technology Foresight, that foresight is a policy instrument that is concerned to assist in the direction of events towards preferable futures. It is therefore to be expected that the methods most frequently used in foresight programmes will be those which focus on the preferable rather than possible and probable futures. This is not to say that such methods are not useful in providing a context for foresight but that the emphasis is on ways of influencing the course of events and not just predicting them. This distinction is sometimes used to differentiate foresight from futures studies.

Formal methods, whilst not strictly essential to the conduct of a foresight exercise, are nevertheless typically used in such exercises, often in combinations. It is therefore useful to know and understand the full range of formal methods available. Selection of methods will depend upon several factors, most notably available and the time financial resources, and the objectives of the exercise. Unfortunately for the novice, no simple recipe exists for selecting and combining methods. This is because many of the methods can be used in a wide variety of ways to serve a variety of functions within a foresight exercise. Moreover, the wide variety of contexts in which foresight might be applied further complicates any attempts to provide generic guidance. Hopefully, by setting out the main methods the reader will begin to discern the most appropriate methodological approach for their own circumstances.

Selecting foresight methods

Except in cases of rapidly conducted panel-based exercises, or programmes with a strong emphasis on large-scale face-to-face interaction and bottom-up approaches, formal methods are likely to be quite prominent in foresight. Generally speaking, formal methods have some useful benefits, including (among others):

- Making the foresight process more systematic.
- Increasing the transparency of inputs, processes, and outputs.
- Constituting "hybrid forums" for interaction and communication between various system actors.
- Aiding the visualization of possible and/or desirable futures.

Thus, the question is not so much whether to use formal methods, as which to use, and how to use them. There are several possible criteria that are used for selecting amongst formal methods. Amongst these are the following:

- Resources, especially time and money, are significant factors in selecting formal methods. Large-scale surveys, for example, can be expensive and time-consuming.
- Desired breadth and depth of participation by experts and stakeholders in the foresight exercise. Some methods, such as Delphi, are good for engaging many people, though this engagement will tend to be rather fleeting. By contrast, expert panels achieve in depth deliberation, but typically amongst a much smaller cohort of people than can be achieved through a survey process like Delphi. Combinations of methods are therefore favoured.
- Suitability for combining the method with other methods, both as feeders and as a complement to the results of other methods (triangulation). Formal methods are rarely, if ever, used alone. Rather, they are combined in a variety of ways. Unfortunately for the foresight novice, there are no simple recipes to follow, since *(a)* different topic areas and audiences require different approaches; and *(b)* formal methods are rather versatile, resisting simple classification according to their (assorted) roles in the foresight process.
- Desired outputs of the foresight, which may be more or less process or product oriented. The former orientation might see a focus upon methods that nurture dialogue and interaction between disparate groups, for example. A more product orientation will ensure that methods are used that generate "hard" results, such as critical technologies.
- The quantitative/qualitative data requirements of various methods are also an important determining factor, especially where data may not be readily at hand.
- Methodological competence is often a key factor, with individual foresight practitioners often tied to particular tools, having limited experience of other approaches. This is especially true of consultant practitioners, where there is often the temptation to offer the same methodological solutions to a variety of customers.

Three key characteristics of foresight methods

A fundamental distinction in futures and forecasting studies is commonly drawn between exploratory and normative methods. This terminology is well-established, but rather misleading (since both approaches involve exploration, of course, and both call into play questions about norms and values). Still, the distinction is useful:

- *Exploratory methods* are "outward bound". They begin with the present as the starting point, and move forward to the future, either on the basis of extrapolating past trends or causal dynamics, or else by asking "what if?" questions about the implications of possible developments or events that may lie outside of these familiar trends. Trend, impact, and cross-impact analyses, conventional Delphi, and some applications of models are among the tools used here. The majority of forecasting studies are mainly exploratory, though when these result in alarming forecasts, there may well be an effort to locate turning points or policy actions that could create a more desirable future.

- *Normative method*s are, in contrast, "inward bound". They start with a preliminary view of a possible (often a desirable) future or set of futures that are of particular interest. They then work backwards to see if and how these might futures might or might not grow out of the present—how they might be achieved, or avoided, given available constraints, resources and technologies. The tools used here include various techniques developed in planning and related activities, such as relevance trees and morphological analyses, together with some uses of models and some less conventional uses of Delphi such as "goals Delphi" methods. A fairly recent development is the use of "success scenarios" and "aspirational scenario workshops", where participants try to establish a shared vision of a future that is both desirable and credible, and to identify the ways in which this might be achieved.

There is little evidence as to when each of these approaches is most valuable, and again in practice, foresight often involves a mixture of the two. It may be that more normative approaches are most likely to be effective where there is a widely shared goal already in existence, and where foresight can then help elaborate the implicit vision of the future. For example, a common long-term territorial goal will be for more rapid and equitable economic development in the territory; or where S&T issues are at stake, it may be to achieve a secure grip on at least some niches of technology innovation, production and use. In such cases, normative approaches can be powerful inputs into priority-setting and other elements of decision-making (and help provide road-maps and indicators that can be used to monitor progress towards the desired future). In other cases, normative approaches may be considered insufficiently objective, or there may be a lack of consensus as to shared goals, at least in early stages of the foresight process. Exploratory methods can then be expected to dominate.

A second important distinction is between quantitative and qualitative methods:

- *Quantitative* methods place heavy reliance on numerical representation of developments. These have considerable advantages (e.g. ability to examine rates and scales of change). They also have notable disadvantages (limited grasp of many important social and political variables, dangers of spurious precision, problems of communicating with less numerate audiences, etc.). Often quantitative methods implicitly or explicitly use simple models of some sort. More complex models relate variables together so their mutual influences can be tracked. Some quantitative approaches involve experts putting numerical values to developments, or creating such values on the basis of the numbers of people agreeing with particular statements or forecasts (as in Delphi).

- *Qualitative* methods are, of course, often employed where the key trends or developments are hard to capture via simplified indicators, or where such data are not available. In addition, various forms of creative thinking are encouraged by such qualitative approaches as brainstorming, Utopian writing and science fiction. Methods for working systematically with qualitative data are becoming more widely available with the development of Information Technology—tools for "mind mapping" and "conversation analysis", etc.—which can also be helpful devices for facilitating meetings and workshops.

The exact mix of methods is highly dependent on access to relevant expertise, and on the nature of the problems being studied. They represent different approaches to handling information, and can contribute powerful insights in their own ways. There is a strongly-rooted tendency to place more weight on statistical information (or quantitative data that may not really merit the term "statistical"). This is misguided: such data can be invaluable in giving a broad overview, in demonstrating the incidence of phenomena, the representativeness of case studies or opinions, and the like. But they can rarely probe the dynamics of a phenomenon in any depth, and are restricted to concepts and indicators that are usually quite limited and liable to give only a partial hold on the issues at stake. In practice foresight work can never be completely dominated by quantitative methods and their results. The task is to establish an appropriate role for such methods.

A third critical distinction is between methods that centre on examining and articulating the views of experts, and those based more on investigating the consequences of assumptions:

- *Expert-based* techniques seek to draw out informed opinion and the evidence that underlies expert judgements. They seek to articulate views about the future, of the trends and contingencies that may give rise to alternative futures, and of goals that should be striven for and the critical priorities and strategies here. The approach may involve large-scale surveys of opinion (such as Delphi), or much smaller and more detailed elaboration of visions (such as cross-impact analysis, scenario workshops, etc.). Where the issues tackled in foresight are ones of wide concern, and especially where they deal with social change, the "experts" may be effectively the whole population—representative views may be developed from samples of the general public. Results may be presented in quantitative form (e.g. Delphi estimates of the date at which particular developments will manifest), or qualitatively (e.g. narrative scenarios).

- *Assumption-based* techniques are ones that elaborate visions and priorities on the basis of knowledge that is usually already public (available statistics, published analyses of likely breakthroughs or other developments and contingencies). Sometimes shortage of relevant data may lead to a special activity to generate relevant statistics. Assumption-based techniques are often more reliant on expert practitioners than on more interactive approaches. For instance, technical expertise is required to set up a simulation model to describe an issue of interest.

It would be easy to imagine that assumption-based methods are mainly quantitative in form, but this would be a mistake. For example, Delphi surveys are expert-based and yield quantitative results, while some sorts of scenario work are mainly qualitative but highly assumption-based. The key issue at stake here is how far we are able to rely upon data and knowledge of processes and relationships that has already been codified and subject to some scrutiny, as opposed to having to elicit opinions and "guesstimates" from experts as to what might be the state of affairs now and in the future. The nature of the topics considered in foresight is such that a combination of the two will almost invariably be called for. Expert judgements have to be deployed where we are considering rapid change, qualitative breaks, and social and technological innovations. The questions that arise are more ones of how to use such opinion than whether to.

Each approach has its advocates but there tends to be a division between "forecasters" who favour quantitative/exploratory methods, and "futurists" who prefer the qualitative/normative. Advocates of one approach may be dismissive of the other despite the fact that there is a considerable overlap between them.

Typologies of foresight methods

Typologies of foresight methods are often problematic, since many methods are rather flexible in their application and defy easy classification. Nevertheless, the various methods will be presented in four groups (according to Miles and Keenan, 2003), as shown in figure I. In the next chapter, 13 methods, which cover some of the main approaches used in foresight studies over the last decade, will be described.

The literature offers a number of other approaches to the classification of methods of thinking about the future.

Figure I. The methods described in the following chapter

Group	Method
Identifying Issues	Environmental Scanning, SWOT Analysis, Issue Surveys
Extrapolative Approaches	Trend Extrapolation, Simulation Modelling, Genius Forecasting, Delphi
Creative Approaches	Brainstorming, Expert Panels, Cross-Impact Analysis, Scenarios
Prioritization	Critical (and Key) Technologies, Technology Roadmapping

Source: Miles and Keenan, (2003).

For example, Ted Gordon (in *Methods of Futures Research*, Annals of the American Academy July 1992) uses a matrix based on the Normative/Exploratory and the Quantitative/Qualitative distinction.

	Normative	Exploratory
Quantitative		
Qualitative		

An much broader approach is taken by Richard Slaughter (1989) who suggests that "The Futures Field" extends from futures research, where the main focus is on seeking knowledge about the future; through futures studies, which is concerned with synthesis, criticism and communication; to the futures movement that is involved in stimulating, re-conceptualising and leading change. At different times foresight is likely to draw on methods across this spectrum.

Despite the limitations, classification is useful in clarifying the assumptions inherent in any method and in selecting those best suited to the purpose of an exercise. Finding the most appropriate methods may depend on accurately assessing the circumstances we are in and the reasons for attempting to use them. It follows from this that any forecast or futures statement should make clear the assumptions incorporated and the methods used, if it does not it should be treated with caution. This is, of course, no more than established good practice that requires the means by which conclusions are reached to be apparent (May, 1996).

The classification set out in figure II is included here to show the wide range of methods available for thinking about the future although only a selection of the most commonly used methods in foresight are discussed in this module.

Figure II. A classification of futures methods

Approach	Concept	Technique	Assumption
Foreseeing	Prediction	Precognition	Special ability
		Prophecy	
		Astrology	
		Genius forecasting	
	Extrapolation	Time series/trend forecasting	Pattern recognition
		S curve	
		Envelope curve	
		Precursor analysis	
		Cycles	
	Analytical forecasting	Casual models	Explanatory system
Managing	Judgemental	Delphi	Expert opinion
	Forecasting	Cross-impact	Interactions
		Content analysis	Scanning
	Management	Issues management	
		Environmental scanning	
		Impact assessment	Analysis
		Cost benefit analysis	

Figure II. *(continued)*

Approach	Concept	Technique	Assumption
		Risk assessment	
		STEEP	
		Mind mapping	
		Causal-layered analysis	Questioning
		Role play	Dramatic representation
		Scenarios	Alternative futures
		Field-anomaly relaxation	
Creating	Policy-making	Problem solving	Rationality
		Decision-making	
		Planning	
		Strategy formation	
		Politics	Power
		Backcasting	Logical steps
		Relevance tree	
		Morphological analysis	
		Roadmapping	
	Speculation	Science fiction and speculative writing	Imagination
	Imaging	Brainstorming/Brainwriting	
		Group support systems	
		Futures workshops	
		Visioning	
		Incasting	
		Creative imagery	

Source: May, (1996).

This classification divides methods into three main types according to the approaches they take to the future. Some methods may bridge the main divisions or in different circumstances be based on different assumptions.

Foreseeing is the attempt to see the future before it occurs and is synonymous with words such as predict, prophecy, forecast, foresight, fore-knowledge. Such approaches assume predictability and that we can obtain knowledge before an event. They are therefore concerned with gaining advance information about the future. In doing so they are essentially passive, the world around us will determine what happens to us but by knowing in advance we may be able to adapt, prepare for the inevitable, or lessen the consequences even though we cannot change the future itself. Weather forecasting is a good example, you may not be able to change the weather but you can take an umbrella to protect yourself from the rain. Some who adopt this approach may regard the future as inevitable or even already existing; it is certainly regarded as an extension of the past and present. Such methods tend to be analytical, often highly mathematical and emphasize possible and probable futures. Rescher (1998) argues however that, "it is only where the future is somehow foreshadowed in the discernible patterns of the past and present that rational prediction becomes possible".

Levels of success of this forecasting approach are limited. Wise (1976) suggested about 40 per cent accuracy for forecasts of technological developments and less for social developments, while Sherden (1998) found the record of most forecasters to be little better than chance. This is a fairly pessimistic assessment and does not include situations in which forecasts become self-fulfilling or are made by those in a position to act in order to bring them about. In both cases the very act of making or publishing the forecast is likely to influence subsequent actions and help move events in the direction predicted. Mercer, for example, contends that the aggregated expectations of decision-makers provide an excellent guide to the future because they are in a position to adjust their behaviour to bring about the expected outcomes. This is indeed the raison d'être of foresight and it should therefore be no surprise that, for example, the "forecasts" in the Japanese foresight programme have a much higher "accuracy", in some areas of over 90 per cent.

Causal models, which are based on computer simulation, may be recommended where there is sufficient data available to develop an explanatory model and the relationships it describes are stable. A good example are the forecasts of passengers using UK airports, prepared by the UK government, though here again there is an element of self-fulfilment, in that once the forecasts are made plans are put into effect to provide the necessary facilities for the predicted traffic. Discontinuities, like 9/11 and SARS, however remain problematic, as they introduce factors not included in the model.

This approach raises the question of whether it is possible that as our understanding of systems develops we may increase the accuracy of our forecasts. This may depend on whether the future is by nature unpredictable or that the current limitations of forecasting derive from our lack of understanding of the systems in question or a lack of ability to foresee the future, which we may be able to improve. The improvement in weather forecasting, which has been achieved with better information from satellites coupled with more sophisticated computer models suggests there are situations in which this may be true.

Traditional forecasting tends to stop here but there are other approaches to thinking about the future, which assume that we are not passive agents but can influence, if not control it. This opens up the possibility of different futures, which are contingent on human choice and action and consequently foreseeing the future may then becomes difficult, or even impossible, because the potential variations become so great. Some, such as Mercer above, have suggested that it may be possible to foresee collective movements even if not individual decisions.

Based on the assumption that the future is not inevitable but can be influenced by human action two further approaches can be identified assuming different levels of influence.

Managing which accepts that the future is unpredictable and that we are not able to forecast with certainty. This approach focuses on managing change, which may be reactive, as in crisis management or positive, as in strategic management or management by objectives. In each case in a futures context it is dealing with the present with the future in mind. Dator uses the evocative image, "Riding the tsunamis of change," to summarize the approach. These methods focus on the uncertainty of the future and on ways of dealing with it.

Creating assumes the future does not exist and has yet to be created; that the future is open to human influence and will depend in large measure on what we do. The approach is positive or proactive and focuses on the development of normative, desirable or preferable futures. Imagination becomes critical in the early stages of these methods, as the following phrase attributed to several authors suggests, “Some see things as they are and ask why. I see things that never were and ask why not.” Creativity is often thought to be a special ability of a limited number of individuals such as artists and designers, while others argue that we all have the ability to be creative but have not developed it.

Jungk and Mullert (1987) for example, suggest that creativity requires a preparedness to:

- Think the otherwise unthinkable.
- Be enterprising and inquisitive.
- Be non conformist and flexible.
- Be open minded to the irrational and off beat.
- Take a chance on being wrong or failing.
- Shun cynical, know-all and perfectionist attitudes.
- Stand up for cranky ideas.

How far these characteristics are valued in most organizations or encouraged by society and particularly by the education system, is open to question.

The foresight programmes that have been undertaken by governments and others have used a variety of methods based on differing assumptions. They have in the main been concerned to influence the future in directions considered favourable to those who have commissioned them; the use of science and technology to boost national or regional economies being a favourite theme. Where those actors who make decisions about the future, particularly of technology, are part of the study and committed to it there is often a close match between the “forecast” and the eventual outcome.

Methods described in the following sections will follow the typology in figure I.

Identifying issues for foresight

It is common for foresight studies to begin with some sort of scanning and framing activity, which together identify and inform the issues on which the foresight will focus. Amongst the most popular methods used are environmental scanning, SWOT analysis, and issue surveys. Each is now briefly described.

Environmental scanning

A large number of approaches are in use to help identify important developments in the environment of organizations. Issue surveys provide one approach, based upon polling experts. A variety of multiple “genius forecasting” may be employed, for example, by requesting a number of experts or well-informed commentators to select and write about topics that they believe will be important for the future.

Other approaches typically involve systematic analysis of some documentary source. Media coverage of issues is commonly used, where typically a team set about locating and classifying, and then working through and presenting, material on a large number of social trends relevant to the future of work. This activity is referred to as environmental scanning and can take a number of forms:

- *Passive scanning:* reading newspapers, magazines and periodicals relevant to our interests and watching television, without really thinking about it. It is how we keep up to date with whatever is our particular concern.
- *Active scanning:* particular sources are regularly scanned, perhaps making an effort to extend the scope beyond the area we normally cover in a more formal process.
- *Directed scanning:* often organized within a team, this implies a much more organized and selective approach to scanning for a particular purpose.

These sorts of approaches are particularly useful for addressing emerging themes that conventional trend analysis might find it hard to spot—often because there are as yet no established data on the issues of interest.

There are several developments of interest here. With the growth of the Web, it is now possible to use electronic means to search for or chart the emergence of press coverage of various themes, and to experiment with classifying the material in different ways. There are also several organizations offering trend-spotting services. Some of these provide regular digests of a wide selection of what they believe to be important developments for the future; others focus on specific areas (such as possible trends in fashion and tastes).

There are also more specialized types of data source that can be examined, and methods of analysis to track developments. These are particularly well developed for examination of science and technology issues. For example, bibliometric approaches may be used—examining the number of journal articles that are addressing particular themes. Patent analyses are used to look for areas of interest in technology development. Such data are used to provide early warning of activities that may provide technological challenges to the established modes of operation of an industry, for example.

SWOT (strengths, weaknesses, opportunities, and threats) analysis

SWOT analysis is an analytical tool used to categorize significant internal and external factors influencing an organization's or territory's strategies—or, in the case of foresight, its possible futures. SWOT analysis involves the collection and portrayal of information about internal and external factors that have, or may have, an impact on the evolution of an organization/territory. It generally provides a list of an organization's strengths and weaknesses as indicated by an analysis of its resources and capabilities, plus a list of the threats and opportunities that an analysis of its environment identifies.

The SWOT is often portrayed as a 2×2 matrix, which presents an overview of major issues to be taken into account in developing strategic plans for an organization—and in preparing foresight studies in expert panels and workshops. The idea is that such an appraisal will enable strategies to be developed that match strengths with opportunities, while warding off threats and overcoming weaknesses where feasible. SWOT is thus not a static analytical tool, but a dynamic part of management, business development, and organizational learning.

SWOT analysis requires knowledge sufficient to support definition and prioritization of factors. Thus it is necessary to access sufficient relevant expert knowledge. For this reason, SWOT analyses are usually prepared by an expert team using a variety of data sources and often a programme of interviews. Evidence is drawn from various sources—expert opinion as revealed through interviews, or statistical or benchmarking comparisons, for instance. Opinion as to SWOT issues can even be derived from Delphi studies (it is quite common for such surveys to ask respondents to indicate how one's country or organization compares to others in various ways, for example).

Issue surveys

Issue surveys are used to consult a wider range of expert opinion than could readily be accommodated in face-to-face meetings, to find out what they consider to be important developments in their areas. Such surveys, using post or e-mail (or even telephone interviews) can be used to inform the development of Delphi studies, background information on important developments, or scenario workshops.

The surveys may be fairly open-ended ones, in which the experts are allowed to elaborate on the issues in their own style, often supplying relevant documentation and the like. However, such material can be hard to process, and many respondents are very reluctant to embark on such an open-ended exercise (its time requirements are practically endless!). Thus more structured approaches are common. One approach used effectively in the UK foresight programme in the mid-1990s involved a four-page questionnaire, in which respondents were successively asked to specify, in their own words:

- What are the major drivers and shapers in the area of interest (thus for transport the drivers might be environment and congestion)?
- What sorts of problems and need do these create (e.g. specific pollution problems, waste of time, safety risks...)?
- What sorts of solution and innovations might be applied to these (shifts to public transport, new types of engine, better traffic information systems...)?
- What sorts of research, knowledge, or capability might be needed to achieve these (research into systems that allow rapid shift across transport modes without wasting people's time or incurring extra expenses, use of fuel cells in designated urban areas, improved transport telematics software, user interfaces, devices...)?

Such approaches can draw on a wide knowledge base, allowing many more people to contribute their insights. They can provide more time for reflective inputs than would be possible in workshops, and engage people who would not be able to commit time to a longer involvement in foresight.

Extrapolative approaches

Although foresight is a distinct activity from forecasting, some forecasting methods have been borrowed by foresight practitioners. Foremost amongst these are the extrapolative approaches of trend extrapolation and simulation modelling. These are statistical approaches based upon well-defined assumptions. Also covered in this section are genius forecasting and Delphi, which are methods also borrowed from the world of forecasting. But in contrast to extrapolation and modelling, these methods rely upon the opinions of experts to generate their results.

Trend extrapolation

Trend extrapolation is one of the most widely used of all forecasting techniques, and many forecasts that stem from expert judgement are probably actually achieved by an impressionistic trend extrapolation of one sort or another. A trend refers to historical data, such as that concerning population growth, economic development, social attitudes, etc. Extrapolation means that these data are projected forward. This may be done impressionistically or by fitting a curve or straight line to a series of data points by hand; or, more usually in contemporary analyses, by mathematical or statistical equation-fitting.

Trend extrapolation is widely used, and fairly easy to employ and explain. But in order to assume that a trend will continue to evolve into the future, we need really to have a good reason to believe that it will persist rather than change its course. Thus it is wise to identify just what forces are driving a trend; then one can consider whether these are liable to persist, and to have the same effects. If we do not think this through, then trend extrapolation is unconsciously founded on the assumption that such forces will continue to operate in familiar ways. It is better for such assumptions to be explicit.

A little rhyme sums up the problems:

A trend is a trend is a trend,
But when will it bend?
Will it turn over and die?
Shoot to the sky?
Or asymptote off to the end?

Formal statistical methods of trend extrapolation have been developed, of varying degrees of sophistication. Fitting a curve to a series of data points by hand is often a good way of gaining insight about the development of a trend. But we are liable to make errors of various kinds when doing this, not least by seeing patterns where there are none, or arbitrarily ignoring data points that do not correspond to the trend we anticipate. Curve-fitting by hand is particularly difficult where there is a lot of “noise” in the data, or where we are dealing with cyclical phenomena (e.g. the business cycle may make long-term growth trends obscure). Various statistical techniques enable straight lines or a variety of curves to be fitted to a set of data points, and projected into the future. Various statistical techniques also exist that allow us to fit S-shaped curves (e.g. logistic curves) to trend data. Such methods are frequently used for examining and forecasting phenomena such as the diffusion of consumer products—or the spread of contagious diseases—in a population. Where there is an obvious ceiling, such approaches can be very powerful, but in the case of many social phenomena there is a good deal of guesswork in deciding where the ceiling might lie or when it might be reached.

Simulation modelling

Computer simulation models are a popular tool in forecasting, allowing a system to be represented in terms of its key components and relationships. More significantly, computer simulation can be used to project how the system will operate over time, or as a result of specific interventions. The wide availability of low-cost computing over the last decade has meant that such tools are slowly becoming a more familiar and less mystifying activity.

There are several major advantages, and also certain drawbacks, associated with modelling. In its favour, the approach can force us to think systematically about our assumptions concerning the dynamics of a system, and make us search for relevant data with which to test, explicate or elaborate such assumptions. It can also allow us to explore alternative starting conditions, events and interventions, and even allow us to experiment with changing assumptions and to compare the behaviour of models of the same system based on different understandings of how it operates. Perhaps most significantly, it allows us to deal with a much larger number of variables simultaneously than ordinary people are able to, and to process the material in a systematic and meticulous way, with innumerable calculations. It can even be the case that outcomes will be achieved that were unexpected or unpredicted by the simulation's designers—this is particularly the case in the more evolutionary models involving games, agents, and genetic algorithms. Finally, computers enable us to present results in detailed graphical form—graphs, charts etc.—allowing us to compare results for different times or conditions.

On the downside, whilst models of social, political and cultural change have been produced for decades, our understanding of how these systems work is incomplete and hotly debated, with very different worldviews being brought into play. It can also be hard to identify and locate appropriate data on key variables, let. al.one to estimate the relationships between them. Clearly, the quality of a model is only as good as that of the assumptions it is based on (and the data with which it has been calibrated). While this is more widely understood than in the past, a continuing problem is that, especially in the case of large and complex simulation models, it can be difficult for non-experts to identify and critique the assumptions that have been built into them. Many large models are subject to little independent inspection, and the details of some are commercially confidential.

Genius forecasting

The rather misleading term "genius forecasting" is used to describe the generation of a vision (or several visions) of the future through the insights of a gifted and respected individual. Some individuals can provide fresh thinking to foresight, and can take up perspectives that may otherwise be neglected in the work of committees and panels. While some such individuals will be working as solitary academics, journalists, or activists, gathering and honing their insights over years of experience and study, it is also common for futurists to draw on the work of many colleagues. We have "genius forecasting" rather than more conventional futures studies where such figures synthesize these ideas of larger study teams in new ways, stamping their own strongly-held views on them. Influential examples here could include Alvin Toffler's *Future Shock* and *The Third Wave*, or John Naisbitt's *Megatrends*.

However, caution needs to be exercised in using such work. The nature of such visions is that they tend to ride on particular hobbyhorses, and to present views that are rather one-sided (emphasizing particular technologies or social problems, viewing these in a monochrome positive or negative light, etc.). Moreover, it is likely that few individuals have the span of knowledge required to cover the whole range of factors that may change the future. Thus it is helpful to place them in the wider context—of other genius forecasts, and of futures efforts that use rather more transparent methods. Indeed, if such studies are used critically—are seen as the work of gifted but fallible visionaries, rather than as the supernatural revelations of prophetic gurus—they can be used for indicating drivers and scenarios that may be useful to consider.

Delphi

The Delphi method is so widely identified with foresight that it is easy to forget that even among national foresight programmes, several make no use of the method. It was originally developed in the United States in the 1950s by the RAND Corporation and involves a survey of opinion—in principle this should be expert opinion. But it is a survey that is designed to feed information back to its respondents, not just to provide material for processing by data analysts. What makes Delphi different from other opinion surveys is the way in which this is accomplished. Delphi does not just involve a one-off posing of questions. The survey is circulated, to the same set of respondents, at least twice. Together with the same set of questions, the respondents in later rounds receive feedback on the structure of responses from previous rounds. The purpose of providing this feedback, and offering the chance for respondents to modify their judgements in its light, is to promote exchanges of views and information—and in the case of Delphi forecasting, to allow people to see how far their forecasts and expectations correspond to those of a wider pool of respondents.

The anonymity of the survey is, furthermore, intended to reduce the dominance of discussions and the exercise of influence by the loudest or most senior figures. Indeed, the Delphi method was designed to encourage a true debate, independent of personalities. Further, to eliminate the force of oratory and pedagogy, the reasons given for extreme opinions are synthesized by the researchers to give them all equal "weight" and then fed back to the group as a whole for further analysis. Ideally, they should receive information on why judgements, and especially extreme judgements, were made. The idea is that all respondents should thus be able to have access to special information that only a few possess, but which can inform judgements that diverge from the average.

The most common application of Delphi has been to investigate when particular developments might happen, requesting judgements usually about the most likely time period in which a particular development might occur. An alternative, that has been used less often but that may be more useful for some purposes, is to inquire about how far a development might have occurred by a particular point in time. Often, alongside these forecasting questions, there will be other survey questions about possible driving, constraints and facilitating factors, or about the economic or social implications, of particular trends.

Delphi studies provide impressive results when conducted well. This will require careful and laborious planning in terms of the choice of participants, preparation of questions, and provision of feedback. Delphi surveys are fairly time-consuming and labour intensive. Drop out rates among respondents may be high, and persuading them to fill in successive questionnaires is troublesome (which is one reason why few iterations have become the norm). Some so-called Delphis do not reiterate the survey or provide adequate feedback to respondents, and their value is thus compromised.

More details of the Delphi method are given later in this module.

Creative methods

foresight is, above all, a social and creative process that relies upon more than just issue definition and extrapolation. Interactive processes that nurture new and interesting knowledge combinations are key to the success of foresight. Amongst these is the popular and versatile method of brainstorming. Much interaction and knowledge generation also takes place within expert and stakeholder panels, which may employ methods such as brainstorming. A more formal and often statistical method is cross-impact analysis, whilst perhaps the most versatile of all foresight methods, scenarios, is now extremely popular.

Brainstorming

Brainstorming is one of the best-known of methods for generating novel solutions to problems. It has been extensively used in futures work because it aims to reduce inhibitions about generating “wild” ideas, and thus to stimulate creativity and novel (or previously unarticulated) viewpoints. The term is applied loosely to any free-ranging discussion, but the “classical” definition refers to a specific process involving two main steps:

- A period of freethinking, which is used to articulate and capture ideas, with no critical comments. This can be organized as a group activity, with people speaking ideas out loud and a facilitator or group member capturing them on a whiteboard or on a PC linked to a display; or there can be a preliminary step at which group members are requested to work alone and jot down several ideas on their own notepads or PCs (this is supposed to reduce the pressure to think along a track established by the group). Once ideas are being articulated, members should be able to ask for clarification of anything that is obscure, and to build on previous ideas. The main rule is that they should not snipe at others or critique ideas at this stage.

- The early stage of idea-generation is followed by more rigorous discussion of these ideas. This typically involves clustering them (usually through a process of group discussion concerning which ideas can be combined together) and prioritizing the most important themes. This latter activity could involve voting. At this stage it is legitimate for group members to introduce considerations that may render some ideas unworkable or irrelevant, though it is important to maintain a friendly spirit and not to personalize criticism.

There are many ways in which these steps can be organized—the core common feature is that the facilitator should provide an encouraging and optimistic ambience, and prevent group-think. Increasingly, brainstorming is supported by computer tools, though the classical implementation through use of flipcharts on which to capture ideas is extremely effective.

Brainstorming is only a starting point. It should not normally be expected to generate output that can be directly used in reports, etc.—although reproduction of a long list of ideas can sometimes be useful for future group work. It is typically applied directly to the topic at hand, for example to brainstorm ideas about important trends, about drivers and inhibitors of a specific development, etc. It may be a useful technique to use in establishing the future work of expert panels, e.g. to pinpoint the topics that will need to be addressed at successive meetings, and the decisions that will need to be taken.

More details of brainstorming are given later in this module.

Expert panels

TF is, by definition, a participative, discursive activity that should be based upon the best available evidence and judgement. These conditions make the use of (expert) panels a natural choice in the foresight practitioner's methods toolbox. Panels not only open up the foresight process to potentially hundreds of individuals, they are also ideal forums for in-depth discussions and debate. For these reasons, panels are the "process centres" in many foresight exercises.

Panels come in many shapes and sizes, although the common conception is of a "Bunch Of Guys Sat Around a Table" (BOGSAT). Such a panel normally consists of 12 to 15 individuals and is mandated to use its collective expertise in addressing a particular problem or set of issues. Experts meet face-to-face, normally in private session, at regular intervals over a fixed time period. During this time, they use their judgement in interpreting available evidence. Panels have often been given very tight briefs, e.g. to arrive at *n* number of Delphi topic statements within *t* months. Once the brief has been completed, they are usually disbanded. In many cases, panels produce their own published reports. Whether this happens or not largely depends upon the overall methodological design of the TF exercise.

The benefits of using panels in TF are manifold and widely acknowledged, as evidenced by their extensive use in foresight exercises. For example, the ease with which panels can complement other methods used in TF is an important advantage. Indeed, with some methods, panels are a near necessity for the generation of inputs, the interpretation of outputs, and/or the overall conduct of the method. Other benefits include deep interaction and the networking of disparate groups.

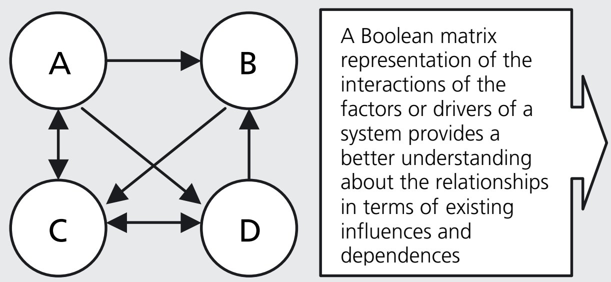
The use of panels in foresight is examined in full in module 2, organizing a TF.

Cross-impact analysis

Like Delphi, cross-impact analysis is an expert-based method producing quantitative results, although there is a more complicated statistical processing of the data required to reach these results. One of the major applications of cross impact analysis is in the preparation of scenarios. The approach is to ask the experts to rate the likelihood of various events occurring—and furthermore, to rate the likelihood of each event occurring if each of the others does or does not occur. The cross-impact method forces attention to chains of causality: *x* affects *y*; *y* affects *z*. This creates a matrix of conditional possibilities. This matrix can be subject to mathematical analysis (via specialized software programs) to assign probabilities of occurrence to each of the possible scenarios resulting from the combinations of events.

Figure III represents a system of four drivers and their interconnections. The arrows on the left of the diagram indicate existence of direct influence of one driver over another (i.e. driver A exerts a direct influence over drivers B, C and D).

Figure III. Four drivers and their interconnections

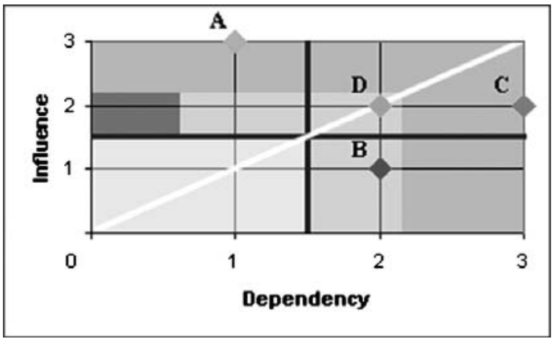


	A	B	C	D	Tot. I
A		1	1	1	3
B	0		1	0	1
C	1	0		1	2
D	0	1	1		2
Tot. D	1	2	3	2	8

Source: Popper, (2003).

Boolean matrices (based on 1s and 0s) have very important properties in the context of networks and evaluation of systems evolution. One (1) means that there is a connection (i.e. influence, impact, effect, etc.) between a pair of variables (drivers) and zero (0) means that there is no connection. The number eight (8) in the bottom right corner of the above Boolean matrix indicates the total number of paths or connections that exists between drivers A, B, C and D (note the eight arrows on the left of the diagram in figure III). The sum of a row represents the total direct influence (through direct paths) that a specific driver exerts over the system (i.e. number 3 at the end of the first row indicates that driver A has three direct ways to influence other drivers within the system). "The evolution of highly influential variables (drivers) will have the greatest effect on the system" (Godet, 1994). On the other hand, the sum of a column represents the total direct dependency that a specific driver has on the system (i.e. number 1 at the end of the first row indicates that there is one path though which the system can directly influence driver A). "Dependent variables (drivers) are those that are most sensitive to the evolution of the system" (Godet, 1994). Both the sum of values of the row and the column of a driver provide two indicators, total influence and total dependency, which will be used to classify each driver in a Cartesian map.

Figure IV. Use of influence and dependency to classify drivers



In the left side explanatory chart driver A belongs to Zone 1, driver B and D belong to Zone 5, and driver C belongs to Zone 2 (see figure V).

The direct influence-dependency map provides useful descriptive information about a system. It helps to explain common sense assumptions that could have been made in advance about the importance of certain drivers. The chart can be divided into five zones: Z1 (Influential drivers: explanatory drivers which condition the system), Z2 (Key drivers: high influence and high dependency, unstable by nature), Z3 (Resultant drivers: influenced by determinant and relay drivers), Z4 (Autonomous drivers: trends or drivers relatively disconnected to the system), Z5 (Regulating drivers: hard to state something in advance about their evolution) and Z6 (Neighbouring drivers: usually remain in the sidelines, but sometimes evolve into dominant ones by relocating themselves into Z1).

Source: Popper, (2003).

Looking for hidden interconnections

The principle of indirect influences is quite simple (see figure VI, adapted from example in figure III). Driver B only exerts direct influence over driver C (B→C). However, driver C exerts influences over drivers A and D (C→A and D). Therefore, B has an indirect path of length 2 that allows it to exert influence over A through C (B→C→A, the linking arrows represent the number of paths or influence loops that variable B goes through in order to influence variable A).

Figure V. Typologies of variables (drivers) within a system

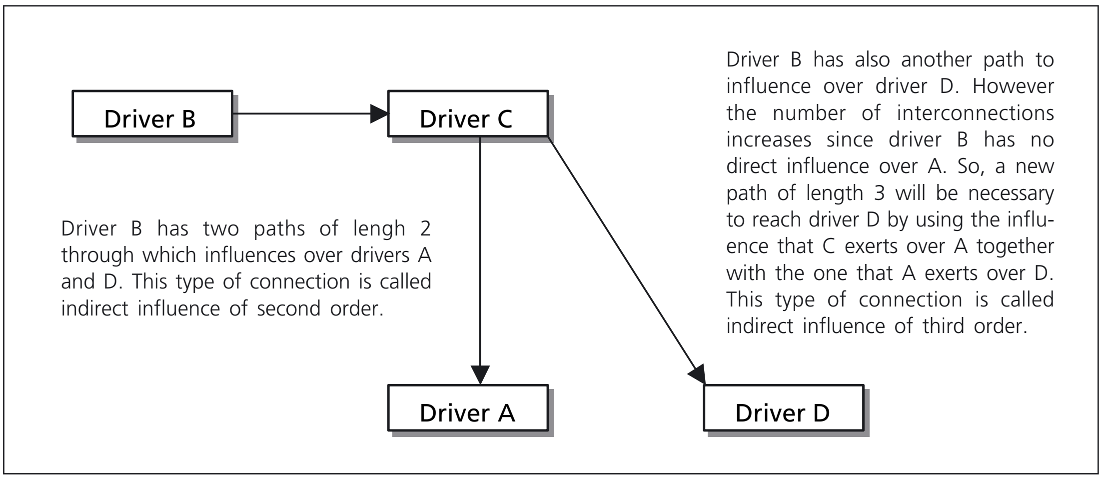
Typologies of variables (drivers) within a system	
Dominant or determinant	Dominants of the system. These drivers have a high level of influence and a low level of dependency (influences or brakes evolution).
Key or relay	Unstable drivers. These drivers have a high level of influence over the system and a high level of dependency; therefore require careful attention and study since all action on them has a regressive effect due to the strong linkage with other drivers.
Neighbouring	Inside on the system. These drivers have medium influence over the system and very low dependency; they usually remain in the sidelines, but sometimes evolve into dominant or determinant ones. Therefore it is important to recognize their evolution.
Regulating or average	Drivers with medium influence and dependency playing a strong role in the working or evolution process of the system. Require attention in order not to produce a fracture.
Resultant or dominated	Indicate evolution of the system. These are very sensitive drivers with low influence and medium to strong dependency.
Autonomous or excluded	Drivers with low influence and low dependency. Do not impact strongly on the system. Have joins with the system, which can possibly be strong.

Source: Popper, (2003).

Mathematically, indirect influences are the result of several multiplications of the direct influence matrix (DIM) by itself (DIM*DIM=DIM2). The number of times the matrix is multiplied generally depends on the size of the system. Small systems consisting of 10 to 20 drivers might require 4 to 5 multiplications (DIM^4 or DIM^5) in order to reach a stable pattern in the indirect influence-dependency map (similar to the one in figure IV). For larger systems of 20 to 60 drivers the hierarchy might still experience minor changes at the 7th or 8th power.

Looking for hidden interconnections involves careful analysis of several graphical representations, such the one in figure VI, of the resulting indirect influence matrices

Figure VI. Using hidden or indirect influences



Source: Popper, (2003).

Figure VII. What is behind the matrix multiplicator?

What is behind the matrix multiplication?

	A	B	C	D
A		1	1	1
B	0		1	0
C	1	0		1
D	0	1	1	

X

	A	B	C	D
A		1	1	1
B	0		1	0
C	1	0		1
D	0	1	1	

=

Indirect Influence Matrix (DIM²)

	A	B	C	D	Tot. I
A	1	1	2	1	5
B	1	0	0	1	2
C	0	2	2	1	5
D	1	0	1	1	3
Tot. D	3	3	5	4	15

The mathematical basis for the example in figure VI involve the multiplication of row B (left) times column A (middle) resulting in number 1 in the cell [B, A].

- Operation: B row * A column = 0*0+0*0+1*1+0*0= 1, which means there a path of length 2 through which B influences over A.
- Operation: B row * D column = 0*1+0*0+1*1+0*0= 1, which means there a path of length 2 through which B influences over D.

Source: Popper, (2003).

(DIM², DIM³, … DIM⁷ and DIM⁸). As shown in figure III, identifying key drivers involves a combination of drivers that have an explicit or direct high level of influence and dependency on the system with those that reach the same hierarchy level though hidden interactions.

Direct and indirect influence-dependency maps provide researchers and decision-makers with an overall picture of the structure of a system. They not only help understand and explain assumptions that have been made in advance before even starting a study but also provide surprising results when counter-intuitive hidden relationships between variables (drivers) result in "popping up" of unexpected key drivers. It is also possible to make use of these maps to detect whether a system is stable or unstable.

Stability of systems is achieved when there is a relatively low number of key or relay variables (drivers) and representative number of dominant drivers (a dictatorship is a classical example for this type of system). Unstable systems usually present several drivers along the main diagonal and many of them located in the key zone (figure IV). In general, some of the detected key drivers involve critical issues very difficult to speak about due to their high level importance. It is also common to see that some of the drivers that are important for the organization that carries out the study are located in a zone of autonomous or excluded variables (see figure IV).

The use of cross-impact method is one of the various numbers of tools that can be used to organize and interpret subjective knowledge by means of rigorous collective and structured reflection about the interrelations between different elements within a particular system. Its usefulness strongly depends on the level of commitment of involved participants and the richness of discussions and reflections on the results of the exercise.

Cross impact analysis seems to be a logical step beyond methods like Delphi, which treat events as completely independent of one another. By examining the relationships between events, cross-impact analysis allows us to approach dynamics more closely. However, in practice, relatively few people use the method regularly, and there has been only limited independent analysis of its utility, probably because of two main limitations. First, it is very demanding of the experts, who have to make a fairly large number of difficult judgements about combinations of events. And secondly, because the number of judgements involved doubles with each new variable added, only a small number of key variables can be examined in practice. Any influences not included in the event set will be completely excluded from the study. The choice of events is thus crucial (Miles and Keenan, 2003).

Scenarios

Scenarios consist of visions of future states and courses of development, organized in a systematic way as texts, charts, etc. They may be used as inputs to kick-start discussion and idea generation in panels, as tools for working groups to marshal their arguments and test the robustness of policies, and/or as presentational devices that can communicate foresight results to a wider public. They may be used more as an element of the foresight process, with their major contributions involving the exchange of visions and thus the deepening of linkages in networks, or as products of the activity that can be circulated to broad audiences. They may be exploratory focusing on what might happen under various circumstances, or aspirational asking how specific futures can be achieved (or avoided).

Often, creating scenarios has been compared to the process of writing a movie script where a main idea is formulated and characters are developed around it. There are a number of questions that are considered in scenarios building: What are the driving forces? What is uncertain? What is inevitable? Around these questions, a number of steps can be defined: (1) identify the focal issue or decision; (2) identify the key forces and trends in the environment; (3) rank the driving forces and trends by importance and uncertainty; (4) select the scenario logics; (5) flesh out the scenarios; (6) assess the implications; and (7) for monitoring purposes, select the leading indicators and signposts.

The ways of producing scenarios vary immensely—from the outputs of simulation models, through the work of small expert teams, to the undertakings of workshops and the delineation of different views in even wider samples of expertise. A popular approach for producing scenarios is through workshops, and this is briefly described here. First, a small group will be typically constituted—or sometimes, parallel small groups will explore different scenarios. A process will be used to obtain views as to critical choices and drivers that could differentiate or lead to distinctive futures. The most important of these will then be selected and used as the basis of an elaboration of the sorts of events that can unfold, and the sorts of end-states that might be reached. The group will then typically be requested to consider what the strategic options might be for the specific scenario to be achieved, or for the key actors to be able to cope with the situation represented.

Scenarios provide planners with one point estimates of innumerable possibilities of what the future holds. In doing so, they help participants to radically alter the way they think about the future: optimization against a specific future target is replaced by a balanced evaluation of the range of strategies that may be required. Participants understand better the alternative needs of futures and are able to develop better-informed strategies and policy options.

More details on the scenario method are provided later in the module.

Priority-setting

foresight studies are often conducted with the primary aim of identifying priorities for technology development and/or research spending. Such priorities are often inferred from some of the methods already described. However, there are also dedicated approaches to identifying priorities. The critical (or key) technologies approach has been used extensively for this purpose in the Czech Republic, France, the Netherlands and the United States. A more recent but increasingly popular method for setting research and technology directions is offered by technology roadmapping. Both approaches are often used independently of foresight exercises and sometimes are described as foresight exercises in their own right.

Critical or key technologies

Critical or key technologies are particularly useful approach as for assessing various technologies (or research directions) when selection of priorities is the major task of a foresight exercise. It is especially useful in situations where straightforward “discrete” recommendations for discussion at the political level are the prime objective. The sorts of questions that typically characterize a critical technologies exercise include:

- What are the key areas of R&D?
- What are the critical technologies (key research directions) that should be preferentially supported from (public) resources?
- What criteria should be applied to choose critical technologies?
- What are the most important measures that should be discussed at the policy level to enable implementation of the results?

A useful definition of critical technology should meet the following requirements:

- *Is it policy-relevant?* It should indicate where the points of potential policy intervention in the linked processes of R&D, commercialization, diffusion and utilization of a given technology are to be found.
- *Is it discriminating?* It should be able to discriminate unequivocally between critical and non-critical technologies. It should be as consistent as possible in level of aggregation and in clarity of classification;
- *Is it likely to yield reproducible results?* It should be sufficiently functional to enable the panels or agencies employing it to develop tests and methods that will prove to be functional, robust, and accessible to those not directly participating in the exercise.

The method is based on four generic steps. First, it is necessary to locate and select a cohort of experts for consultation. Secondly, an initial list of technologies is generated—this can be produced starting from existing lists (e.g. from previous foresight studies), or the list can be produced by a combination of brainstorming and bibliographic searches. In other cases, panels of experts are used in combination with patent analyses, bibliometrics and other studies. The third step involves clustering and prioritizing the list of technologies. This is typically done through discussion and often voting procedures. It is at this stage that the criteria of criticality are applied. Finally, the fourth step is to assemble the final list of critical technologies. The final list may be accompanied by "ID sheets" of identified critical technologies, specifying their main characteristics, application areas and the critical problems to be addressed. The outcomes of the exercise do not constitute final decisions; rather, they formulate important recommendations by experts to policy-makers .

More details on the critical technologies method are provided later in the module.

Technology roadmapping

Technology roadmapping (TRM) is used widely in industry to support technology strategy and planning. Increasingly, the approach is being applied in foresight studies, especially in those exercises that are focused upon particular industrial sectors. Technology roadmaps can take many forms, which can be attributed to the flexibility of the roadmapping concept. In general, however, roadmaps are comprised of multi-layered time-based graphical charts that enable technology developments to be aligned with market trends and drivers. In this way, research and other development directions can be established and actions determined in a goal-oriented manner.

More details on the technology roadmapping method are provided later in the module.

Some other techniques

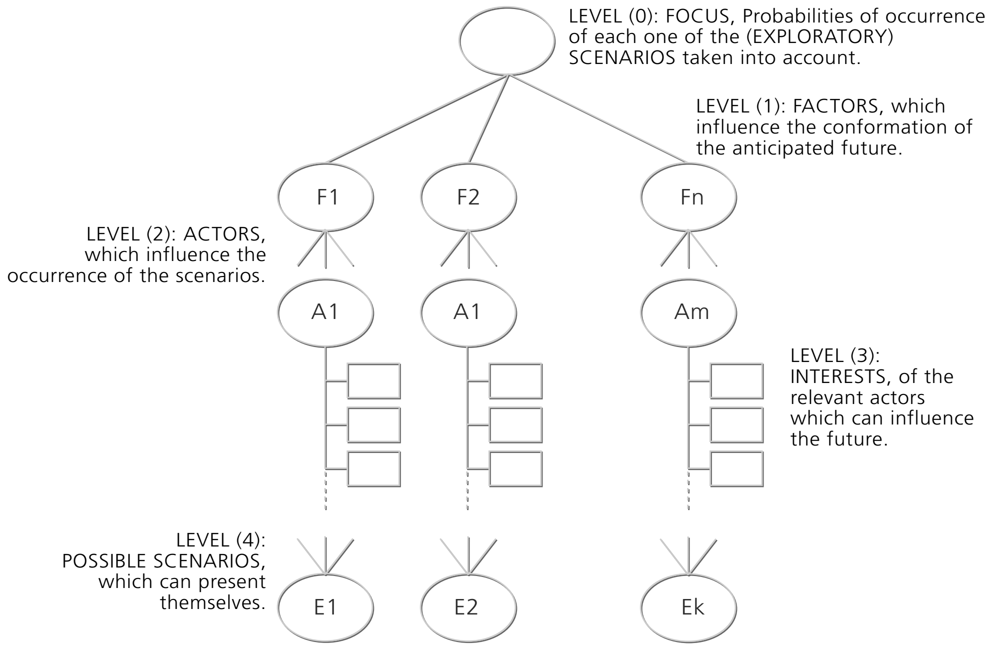
Analytical hierarchy process

The analytical hierarchy process (AHP) can be used to describe scenarios in terms of indicators. This technique was developed by Thomas L. Saaty, a North American mathematician who specialized in modelling problems pertaining to non-structured decision-making. Although fundamentally created as a backup tool for decision-making, the technique has also been applied to problems of future visualization. It is an interesting approach to problems relating to prospective technology (Morales, 2001).

Unlike other techniques used in this field, it focuses on the behaviour and decisions of multiple actors rather than on spontaneously occurring events. In this sense, the technique gives a causative perspective of the processes creating future scenarios.

The technique uses so-called hierarchical networks for constructing a model of the probability or the occurrence of each possible scenario. The team responsible for the management of the study must identify what these possible scenarios actually are.

Figure VIII. Generic hierarchical-network model for applying AHP techniques in prospective studies



Source: Morales, (2001).

The establishment of the probability of occurrence (reduction of uncertainty) of each scenario considered is determined by applying algorithms of the hierarchical-network model. The hierarchical network model, which is of a generic character applied in prospective problems, adopts the form illustrated in figure VIII.

The Bayesian model

The Bayesian model is not a technique to facilitate the construction of future scenarios, but one which allows us to understand which of the possible future scenarios will become a reality, based on observed evidence. It is a powerful tool for anticipating tendencies in a specifically determined scenario. The technique serves as a decision-making support tool that alerts us to what might occur in the future.

The technique involves the following steps:

1. Formulate the possible scenarios in the established time horizon for the TF study. This is usually done verbally, with a description of what may occur. Such scenarios must be mutually exclusive—that is, the occurrence of one scenario necessarily implies non-occurrence of the other scenarios that have been introduced. The other requirement is exhaustiveness—that is, the formulated scenarios must conform to the spectrum of everything which might possibly happen;
2. Assign the a priori or initial probabilities of each scenario in relation to the information available at the time the exercise is initiated;

3. Register the events which start to occur, i.e. those events constituting observable evidence;
4. Adjust estimates of the probability of occurrence of each scenario, based on observed evidence. These are known as “revised probabilities”;
5. Graph the results obtained in order to visualize the tendencies of probability of occurrence in every one of the scenarios.

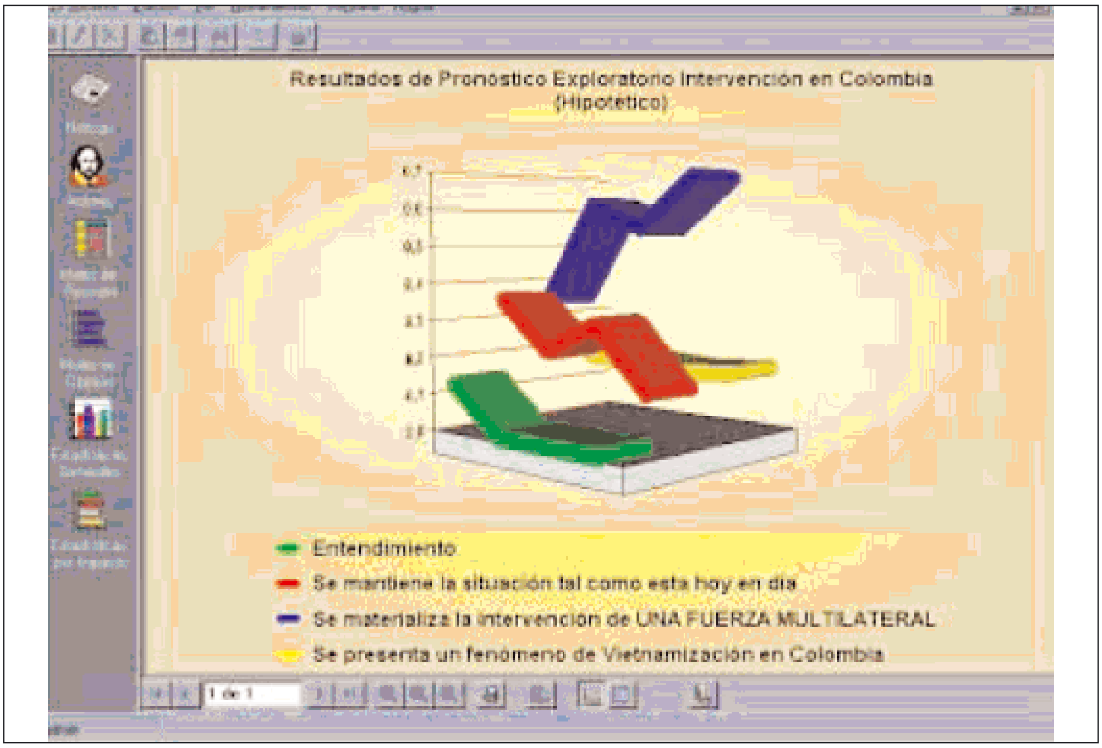
Although the calculation of the revised probabilities involves rather complicated formulas, software tools actually make the application very simple. The formula for the calculation of the revised probabilities of each scenario is the following:

$$P\left(\frac{H_i}{E_1,E_2,\ldots E_n}\right)=\frac{P^{*}(H_i)\times P\left(\frac{E_1}{H_i}\right)\times P\left(\frac{E_2}{H_i,E_1}\right)\times\ldots\times P\left(\frac{E_n}{H_i,E_1,E_2,\ldots,E_{n-1}}\right)}{\sum_{i=1}^{K}P^{0}(H_i)\times P\left(\frac{E_1}{H_i}\right)\times P\left(\frac{E_2}{H_i,E_1}\right)\times\ldots\times P\left(\frac{E_n}{H_i,E_1,E_2,\ldots,E_{n-1}}\right)}$$

(One type of software package available on the market for this type of technique is RADAR®, produced by Visión Grupo Consultores (www.visiongc.com).

Figure IX illustrates the results of an example of the application of a technique, using the appropriate software tools:

Figure IX. Results of an example of the application of a technique using the appropriate software tools



Source: Morales, (2001).

Morphological analysis

The morphological analysis technique was developed by Fritz Zwicky, a Swiss astronomer. This technique was originally directed at exploring new forms that systems could adopt from a technological point of view.

The technique is founded in the systems approach and requires the identification of the parameters of the systems under study. For example, in the design of automobiles of the future, the analysis would stipulate the type of parameters that characterize this type of transport system.

Some of the parameters for automobile design could be the following:

P1: Wheels.
P2: Brake system.
P3: Engine.
P4: Transmission.
P5: Engine type.
P6: Power source.

Once the characterizing parameters of the system have been defined, the possible forms for each of these descriptive parameters are identified. In the case of parameter P5—engine type—possible forms could be internal combustion, external combustion, turbine, electric, etc.

Based on the number of possible forms that each parameter can adopt, the possible morphological field is determined. If in the case of the automobile system, the number of possible forms of its descriptive parameters are: P1 = 2, P2 = 3, P3 = 4, P4 = 3, P5 = 4 and P6 = 5, then the morphological field will comprise 1,440 possible solutions (2×3×4×3×4×5 = 1,440). Of this "possible" morphological field, the "feasible" morphological field should also be determined, where only feasible elements will remain as solutions. For a solution to be considered feasible, the elements or forms in their different characterizing parameters must be compatible.

Critical evaluation of methodologies—comparison of Delphi, cross impact, the AHP technique, morphological analysis and Bayesian techniques

Figure X summarizes techniques to be used for types of existing problems and conditions in order to satisfy a requirement that has already been determined. It provides an orientation, which in addition to other more specific elements of information pertaining to the proposed requirements, will facilitate the selection of the technique or techniques to be used.

It is important to reiterate that it is perfectly feasible to make simultaneous use of two or more techniques in order to satisfy a requirement which has already been determined. For instance, applying the Delphi and Bayesian models for morphological analysis is a perfect example of employing two techniques simultaneously. The technique identified as "phase 1" in figure X pertains to the exploration of future scenarios. The "phase 2" technique pertains to follow-up exercises to determine which of the possible scenarios will actually materialize as based on the evidence presented.

Figure X. A comparison of some techniques applied in foresight

Technique	Type	Application in forecast and/or prospective exercises	Requirements for application
(1) Delphi	(Phase 1) Exploratory technique	Construction of exploratory scenarios; Forecast of the behaviour of variables or systems	A group of experts must be available for the subjects of interest; Simplicity is required in order to gather information; Specialized software is useful.
(2) Cross-impact matrices	(Phase 1) Exploratory technique	Construction of exploratory scenarios	A group of experts or specialists in the subjects of interest must be available; Specialized software required to conduct the simulation of events; The group which participates in providing the information must handle the concepts of simple and conditional probabilities with precision; The probability of occurrence of each possible scenario is sought.
(3) AHP technique	(Phase 1) Exploratory technique	Construction of exploratory scenarios; Forecast of the behaviour of variables and/or systems	A group of experts or specialists must be available in the subjects of interest; Specialized software is required to process the information; Participants must be familiar with the AHP technique; Information sought on which group of scenarios is the most likely to occur; Elements of causation in the contemplated scenarios can be determined.
(4) Morphological analysis	(Phase 1) Exploratory technique	Construction of exploratory scenarios	A group of specialists or experts must be available; Specialized software is required.
(5) Bayesian techniques	(Phase 2) Anticipatory techniques based on evidence	Forecast which of a group of scenarios will occur	A group of analysts with knowledge of subject-matter must be available; Specialized software is required; A group of analysts must be trained in the use of the Bayesian model.

Source: Morales, (2001).

Conclusions and recommendations

All of the methodologies used in TF exercises, irrespective of the complex mathematical models (as in the case of the Bayesian technique), numerical techniques or simulation techniques (cross-impact matrices) are, by definition, techniques of a qualitative nature.

The reason for this is that all of them take as inputs the opinions (value judgements) of the experts and/or analysts who participate in the study. Such opinions and value judgements are sustained by knowledge, experience, intuition and common sense. In this regard, all results obtained are approximations of what is possible; however, at no point are the numerical results to be treated as if they represent exacting accuracy. The techniques are a powerful and efficacious tool for approximating the future in a specific field, but none of the results should be viewed as fact.

2. DELPHI METHOD

The Delphi method consists of a survey conducted in two or more rounds and provides the participants in the second round with the results of the first so that they can alter the original assessments if they want to—or stick to their previous opinion. Nobody "loses face" because the survey is done anonymously using a questionnaire (the first Delphis were panels). It is commonly assumed that the method makes better use of group interaction (Rowe et. al., 1991, Häder/Häder 1995) whereby the questionnaire is the medium of interaction (Martino, 1983). The Delphi method is especially useful for long-range forecasting (20 to 30 years), as expert opinions are the only source of information available. Meanwhile, the communication effect of Delphi studies and therefore the value of the process as such is also acknowledged.

During the last 10 years, the Delphi method was used more often especially for national science and technology foresight. Some modifications and methodological improvements have been made; nevertheless, one has to be aware of the strengths and weaknesses of the method so that it cannot be applied in every case. It is useful for an assessment of new things to come and in cases that can be explained very shortly. This means for complex themes it is better to use other methodologies such as scenarios and to take into account what Delphi results can provide as single information pieces. Thus, Delphi studies were mainly applied in science, technology and educational contexts, but one can think of different occasions.

Delphi studies are rather complex procedures and require some resources depending on the breadth of the study planned. Delphi studies are processes that include preparation, a survey in two or more rounds and some analyses and application (implementation) when the survey is finished. All three phases are important and are addressed here.

History of Delphi

The Delphi method belongs to the subjective-intuitive methods of foresight. Delphi was developed in the 1950s by the Rand Corporation, Santa Monica, California, in operations research. The name can be traced back to the Delphic oracle, as Woudenberg (1991, p. 132) reports that the name "Delphi" was intentionally coined by Kaplan, an associate professor of philosophy at the UCLA working for the RAND corporation in a research effort directed at improving the use of expert predictions in policy-making. Kaplan et al. (1950, p. 94) referred to the "principle of the oracle" as a "non-falsifyable prediction", a statement that does not have the property of being "true" or "false". Thus "Delphi" for the modern foresight method seems to be more than a simple brand name.

The foundation of the temple at Delphi and its oracle took place before recorded history. Thanks to archaeologists and historians we have extensive knowledge of the functions and benefits of the oracle (Parke/Wormell, 1956). For a thousand years of recorded history the Greeks and other peoples, sometimes as private individuals, sometimes as official ambassadors, came to Delphi to consult the prophetess, called Pythia. Her words were taken to reveal the rules of the Gods. These prophecies were not usually intended simply to be a prediction of the future as such. Pythia's function was to tell the divine purpose in a normative way in order to shape coming events.

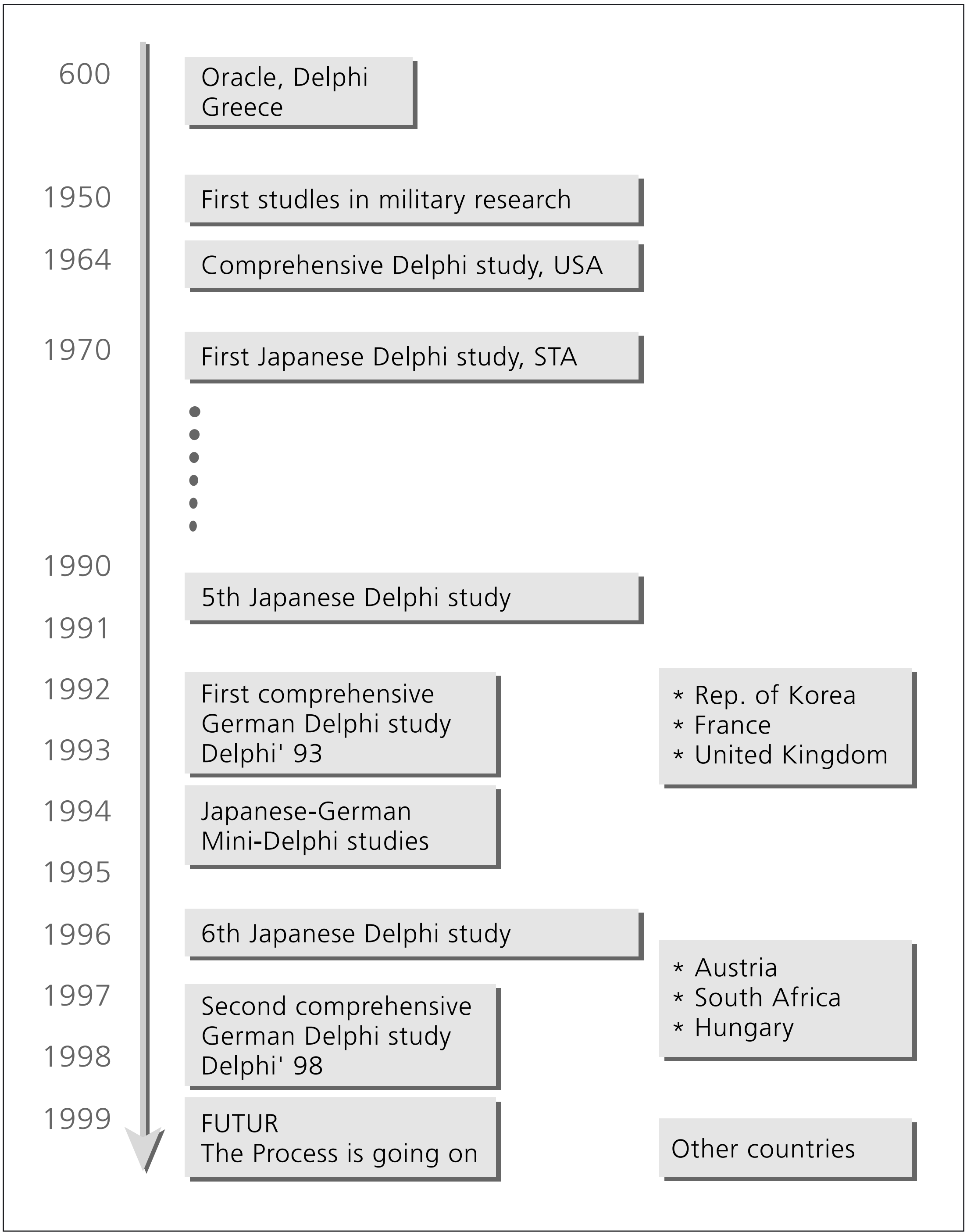
One should consider that the Delphi monastery was one of the very few spots on earth where knowledge was accumulated, ordered and preserved. The information came from the ambassadors through their queries and the answers were written on metal or stone plates, several of them discovered by archaeologists. The temple was the locus of knowledge, or, if we put it more mundanely, the Delphic oracle was probably the largest database of the ancient world. The priests could read and write; who else could do so in Greece? If due allowance is made for these circumstances, modern psychology will not find special difficulties in accounting for the operations of the Pythia and of the priests interpreting her utterances. Knowledge was intended to be used and disseminated to make the world a better place.

Certainly, the consultations were religious in form and not mere inquisitive speculations on the future or attempts to obtain practical shortcuts to success, but at least in earlier periods religion entered into every aspect of Greek life and there were few subjects on which the advice of Apollo was not sought (Parke/Wormell, 1956). There is no doubt that the oracle acted as an international arbitrator. It shared the rise of Hellenic civilization to which it contributed no small part. It is no wonder that a witness of that time, Socrates, judged: "The prophetess at Delphi (...) turned many good things towards the private and the public affairs of our country" (Socrates ca. 400 BC).

Thanks to the oracle, the Greek people learned over many generations to abstain from bloody vendetta, to apply to courts when quarrelling in private life occurred, and to solve disputes in a fair way. It can be traced back to the oracle that one should not poison the well of one's enemy and should take care of the olive trees in war. Thus the idea of the long-term oriented development of landscaping achievements we owe to the Delphic oracle. Based on this impressive historical material, let us turn now to the routes of the modern Delphi method.

In figure XI, as an illumination of the "genealogical tree" of the Delphi technique, the major steps achieved in a chronological manner are listed. The major national endeavours using the Delphi technique are taken into account, but not for example the many experimental or scientific applications where, say, 20 students are engaged in the frame of a master's or doctoral thesis. Also not included are business applications on a more focused and less sophisticated level. It has to be stressed here that the focus lies intentionally on large holistic surveys with a likely impact on society. For the other types of Delphi applications, refer to business management text books or monographies on strategic planning where Delphi applications are mentioned among the other tools (compare Linstone/Thuroff, 1975; Martino, 1993; Jantsch, 1967; Cuhls, 1998).

Figure XI. Genealogical tree of Delphi



Source: Cuhls, (2003).

The initial work, as stated above, was performed at RAND after 1948. In 1964, for the first time, a huge Delphi survey in the civil sector was published (Gordon/Helmer 1964). Shortly after, the lead in further development and broader application of the Delphi technique was taken over by Japan. Japan started its development of S&T later than western countries but was nevertheless immensely successful. There are many success factors for this story—and one of them was the adaptation of large foresight studies at the end of the 1960s. In Japan, the Delphi method was selected for foresight activities, and the Science and Technology Agency in 1969 started to conduct a large study on the future of science and technology. Before, in a systematic attempt, foresight knowledge from the USA was invited. Although the first large Delphi study in Japan did not correctly describe the oil price shock and was conducted and published just before that happened, the Japanese Delphi process continued every five years. It is regarded as an update of data concerning the future. In 1997, the sixth study was finished, the seventh was published in 2001, the eighth is in preparation.

With the resurrection of foresight in general and the possibilities to filter all these “options” of different actors, the Delphi technique was taken out of the toolbox and implemented in Europe in a different manner than in the early years. In the new wave of large-scale government foresight in Europe, Dutch and German government agencies and similar bodies were among the first, with France and the United Kingdom joining in quickly. The Germans organized a learning phase starting both from the “mediating” publication of Irvine and Martin (1984) as well as from Japanese experiences and cooperated in their first Delphi with the Japanese fifth endeavour (Cuhls/Kuwahara, 1994). France in turn followed in just copying the German approach. In none of these countries was a sole resort to the Delphi technique considered useful. In the Netherlands, Delphi methods were not embarked upon at all, whereas in Germany parallel approaches are reported, some using the Delphi method, others not. The same is true for France where a Delphi survey and the critical technologies approach (Grupp, 1999) were pursued in parallel and organized by different, even competing ministries. Again in cooperation between German and Japanese institutions, joint methodological developments were achieved in the frame of a “Mini-Delphi”.

Definition of Delphi

The *Delphi method* is based on structural surveys and makes use of the intuitive available information of the participants, who are mainly experts. Therefore, it delivers qualitative as well as quantitative results and has beneath it explorative, predictive even normative elements. There is not the one Delphi methodology but the applications are diverse. There is agreement that Delphi is an expert survey in two or more “rounds” in which in the second and later rounds of the survey the results of the previous round are given as feedback. Therefore, the experts’ answers from the second round are under the influence of their colleagues’ opinions. Thus, the Delphi method is a “relatively strongly structured group communication process, in which matters, on which naturally unsure and incomplete knowledge is available, are judged upon by experts”, (Häder and Häder 1995, p. 12).

Wechsler (1978) characterizes a "Standard-Delphi-Method" in the following way: "It is a survey which is steered by a monitor group, comprises several rounds of a group of experts, who are anonymous among each other and for whose subjective-intuitive prognoses a consensus is aimed at. After each survey round, a standard feedback about the statistical group judgement calculated from median and quartiles of single prognoses is given and if possible, the arguments and counterarguments of the extreme answers are fed back...". This sounds a bit complicated but the essentials are:

- Delphi is an expert survey in two or more "rounds".
- Starting from the second round, feedback is given (about the results of previous rounds).
- The same experts assess the same matters once more—influenced by the opinions of the other experts.

Characteristics of Delphi are therefore specified as (Häder/Häder, 1995):

- Content of Delphi studies are always issues about which uncertain respectively incomplete knowledge exists. Otherwise there are more efficient methods for decision-making.
- Delphi is a judgemental process about uncertain issues. The people involved in Delphi studies only give estimations.
- The experts are involved on the basis of their knowledge and experience. During the rounds, they have the opportunity to gather new information.
- The psychological process in connection with communication is emphasized. (Pill, 1971, p. 64; Dalkey, 1968 and 1969; Dalkey/Brown/Cochran, 1969; Dalkey/Helmer, 1963; Krüger, 1975).
- Delphi tries to make use of self-fulfilling and self-destroying prophecies in the sense of shaping or even "creating" the future.

When does the use of a Delphi make sense?

The Delphi method is mainly used when long-term issues have to be assessed. As it is a procedure to identify statements (topics) that are relevant for the future, it reduces the tacit and complex knowledge to a single statement that it is possible to make a judgement upon. Therefore, it can be useful in combination with other methodologies like scenarios, technology lists, etc. On the other hand, in more complex issues, when the themes cannot be reduced to relatively simple statements or when thinking and discussions of alternatives are required, Delphi is not the method of choice. It is also suitable if there is a (political) reason to involve many persons in the process (Eto, 2003).

The Delphi technique as a foresight tool has survived the changing challenges of the past 50 years. The method can serve different understandings of forecasting or foresight and has been used for covering technical perspectives, organizational perspectives, and also personal perspectives. Individuals can express a distinctly different opinion as compared to the group perspective. As multiple perspectives are recommended for decision-making, (Linstone/Mitroff, 1994; Linstone, 1998) the Delphi technique seems to have an appeal in quite diverse situations with long-term implications. As it can be shown in controlled scientific experiments that the position of Delphi estimates is not better than those of other consensus-oriented methods (Woudenberg, 1991) it must be the communicative force of Delphi approaches that facilitates the switching between different perspectives. What users especially like are the sets of data about the future that are gathered. Writing down future topics seems to have an immense psychological effect because it transfers implicit and tacit knowledge into more visible, explicit, and therefore transferable knowledge.

Nevertheless, the danger that many persons regard this as “the future” that “will come true” cannot be neglected. When the media in Germany used Delphi ’98 data for an outlook into the next century, they often made the mistake of arguing that the future will be like it is described in Delphi ’98 disregarding that the decisions of today (or non-decisions) have a strong effect on the things to come and that Delphi can only provide “potential answers” to problems that can already be identified today.

How to organize a Delphi process

There are different ways to in which to organize a Delphi process and before starting, it is important to answer the following questions:

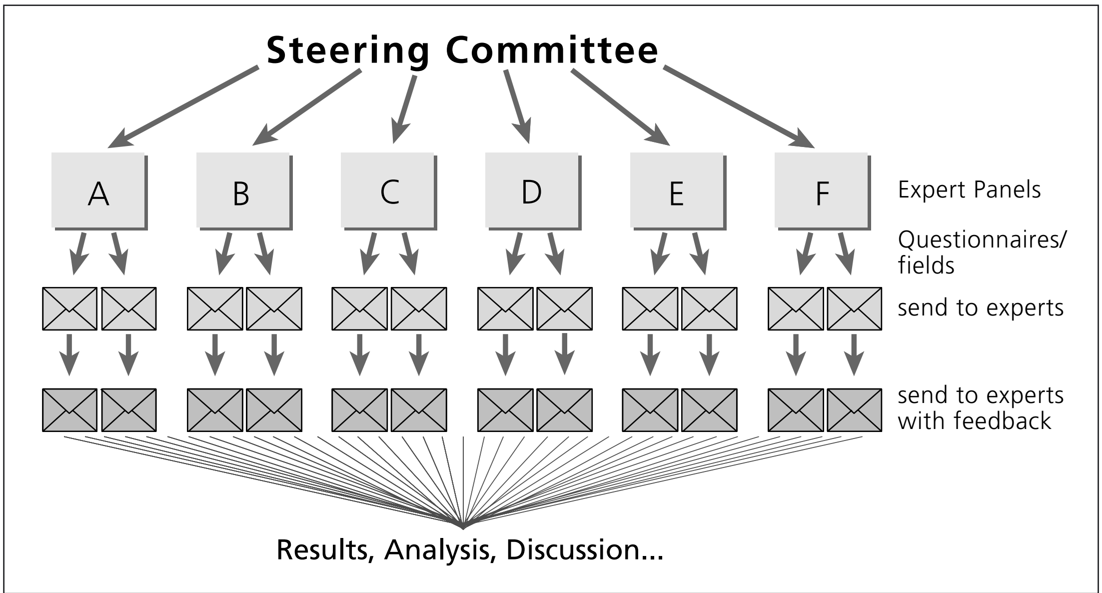
- What is my objective?
- What resources (manpower, money...) do I have?
- Is Delphi the right choice?
- How can I formulate the statements?
- What are my questions?

The formal organization of a Delphi process

Delphi is usually used in combination with other methods. For example, the topic statements have to be formulated, a process that requires methods such as creativity procedures, scenarios or future workshops. In the following, a more “standard” procedure is described. It starts with the organization of the process as such. In figure XII, this is illustrated by the “real” example of the Delphi ’98 in Germany (Cuhls/Blind/Grupp, 1998 and 2002).

The first step is to set up a steering committee (if you need one) and a management team with sufficient capacity for the process. Then expert panels can be used to prepare and formulate the statements unless it is decided to let that be done by the management team. The whole procedure has to be organized in advance: Do you need panel meetings or do the teams work virtually? Is the questionnaire an electronic or a paper one? This means, that logistics (from Internet programming to typing the results from paper versions) have to be organized. Will there be follow-up workshops, interviews, presentations? If yes, these also have to be organized and prepared. Printing of brochures, leaflets, questionnaires, reports have also be considered. The last organizational point is the interface with the financing organization if this is different from the management team.

Figure XII. Organization of a Delphi survey



Source: Cuhls, (2003).

How to formulate topics

When the organization is roughly defined, the fields of the Delphi should be decided. In some cases, one thematic field is enough, but in many cases the purpose is to get an overview of several fields. The number can be flexible. There is always the possibility to add, remove or re-name fields. To give some examples, the German Delphi '98 (Cuhls/Blind/Grupp, 2002) fields were:

- Information and Communication
- Service and consumption
- Management and production
- Chemistry and materials
- Health and life processes
- Agriculture and nutrition
- Environment and nature
- Energy and resources

- Construction and dwelling
- Mobility and transport
- Space
- Big science experiments

Then, the topics have to be formulated. This is a time-consuming process. It has to be clear where the topics stem from. The easiest way is desk research and to take topics from literature and surveys that are available. But the more creative way is to use working groups to structure the field and formulate topics. One can start from scratch, but then it is very difficult to focus the themes. Therefore, the more efficient way is to feed in already existing material from re-search. Then brainstorming, brainwriting or other creativity activities can add themes. When there is a critical mass of topics, you need a filter system. What are the topics that are relevant for your specific Delphi with your specific objectives? Here you can already make some formal or informal judgements. It is recommended not to have more than 50 topics per questionnaire but it may also depend on the questions you intend to ask

It is also helpful to start structuring the field before the creative phase and then flexibly adapt the structure of a field. Figure XIII is one example from services and consumption in the Delphi '98:

Figure XIII. Structuring example from the German Delphi '98

New services (based on new media)

Teleshopping

- electronic supermarkets
- biometric technics for the authentication of trade transactions

Finance services

- digital money for electronic money transactions
- permanent monitoring as deterrence against money-laundering and fraud
- robot-leasing

Leisure

- pay-TV
- virtual reality for journeys, sports events, film shows, etc.

Source: Cuhls, (2003).

Therefore, it is often necessary to filter twice or even three times because the experts in your working groups often add topics instead of reducing the number. The last step is the final formulation. Often there are stereotypes of verbs (e.g. for science and TFs), that, for example, indicate innovation phases (is elucidated, is developed, is used, is in widespread use) so that the topics are clear. The topics have to be formulated in a way that misunderstandings are minimized. It is also necessary not to have two different things mixed in one topic. And the topics have to fit your questions, so that the questions can be answered or the criteria you have can be judged upon.

The next step is to develop the criteria. It depends on the questions to be asked but among the major criteria or questions are always those about the estimated time of realization. Others are necessary for the assessment of the validity of sample and answers like the self-estimation of the "expertise" of the participants. Here are some examples from national Delphi studies (e.g. the German Delphi '98, Cuhls/Blind/Grupp 1998 and 2002, or the 5th Japanese Delphi, NISTEP 1997).

Are they important for:

- The enlargement of human knowledge?
- The economy?
- The development of society?
- The solution of environmental problems?
- Work and employment?
- Or are they unimportant?

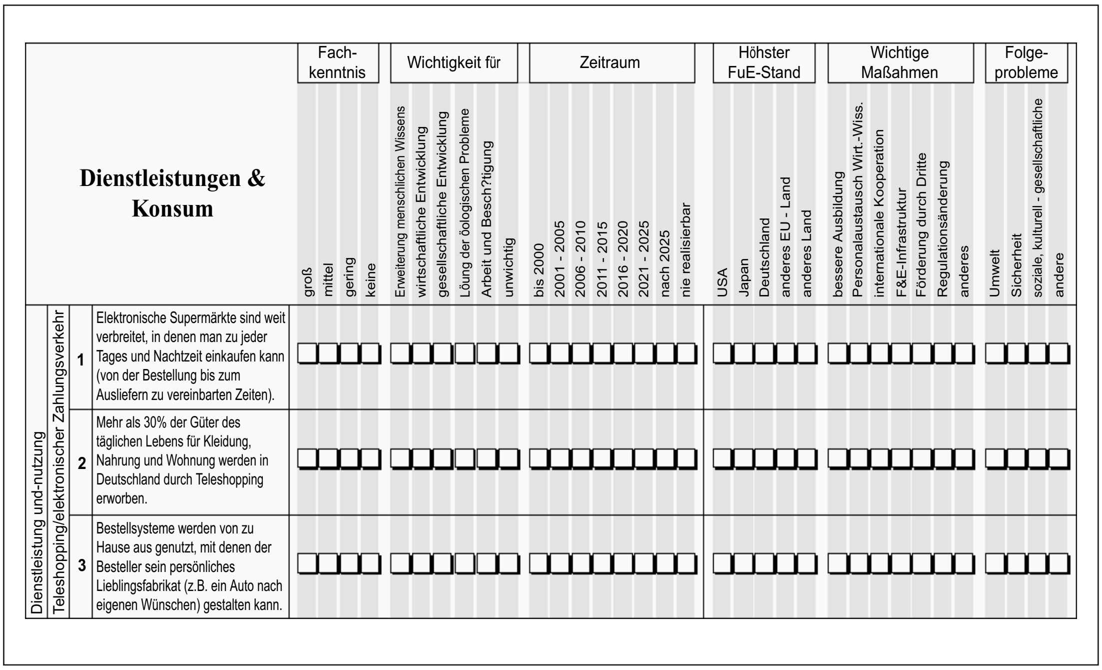
Other criteria can be:

- What is your expertise on the specific topic? Is it very high (do you work in the field), is it high, medium or low?
- Which country is leading in the field?
- What measures should be taken? Here, options can also be given, e.g. better education, more financial support, etc.

The time of realization is normally asked in five-year steps because single years would be so exact that nobody would be able to estimate. The normal time horizon of Delphi studies is 30 years ahead but it is also helpful to ask for a later time (after 30 years) or "never". The analysis is often done in percentiles (lower quartile, median, upper quartile) in order to show the breadth of the opinions. But simple graphics or percentages can also be used, especially if there is the hypotheses that "statistical camels" occur (there are two opposing groups of participants, one part judges an early time, added normally by high importance, and the other with late time horizons and low importance, representing different lobbies, or different schools of thought). The presentation of the data should be thought of in advance and depends on the "clients" or users.

It is always useful to have open questions. The illustration of the design of the Delphi '98 questionnaire is only a part and the "comments" are missing. What is often done is to have a part on comments or to ask for new questions, topics and alternatives to the statement given (e.g. in the German mini-Delphi, see Cuhls/Breiner/Grupp, 1995).

Figure XIV. Example of a questionnaire design



Source: Cuhls, (2003).

When designing the questionnaire (for an example see figure XIV), it is important to consider from the beginning how to give feedback to the participants during the second round. A usual way is to provide percentages or graphics from the accumulated data in a similar form as in the first round questionnaire. But that often gives the impression of a very "full" picture and too much information has to be shown on one page. The new electronic media provide many more possibilities. There is much room for creativity.

Dimension of a study, resources needed

As in all processes, the resources are crucial: Is there enough money, time and personal capacity available? Therefore, one has to calculate from the beginning, what resources are needed. Delphi surveys belong to the more resource-intensive foresight approaches, but also here, there are differences. A Delphi survey with statements from literature and an already existing database for addresses in one field sent by e-mail is relatively cheap (cheaper than e.g. workshop approaches). Huge processes with preparation workshops, a database that still has to be created and a larger range of fields is expensive. In many cases, printing costs make a huge part of the overall costs (e.g. if you print questionnaires, leaflets and reports).

Public relations activities and awareness campaigns can also be very costly. Here, no estimates can be given as especially costs for staff vary a lot between countries. Just to give a number: the raw German Delphi '98 cost about Euros 700,000 including the end report (re-financed via selling it; it was only free for participants). Follow-up additional expenses were paid for international comparisons, presentations, newsletters, conferences, etc. Thus, it is recommended to answer in advance the following questions which determine the costs:

- Do you intend to have many workshops? How many? They can be calculated easily.
- What do you intend to print? Do you need designers?
- How much programming is needed?
- How many participants do you have? This determines the number of questionnaires but also the number of persons to nominate and addresses you have to deal with in your database.
- Do you pay participants?
- Do you need to type the results (e.g. from a paper questionnaire)?
- What are the management costs? What are your salaries? And how many external persons contribute to the process that they have to be paid, too?
- How much follow-up/PR do you intend? How do you intend to present the end results?

Delphi processes are rather time consuming. Therefore, a Delphi needs some time especially when postal delivery is planned. But also for an Internet or electronic versions, the participants need time to answer the questionnaire. Preparation time, analyses and implementation should also be calculated. Therefore, for a larger Delphi with different fields, at least one year should be calculated.

Who is involved? Who is an expert?

These questions sound trivial but they are not. Most science sociologists assume that there is a positive relationship between involvement in a research area and assessments of it and that this relationship derives from the tendency of scientists to select problems in areas where there is high pay-off for successful solutions and career. The tendency to overrate fields in which a person works may be termed “bias”. Not only a tendency toward positive bias for fields in which researchers have been active was found, but also that this bias is stronger in less innovative sub-fields. As market signals fail to be useful for business strategy in the long run and expert assessment is not always objective, Delphi surveys may play a part in science and innovation management.

There are three examples from the first German Delphi ’93: first, in the field of volcanoes, there were so few specialist experts, as this is not a direct danger for Germany, that the topic could not be analysed as a single item (volcanoes are an issue in Japan, and Germany was using the Japanese Delphi in this survey). Secondly, specialist experts and thus future knowledge may not be available in some countries. The availability of experts in the case of biotechnology in Germany was mixed. Among the 73 respondents who were all experts in biotechnology, many did not answer in particular sub-areas (most expressed for tissue and organs). The largest number of specialist experts (i.e. those working in the sub-area) among all experts in Germany is found in molecular biology, but not in the sub-area of tissue and organs. An almost perfect correlation was found between the number of experts and their rating of German research performance. In sub-areas where Germans know more, they are good. In sub-areas where they are not advanced, they know little of the opportunities.

A test for Delphi expert bias in the energy area from the German Delphi '93 tends to support that view. Top experts rate the importance of their own research speciality significantly higher than the other experts—both in Japan and in Germany. At the same time, the top experts downplay technical constraints in Germany (less so in Japan) in their own working area (see Cuhls/Kuwahara 1994). An unwanted test also made clear that the "higher level" experts also do not tend to change to the direction of the mainstream answers and remain with their opinions in the second round (see Cuhsl/Breiner/Grupp 1995).

In the Delphi '98, this is not so obvious. There are topics for which the specialist knowledge experts see more problems (or ask for more measures to be taken), but for others all the other persons ask for more measures. In some cases, the special experts rate the topic to become reality earlier than the "medium" and "lower level" experts, in other cases, they are much more reluctant with a prognosis on the time horizon. What can be observed is that in the first round, more experts claimed to work on the field (13.5 per cent) than in the second round (10.18 per cent). This could be for several reasons. New foresight approaches tend to involve more and different stakeholders of the innovation systems in order to provide multiple perspectives (Cuhls 2000, Linstone, 1999) on the issues. Therefore, more and more, the expert definition is broadened. Often persons are involved, who know about the subject, whatever their special expertise. Participants have to be selected carefully according to the themes required. It is recommended to invite a mixture of persons from industry/business, academia, research institutions, etc.

As in all surveys, the sample in the end needs to be large enough to draw valid conclusions; therefore the number of answers per topic has to be high enough. The sample as such also has to be selected and additionally to the already mentioned criteria, the sample mix should comprise, for example, persons from different age cohorts, sector groups, etc. Often, female participants are under-represented, which is always a problem that has to be dealt with. Lobbying should be avoided or dealt with (e.g. involve the same number of persons from the different lobby groups).

To identify addresses is less and less difficult: Internet, databases, trade fair catalogues, members lists, etc. can be obtained rather easily. To structure the database in order to facilitate mailing, storing data and at the same time meet data security standards is more difficult but has also to be considered.

How many participants do you need? That depends on the number of topics, the fields, the expected response or participation rate and other issues. If a small Delphi in a computer groupware room is used, the sample will be very small. If a national foresight with a specific representativeness is asked for, many persons are needed and it is often attempted to achieve about 100 answers per topic. But this also depends on the country. In a small country, you cannot expect so many experts in the field. And in some future-oriented fields, there are only a few persons available, even in large countries. To involve the general public in such an endeavour is generally possible, but then, the questions have to be rather simple and easy to understand. In Internet surveys, it is very difficult to hold the control on the sample; this should also be taken into account.

Analysis of results

As in most Delphi surveys, you gather a lot of statistical data that can be used in very different ways. But also comments are often requested and can help to interpret the statistics or be analysed in a qualitative way. Especially the combination of Delphi and scenarios makes many qualitative presentations possible. The following examples are just a few from the possibilities available. Looking at the different international reports, there is a wide range of possibilities. What a Delphi manager should do is to think about the analysis in advance because this has implications for the criteria and the whole design of the questionnaire as described above.

Rankings

Figure XV. Ranking of agreements on megatrends

Megatrend	Agreement	Time Frame	Disagreement
In industrialized countries over 1/3 of the population will be older than 60 years.	89	2008-2019	7
The unemployment rate will increase permanently in the developed countries.	74	1999-2006	22
World population wil surpass the 10 billion border.	72	2010-2025	19
Germany will again become an internationally attractive location for investment.	61	2003-2009	27
Women will at least keep one-third of all executive positions in business.	57	2008-2020	32
Rationing of energy consumption for private households will be enforced.	54	2011-2025	41
Increasing environmental problems will negatively affect the health of most people.	53	2003-2015	42
A European government will be developed that will substitute national sovereignity.	52	2010-2024	42
Increasing individualization hamper the functioning of representative democracies.	49	2003-2012	33

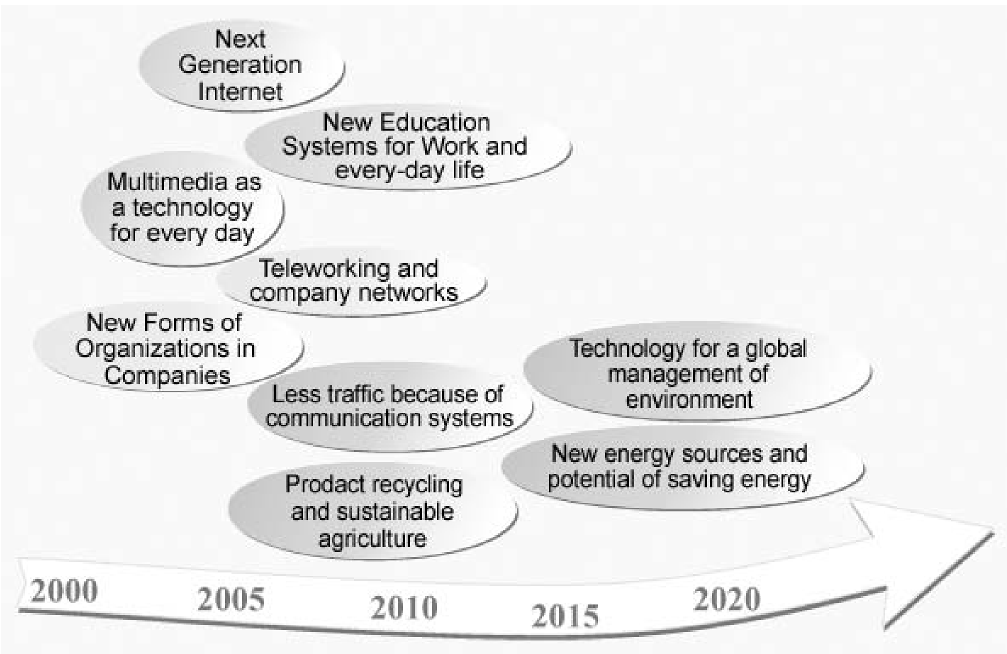
Source: Cuhls, (2003).

Simple ranking of statistical data is the easiest way of presenting results. First the data has to be aggregated; sometimes an index has to be built. Often, the importance categories are used to figure out the most significant topics. But also the measures or other assessments can be ranked. The early Japanese Delphi studies worked a lot with rankings (e.g. also NISTEP, 1997). Figure XV stems from the Delphi ’98 but is of a different character. Here, megatrends are ranked according to the level of agreement (persons could indicate agreement to a topic or not) The megatrends were then used to analyse the personal opinions of the answering participant cohorts by a factor analysis (for details, see Blind/Cuhls/Grupp, 2001).

Qualitative clustering

Another possibility is a half quantitative and half qualitative form of analysis. In the Delphi '98 the most important topics from the different importance categories (for the economy, the society...) were ranked and those which were most frequently highly scored were clustered qualitatively and described under a joint heading. This was done to provide a very compact picture of results. Figure XVI illustrates this. It can be argued that this is a bit arbitrary, but the fact that ICT technologies invade all other fields and other clusters could easily be backed up by statistical data. The arguments for clustering were described in detail in the results.

Figure XVI. The most important topic cluster



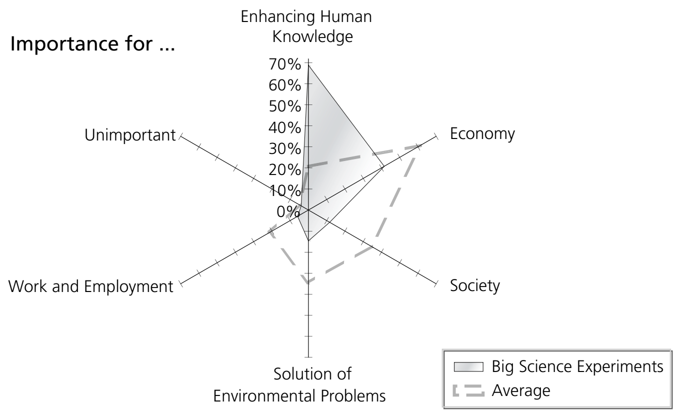
Source: Cuhls, (2003).

Different graphics

As in every report, graphics are useful to illustrate and make understanding easier.

Figure XVII shows an example for the different importance categories of the Delphi '98 (all data compared with the innovation field, big science experiments).

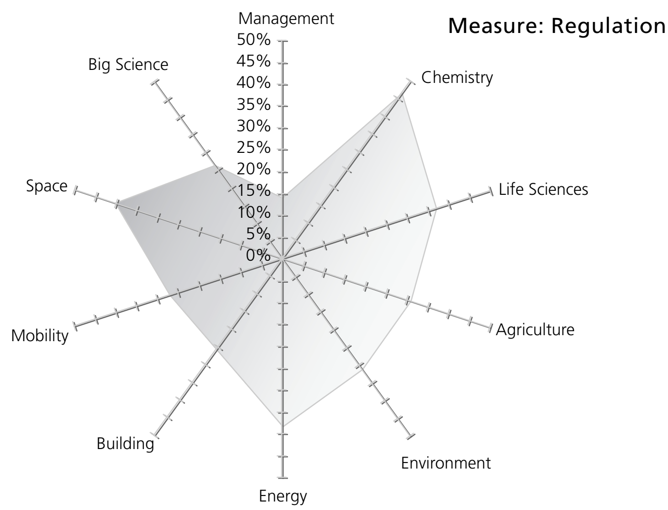
Figure XVII. Importance categories



Source: Cuhls, (2003).

Figure XVIII shows a different approach. Here the question was not about the categories but in which innovation fields there is the highest demand for new regulation, different or less regulation (category: measure regulation). The result is not shown in a simple ranking but in a graphic which is scaled only up to 30 per cent because (interestingly for Germany), this issue did not often arise. The results can be interpreted in more detail from the comments. Later on, single topics were identified, and deepened in interviews.

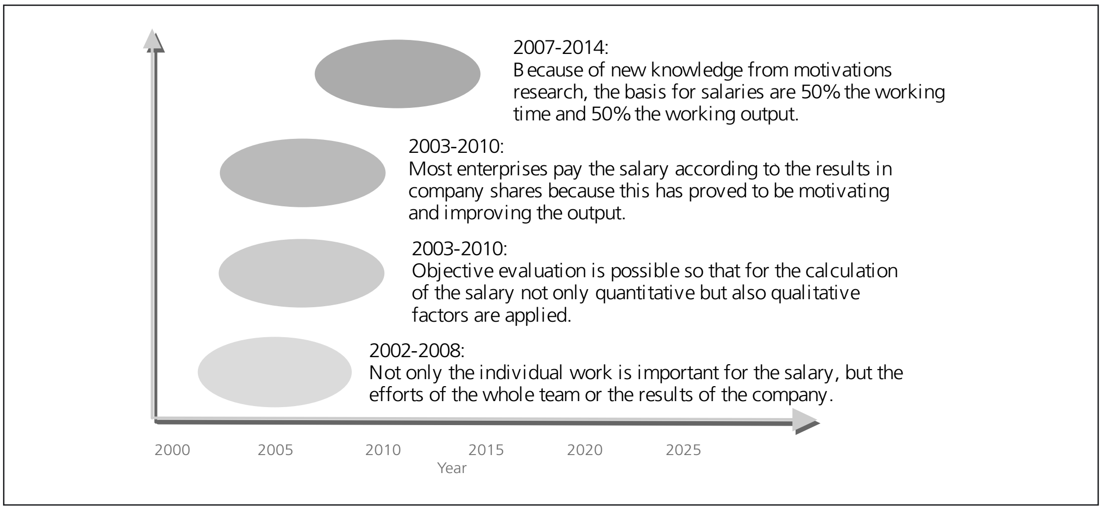
Figure XVIII. Measure regulation judged in the different innovation fields



Source: Cuhls, (2003).

Scenarios or roadmaps

Figure XIX. Example of a "roadmap" from the field of mangement and production



Source: Cuhls, (2003).

As in most Delphi surveys, a question about the time of realization was included, and from this information small roadmaps of the field can be drawn. If the categories and statements fit each other, small scenarios can also be derived. Figure XIX shows a kind of roadmap concerning the development of salary payments in Germany. This analysis can also help to identify breaks in the assessment of the statements. Checks can be made to see if it is plausible if one development is realized earlier than another. It could be the case that a technology that would be necessary for a particular development of another one has not yet been developed—the experts judging that the dependent one occurs earlier; this would lead to a question of plausibility. In the German Delphi '98 breaks were found, especially in the field of management and production, but no implausibility.

To be able to compare topics, it is important to formulate them in an identical way. Figure XX gives an example from the Delphi '98. It is a comparison of the most important topics for the economy in the field of agriculture and food in the German and Japanese Delphis (ranked according to the difference).

More sophisticated calculations and matrices

More sophisticated calculations and matrices are possible. The Japanese colleagues even tested fuzzy logic and in the Japanese-German comparison a kind of input-output model with a specific software (DEA) was applied (for details see Cuhls/Kuwahara 1994). There are different questions that can be tested. One check concerned if there is a correlation between the importance and the time of realization in a Japanese-German comparison. In figure XXI this graphic is shown. It demonstrates, that the hypotheses "the higher the importance, the earlier the topic" Japan, although there is the tendency in Germany that earlier topics have slightly higher importance rates.

Figure XX. Comparison of identical topics in the field of agriculture and food

Agriculture and Food	Germany Importance for the economy	Japan Importance for the economy
Plants which are specially cultivated for resistance to drought and salt and provide barriers to desertification are in practical use.	78.3	25
Cell fusion and gene technology will make possible the cultivation of new breeds of fish which are very suitable for fish farming due to their strong resistence to disease and fluctuations in water temperature.	93.8	56.3
The cloning of prize-winning high-performance cattle by core transplantation is practised.	95.0	46.1
In order to achieve certain breeding goals (resistence to disease, fertility) in domestic animals gene transfer to fertilized eggs or to early mammal embryos is practised.	91.3	44.4
Techniques are widespread, e.g. using microorganisms, which enable earth-bound phosphorus to be absorbed by cereals.	79.8	22.4
The use of transgenetic animals, into which genes that hamper or prevent the defensive reactions in xenotransplantations were transplanted, is widespread for the transplantation therapies of inner organs.	50.0	37.2
A system to utilize marine organisms and their environment is achieved which can keep the balance between the exploitation by the fishing industry and the habits of fish shoals under the prevailing biological aid ecological conditions.	61.5	25.7
Biological control systems are widespread which offer protection against disease and vermin through biological pesticides (natural microbial enemies. pheromones etc.).	74.3	26.2
Biodegradable packaging manufactured from renewable raw materials are in common use.	70.5	50.8
After the mechanisms of forms and functions of the ecosystems are understood, rational monitoring and exploitation procedures for rainforests, including the presently existing life forns, will be implemented in tropical regions.	50.7	10.6

Source: Cuhls, (2003).

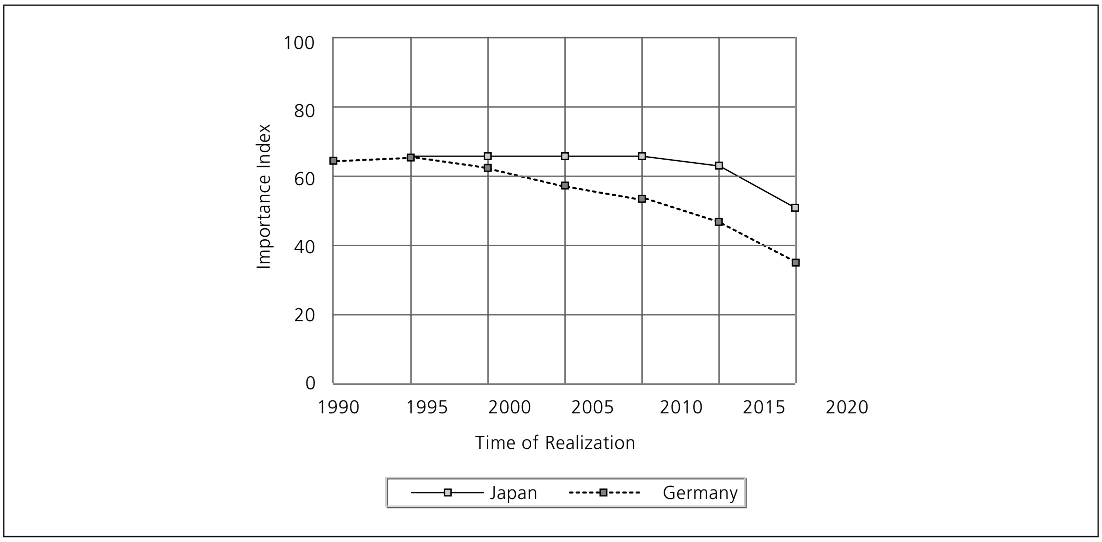
But these are just a few examples: with creativity, many different analyses and results can be obtained.

Implementation

In some surveys, it is enough to provide results in the form of graphics or statistical analyses as "information about the future". But how can the "results" be used further? New foresight processes should be more than just providers of data and results. As the providers of foresight results and the users, which means the decision-makers, are in most cases not the same persons, there remain difficulties of:

1. Bringing them together.
2. Linking the needs of the users and the concepts of the methodologies.

Figure XXI. Importance index versus time of realization



Source: Cuhls, (2003).

3. Making potential users aware of the possibilities (marketing) so that they have choice.

4. Establishing mechanisms of transfer.

5. Delivering results that are useful.

6. Involving persons who have the power to decide and implement.

Until recently, the use of foresight results in Germany and other countries have been based on ad hoc activities. But there are different possibilities (see Cuhls/Blind/Grupp, 2002). One of the most interesting was the use in an evaluation of the Fraunhofer Society by an international panel using a SWOT analysis. There were many different uses of Delphi '98, especially by companies, but a more strategic approach would certainly bring more results.

Some recommendations

The major recommendation is to clarify the objectives of the foresight approach at the start. The second is to ascertain if a Delphi is the right choice and if there are enough resources for a Delphi (this is rarely possible without the combination of creativity methods and those for the formulation of statements). If you have considered all the pros and cons, and you decide to conduct a Delphi, then consider at least the following:

- What should be the breadth of the study?
- How many and which fields should be included?

- How will the study be organized? Who manages the process?
- Who will be invited to participate (active or non-active)?
- What results can be expected?
- What questions are to be asked?
- How is the questionnaire to be designed?
- What kind of analysis is required?
- How do you intend to implement the results?
- Will there be follow-up activities (public relations, publications, workshops, presentations, conferences etc.)?

These questions should be considered as early as possible.

Delphi is a very interesting tool, especially for companies but also research organizations who for example in Germany were the major users of data and who also conducted their own Delphi processes. Delphi has its advantages and disadvantages that are described above and elsewhere but the major danger is—as in all foresight processes—to regard the results as facts because they are presented in the form of data. They are working tools and although information about the future is provided, the future cannot be predicted and will always be different from what you expect.

3. BRAINSTORMING: A CREATIVE PROBLEM-SOLVING METHOD

Creativity and the generation of new ideas are no longer the sole preserve of a few eccentric companies, but a daily necessity for all businesses and organizations around the world. The question is, how can managers introduce a creative way of thinking into an organization or a team of employees? Where should they start and how should they proceed?

Brainstorming, brainwriting and mind mapping are good starting points. They can help to unlock quickly and easily the hidden creative powers that all human beings possess. They not only help people to step outside the norm and generate innovative ideas, but also create an atmosphere that is highly productive and enjoyable.

In this section the principles and benefits of these main creative methods are discussed. Readers are given clear suggestions as to when, where and how to start using examples from daily practice; they are shown how to lead and manage a brainstorming session, how to avoid making common mistakes, how to analyse and implement results and how to create an organizational culture in which new ideas can flourish.

In the final section of the chapter, brief descriptions of brainwriting and mind mapping are given.

What is brainstorming?

Brainstorming as a technique was first introduced by Alex Osborne in the 1930s. It is a method used in groups in order to support creative problem-solving, the generation of new ideas and greater acceptance of proposed solutions.

How it works

The brainstorming technique is based on the capacity of the human brain to make associations. For example, when a person sees or hears the word "fun", the brain automatically searches for word associations and produces suggestions such as cinema, theatre or concert, or terms such as humour, friends, relaxation, free time, sun, sea, etc.

Although the capacity of one person is somewhat limited, the production of words increases enormously if there are more people working together. The reason for this is that the word associations thought of by others makes the brain of each person work faster and search in much wider areas than it would without such stimuli. The theory of associations is the first principle of brainstorming.

It is already well known that the brain works best when the left and right hemispheres work together. This state comes about when people are relaxed, calm, happy and feel they are in an atmosphere of trust and support. Unfortunately, our work life is seldom like this: stress, the large number of tasks to be carried out and busy schedules are the enemies of relaxation. Therefore, the second principal precondition of brainstorming is that it should be carried out in a relaxed atmosphere in order to support the creative attitude of people and get the best out of them.

Organizing a brainstorming session

As in any session or meeting, there are certain rules that need to be followed in order to ensure that a brainstorming session produces good results. The session can be divided into three phases: a preparation phase, the brain-storing session, and evaluation and implementation of the results.

The preparation phase

In the preparation phase, the following questions should be answered:

- What is the purpose of the brainstorming session and what is the topic?
- How many people and which people should be involved?
- When and where will the session take place?

What is the purpose of the brainstorming session and what is the topic?

The key to good results is correct topic definition. Often, the topic chosen for the brainstorming session limits the outcome by suggesting one of the possible solutions to the problem.

For example, the question "How can we expand the space available for production?" produces a very different result from the formulation "How can we gain the space we need for our work?" In the first case, the only solution expected is buying or renting new premises, whereas in the second case, it could be found that a good cleaning policy, new storage systems or faster processing resolve the problem.

Tip for topic preparation

Thought should be given to what will be different and how the change will be evident after the implementation of the solution, when the problem is solved. The objectives should not be confused with the means (for example, "How to make a better advertisement" (focusing on advertising as a means) should not be confused with "How to increase company profits" (which is the real objective of an advertisement).

How many people and which people should be involved?

Any brainstorming session will be richer in ideas if it is attended by people who are not directly involved in the problem. Sometimes, it can be the secretary, the office manager, the marketing or production manager, line employees, even a customer or student who brings the most valuable idea. A fresh approach can produce very different word associations from those which have been discussed in the group many times before.

A good number of participants for a brainstorming session is between 6 and 12 people. A smaller group can be equally productive, but the flow of ideas will probably be slower. However, working with bigger groups is more difficult, time-consuming and requires more effort to write down all the ideas. If there is a larger number it may be advisable to split them into smaller groups.

When and where will the session take place?

At first glance, this is a simple question, but in reality the environment, room layout and timing play a more important role than we think by influencing the atmosphere and working style of the session and therefore the results.

While smaller brainstorming sessions can take place on the premises, when solving an important issue such as the company strategy for the coming years, it is wise to escape the normal routine and hold the meeting at a nice hotel nearby or even outside the city. A new and unknown environment stimulates different thinking and the ideas generated will have a different value from those influenced by the company environment.

The best arrangement for the room is a "U"-shape. This means that the chairs are arranged in a half circle around the room and a flip chart is placed in the middle, within view of all the participants. Everybody should see the flip chart. Tables may be provided, but are not necessary; people may sit or stand as they choose, but should be comfortable.

The room should be calm, well ventilated and well lit. Different colours aid brain activity. At the beginning of the session, all telephones should be switched off and staff should be asked not to interrupt the session.

Brainstorming sessions can be held at practically any time of day, except after lunch, when brain activity decreases due to biorhythms. It is likely that sessions held between 10 and 11 a.m., when brain activity is highest, and evening sessions are the most productive.

The brainstorming session should not exceed 20 to 30 minutes, but the time required will depend also on the management of the meeting and the other items on the agenda.

The rules of brainstorming

For the best results, the following rules for brainstorming sessions should be observed:

(a) No criticism or judgement. Other people's ideas or our own ideas should not be criticized however foolish or outlandish they may seem. Judgement stops the creative process, causes tensions in the group and arrests the generation of ideas.

(b) During brainstorming participants are completely free to express themselves. They are not bound by their company position or by their boss or colleagues; nothing is unwanted and nothing is wrong.

(c) The quantity and not the quality of ideas is what matters. The world's most creative people suggest that it is not that each of their ideas is bright, clear and new, but that some of their many ideas are very good. In a 20-minute session it is normally possible to produce between 120 and 150 ideas; piggy-backing on the ideas of other members of the group should be encouraged as the comments of others often spark our own ideas.

(d) All ideas are recorded on the flip chart. When a page of the flip chart is full, it is posted on the wall so that all participants can see it and a new page is started. The ideas produced for the second page may even be the same or similar. In this way, the participants are not forced to register all the ideas and can create more freely. However, the formulations may be condensed in order to maintain the pace of the session.

(e) The results are evaluated after a lapse of time. In order to ensure that no idea is promoted or eliminated prior to proper consideration, the results are evaluated several days later, the following day, or at a minimum, after several hours have elapsed.

Leading a brainstorming session

A well-managed brainstorming session involves several steps, as follows:

(a) At the beginning of the session, the moderator should explain the objectives of the session and describe the chosen topic. All participants should switch off their mobile phones.

(b) The moderator should explain the rules of the brainstorming session and hang them on the wall. If the participants are already familiar with them, it is enough to make sure that all the participants know them well.

(c) To warm up a group, a humorous topic can be used, such as "What else can you do with a saucepan?" After several minutes of brainstorming, when the atmosphere is relaxed, the predefined topic can be introduced.

(d) All suggestions, however outlandish, are recorded on the flip chart. The participants should be patient and check that all their ideas are written down.

(e) The moderator may help the participants with generating ideas. He or she can also try to unlock hidden ideas by asking "What else?", "What next?" and by making comments such as "very good", "thank you", etc., but should not influence the participants by asking questions supporting any of the areas of the results.

(f) At the end of the session the moderator should thank the participants for their active approach and make sure that they know how the results will be evaluated and used.

Evaluation phase

The evaluation of the results of the session should be deferred for several days, overnight or at least for several hours. During that time, the brain recovers and has time to calm down, reflect or produce new word associations and solutions. Those can be added to the list prior to the evaluation. The ideas are then grouped according to the topics and formal evaluative methods can be used.

Another approach that can be used to evaluate the results is a method using coloured stickers. For example, 10 to 20 stickers can be distributed among the evaluators and they can be asked to affix them next to the ideas on the flip chart. The more they like an idea, the more points they can give it by affixing stickers. They can give all the points to one solution or distribute them among more of them, as they wish. In this way the preferences of the group can be seen and priorities among the results can be identified. For example, the results of the session aimed at how to improve the recognition of a shoe trademark may be those given below:

- Contact a professional advertising agency 25 points
- Carry out market research 22 points

- Improve the client database 18 points
- Organize a competition for journalists 12 points

Examination of the results should reveal a strategy to be followed, as well as a point of departure.

Common mistakes to avoid

Moderators or managers should be aware of problems that may arise when working with brainstorming. They include:

(a) Participants have a negative attitude. Participants may feel negatively towards the manager of the session, towards the topic itself, towards the idea of brainstorming or they may not believe that a solution is possible at all. In that case, the moderator or manager should discuss these problems with the participants in advance.

(b) Judgements are made during the session. If participants express negatively about the ideas, such as “it cannot work in our company”, “it would be too costly”, “there are not enough resources for that”, and so forth, the moderator or manager should explain that such judgements interrupt the flow of ideas and should tell the participants that he or she will return to their comments at the evaluation phase.

(c) Too many brainstorming sessions have been held previously. The participants may be reluctant to participate because they have been asked to contribute to too many brainstorming sessions. The moderator or manager should ascertain the reasons for the reluctant participation, but is likely to find that earlier results were not properly evaluated and implemented, which alienated previous participants. At the beginning or end of any session it should be made clear who is responsible for evaluating the results, that it will be done and that people will be informed of the results.

What are the benefits of brainstorming?

The benefits of a well-organized brainstorming session are numerous. They include:

(a) Solutions can be found rapidly and economically.

(b) Results and ways of problem-solving that are new and unexpected.

(c) A wider picture of the problem or issue can be obtained.

(d) The atmosphere within the team is more open.

(e) The team shares responsibility for the problem.

(f) Responsibility for the outcome is shared.

(g) The implementation process is facilitated by the fact that staff shared in the decision-making process.

What issues can be solved by brainstorming?

The topics that interest most companies or organizations relate to improving processes, the organization of the company or organization, communication, customer and employee relations, strategy, products, quality and any other outputs of the company.

The following recent topics have arisen with different groups:

(a) How can we improve the time management of our group?

(b) How can we promote our products better?

(c) What can the vision of our company be for the next five years?

(d) How can we find out what our customers want?

(e) How can we improve cooperation between production and marketing?

(f) How can we enhance cooperation between account managers and the creative department (for example, in an advertising company)?

(g) What new products can we introduce to our customers two years from now?

(h) What can we do to make our sales and marketing department more efficient?

Brainstorming can also be used as an introduction or warm-up exercise in a training session. Possible questions could be as follows:

(a) When (or under what circumstances) does company communication work well?

(b) When (or under what circumstances) are our customers satisfied with the company?

(c) How can we prevent stress or how can we cope with pressure better?

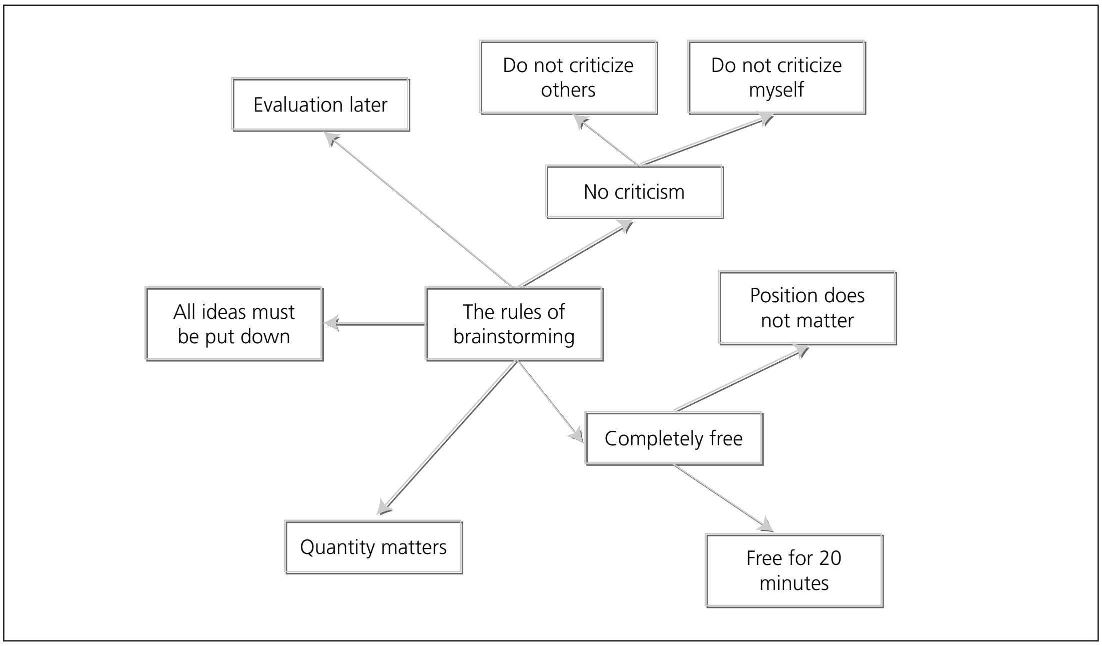
Additional creative methods

Two other similar creative methods deserve mention here: brainwriting and mind mapping. Brainwriting is similar to brainstorming. The only difference is that the participants are given a set of coloured sheets of paper (between 5 and 20 sheets) and the ideas are first written down, one idea per sheet. The sheets are then attached to a flip chart or posted on the wall, organized in the best possible way. Typical patterns can thus be seen very quickly and the number of repetitions of the same idea indicates the preferences of the group.

An alternative is the generation of individual ideas by simply writing all ideas on a sheet of paper. This method can be used as a preparation for a presentation, a meeting with a client or problem-solving.

Using the mind mapping system further enhances the brainwriting method. The slogan that we want to examine is written in the middle of a clean A4 sheet of paper: "The rules of the brainstorming" (figure XXII). As our brain works we can generate ideas in different branches and a tree slowly grows. Using this method, it is possible to grasp rapidly the logic of things, their connections and priorities. The human brain works in a holistic manner, which is the easiest way for it to work. This method is useful for any kind of human activity, including making a daily schedule, holiday planning and managing quality.

Figure XXII. Example of a simple mind map: the rules of brainstorming



Source: Balackova, (2003).

Summary

Techniques such as brainstorming, brainwriting and mind mapping can offer companies and organizations new ways of encouraging staff to think creatively in order to solve problems and improve company operations. Staff welcome the opportunity to contribute their ideas and find brainstorming sessions fun and productive. Once these techniques have been adopted, it is hard for staff and managers to imagine how the company used to function adequately without them. It takes courage to experiment with the new, but the potential rewards are manifold: better results, faster generation of new ideas, the introduction of an element of fun to the work routine and a better working environment.

4. SCENARIO PLANNING

The term "scenario" is used to cover a wide range of different activities, even within foresight programmes. Scenarios may be used as inputs to kick-start discussion and idea generation in panels, as tools for working groups to marshal their arguments and test the robustness of policies, as presentational devices that can communicate foresight results to wider publics. They may be used more as an element of the foresight process, with their major contributions involving the exchange of visions and thus the deepening of linkages in networks, or as products of the activity that can be circulated to broad audiences. They may be exploratory focusing on what might happen under various circumstances, or aspirational asking how specific futures can be achieved (or avoided). And the ways of producing scenarios vary immensely—from the outputs of simulation models, through the work of small expert teams, to the undertakings of workshops and the delineation of different views in even wider samples of expertise.

This section explicates some of these issues, and examines some examples of how scenarios have been used in (technology) foresight. It will indicate the methods used in main approaches, and then focus more specifically on the approaches used in scenario workshops. A comparison between two main types of workshop will be undertaken (one more exploratory, one more aspirational), and the sorts of technique used to mobilize participants and structure inputs and outputs. Finally, lessons will be drawn as to the application of scenarios within foresight exercises. What sorts of scenario approach might be used effectively in different contexts, and what sorts of planning, capability, and resources could be required? What are the pitfalls and problems, as well as the advantages and utility of these approaches?

Scenarios

Definitions

The term "scenario" has many uses. A google search using the term will come up with many hits before getting anywhere close to the origins of the word in theatrical scene-setting. One can immediately find large volumes of usage referring to computer-related applications (e.g. "Scenario 4: Use user-defined SQL Step 1: Edit the file user.sql and add your personal SQL statements…"; "as a partner of ENHANCE (Enhanced Aeronautical Concurrent Engineering—an EU project), IBM is helping to implement a scenario defined with SNECMA ..."), and in financial and other professional service applications (e.g. "The following picture gives an example of a volatility scenario for a yield curve…... To modify an already defined scenario you click on the target scenario in the left canvas with the left mouse button"; "... 4. Identify Sales Forecast Exceptions Scenario A. ..., Sales Forecast Exception Criteria are established and defined in the Front End Agreement..."). This mainly serves to confirm the existing knowledge of who the heaviest users of the Internet are (for some reason pornographers and music "pirates" do not seem to have picked up on the term "scenario" much). It also demonstrates that such users are finding it helpful to wield a term that allows them to outline sets of options or sets of alternative possibilities, which is not so far from our sense of the term.

Here, scenarios are used in the sense of visions of future possibilities—and particularly, visions *(a)* that have been derived and presented in a fairly systematic way and *(b)* that strive for some holistic sense of the circumstances in question. The term is sometimes used to refer to quite restricted visions (e.g. the effects of running a narrow econometric model with assumptions of 2 per cent as opposed to 5 per cent growth rates). However, the sense used here goes beyond simply profiling the future in terms of one or two key variables, to present a more fleshed out picture, linking many details together. Typically there will be a mixture of quantifiable and non-quantifiable components. They may be presented in discursive, narrative ways (illustrated with vignettes, snippets of fiction and imitation newspaper stories, etc.) or tabulated in the form of tables, graphics, and similar systematic frameworks.

Such scenarios have been used widely in futures studies from the 1960s onwards (e.g. in the work of Herman Kahn, Michel Godet, etc.). The methods used in scenario generation vary, the static or dynamic emphases of the scenario receive more attention, the uses and styles of presentation vary considerably. Here, some of the main varieties of scenario in use in foresight work today will be examined.

Histories and images

An important distinction may be drawn between scenario visions that are more or less dynamic or static. The former concern events or trend developments ("future histories"), whereas the latter are more focused on a point in future time ("images of the future"). Whole books can be found that, for example, present a view of a future without a great deal of explication of how to get from here to there. For example, in Gerard O'Neill's *2081*, the technological elements of this visionary future all worked perfectly together. There was practically no hint of the failures, errors, disasters that almost inevitably dog any large-scale human enterprise—and this in a future of space colonies, automated vehicles, and the like. It is rarer to find studies that emphasize the history without spelling out the type of future that might be arrived at, but a case in point from the dim past may be Freeman and Jahoda's 1978 study, *World Futures: The Great Debate* that started with a set of alternative futures (some more desirable, some less so) and examined the paths which might lead to them in some detail.

Normative/exploratory and inward/outward bound scenarios

A long-established distinction in futures and forecasting studies is between more or less "exploratory" and "normative" approaches. The former methods essentially involve starting from the present and posing "what if" questions: What if the growth rate is x per cent or y per cent? What if events W or Z happen? What if we pursue one or other strategy? In contrast, the latter methods can be seen as starting from a point in the future, and asking "how" questions: What would it have taken to have reached a future where the parameter of interest is x per cent greater than its current value? What would have led us to situation Y?

Because all scenarios are full of normative content—including the choice of "what if" and "trend rate" variables,—terms "outward-bound" and "inner-directed" could be used for these two orientations. It is unlikely, however that decades of usage will be shifted overnight.

Both orientations can be used in scenario analyses. Variations of each can be very useful in fairly similar situations, and indeed, recent workshops that use inner-directed approaches ("success scenarios") intensively to formulate priorities, targets and indicators, are usually preceded by some development of outward-bound scenarios. The aspirational scenario is worked up in a workshop, on the basis of workshop participants" views of what are feasible and desirable developments.

Single or multiple scenarios?

Singular visions

Some scenario studies are focused on a single vision of the future. O'Neil has his own "hopeful view"—explicitly a critique of the "limits-to-growth dogma, which would suggest that we must deny freedom to individuals and accept a narrow, regulated existence". The book expands upon this vision, and does not explicate alternatives. The discursive discussion of issues frames an extended vignette in which the protagonist journeys from a space colony to Earth, encountering various technological marvels to do with computer and communication systems, energy sources and delivery means, and so on.

The singular scenario can be useful as a means of:

- Illustrating and communicating features of forecasts and future-relevant analyses.
- Providing a framework in terms of which views of different aspects of future developments can be integrated and their consistency or otherwise examined.
- Structuring and guiding discussion so that visions, elements of visions, and the assumptions that underpin such visions, can be explicated and elaborated.

Scenario workshop methods are particularly relevant to this latter objective. The process of dialogue can be used to generate organization-relevant scenarios (products that can be used later and communicated to others), and also to support a creative exchange of views and information among workshop members. The scenario workshop process is one that can yield benefits to participants in terms of improved understanding and networking, as well as providing products such as reports and priorities.

2025

More recently, in 1998 Joseph Coates and his colleagues presented the slightly more modestly titled *2025: Scenarios of US and Global Society reshaped by Science and Technology*—similarly to O'Neill this is oriented around the implications of "enabling technologies"—though the four in question include new materials and biotechnologies, and they also treat environmentalism as the "fifth primary driver of change". At first glance the volume features 15 scenarios. But these are really different slices of (more or less) the same evolving future. Each focuses on specific topics, for example:

- Harvesting the fruits of genetics.
- Working toward a sustainable world.
- People and things on the move.
- Balancing work and leisure.

Each of these areas is described in various ways. There are fairly detailed accounts of circumstances in the US and "World 1" (affluent countries), "World 2" countries (the bulk of the global population), and "World 3" (destitute countries and regions). There are vignettes describing everyday life or other case studies, which help to bring the scenarios to life. There are suggestions of unrealized developments ("hopes and fears") that might have made the scenario quite different had they happened. And there are elements of the history of the future—lists of possible events, with suggested dates.

This latter feature means that it is possible to use this material for studies with a shorter time-horizon than the relatively remote 2025. Examples of a few of the developments (and their effects) within the timespan to 2010 are:

- Late 1990s—flat screens introduced, changes the use of computer screens from office to domestic furniture and to decorative tool for work and entertainment.
- 2000—International Global Warming Federation forms, transfers technologies in response to global warming.
- 2001—breakthrough in battery technology for electric vehicles, giving range of 250 kilometres per charge.
- 2001—US Retooling Manufacturing Act, and (with change in antitrust rules) establishing formal industrial policy and promoting greater industrial concentration.
- 2001—Virtual reality industry surpasses $2 billion in annual sales, covering entertainment, military, simulation and business training applications.
- 2002—collapse of derivatives market, SEC intervention to severely restrict derivatives.
- 2002—US Energy Transition Act, mandating reduced energy use and providing tax incentives for switch to renewables.
- 2003—Human genes and functions fully matched, testing of people for susceptibility to genetic-based traits and diseases (of which many more are located than anticipated), near certainty is possible, eventually becomes routine.
- 2004—Genetic Recording Act, safeguards for people's genetic information reduce social resistance to genetics testing.

- 2006—Authentication and Certification Act, requires certification of images with respect to authenticity or extent of doctoring.
- 2007—Lima Space Weapons Treaty, preserves space as a weapons-free zone.
- 2009—adoption of global patent system.
- 2009—ISO establishes materials characterization standards covering composites and other advanced materials, enabling greater recycling and reclamation, easier materials choice and development of new applications.
- 2010—Recognition of prenatal psychology as a scientific discipline, establishment of practices of prenatal intervention for mental stimulation and personality shaping.
- 2010s—Rise of the Quality of Life movement, emphasizing improved everyday life, aesthetics and amenities of home and community.

In addition, Coates presents an inventory of 83 high probability developments by the year 2025. Some of these concern science and technology ("Genetically engineered micro-organisms…used in the production of some commodity chemicals as well as highly complex chemicals and medicines…in agriculture, mining, resource up-grading, waste management and environmental clean-up"; "…world-wide, broadband network of networks based on fibre optics…communication satellites, cellular and microwave will be ancillary. Throughout the advanced countries…face-to-face…[etc.]… communication will be available to any place at any time from anywhere.") Others involve socioeconomic factors ("World population will be about 8.4 billion people"; "…worldwide unrest reflecting internal strife, border conflicts and irredentist movements… peaking between 1995 and 2010".) Finally, another 24 likely, but less probable developments (e.g. "Mastodons will walk the Earth again and at least 20 other extinct species will be revived"; "Privatization of many highways…tied to the evolution of an intelligent vehicle-highway system") are indicated.

Coates' work constitutes a very rich—if not infallible!—source of informed speculation and provocation about developments that are largely framed in terms of the evolution of science and technology. In many ways he is shouldering the techno-optimist banner earlier carried by Herman Kahn, though Coates' work is more sophisticated in many ways. Some forecasts have a technological fix flavour; he is rather sanguine about prospects for managing the global environment; his views about the development of genetic engineering and medical practice are likely to raise hackles in some quarters. But he is hardly an unqualified techno-optimist, anticipating that, for example, widespread contamination by a nuclear device on a scale significantly greater than Chernobyl is highly probable in this timescale, that epidemics and mass starvation will persist, that impacts of global warming will be experienced. Among his concrete speculations, for example, are rather scary stories about genetic screening and about the eco-collapse of Haiti.

The "scenarios" in this volume could certainly be used to provoke debate, and thus be the seed for true alternative scenarios. The work was produced as an output of multiclient studies, and draws on years of working and networking within the US futures community.

UK2010

A rather less ambitious study that uses one scenario (and describes the various vignettes located within it as scenarios) has been conducted within the context of the UK's foresight programme (2nd cycle). Scase (1999) presented an analysis of Britain towards 2010 that set out to map major social and demographic developments (a demand from several of the panels).

The three "scenarios" presented here tell the stories of different individuals, selected so as to illustrate how UK society might look like a decade from now, simultaneously highlighting specific trends in British society (e.g. greater individualism, personal mobility, individual freedom and choice, and use of information and communication technologies) and the persistence (or worse) of a society divided by economic, educational, social and cultural inequalities.

The study addresses a series of major social topics, within each outlining—sometimes on the basis of statistical data, sometimes using literature sources—what major trends seem to be at play. For example, in the sphere of politics, these trends include:

- The end of political ideology.
- A cynical electorate.
- "Me" politics grow.
- A global economy places limitations on governments.
- Demographics place greater demands on the State.
- ICTs have the potential to revolutionize government.
- Civil service cultures present barriers to change.
- ICTs offer both opportunities and threats.
- Lack of computer literacy places a brake on virtual government.

The "scenarios" really serve to explicate some of the human implications of these trends, and to illustrate the huge diversity that can underlie averages. Studies such as those discussed above show that not all scenario studies feature multiple alternative scenarios, and that effective use can be made of a single scenario—to present an ideal vision, or to highlight the major trends in a best-guess future.

Multiple scenarios

Most authors discussing scenario analysis recommend the use of multiple scenarios. The future is uncertain, and analysis of just one scenario does little to communicate much about the range of opportunities and challenges liable to confront us. Often scenario analysis is identified with multiple scenario analysis, and the use of several alternatives is held up as offering opportunities to:

- Challenge received wisdom by demonstrating the plausibility of several diverse futures.

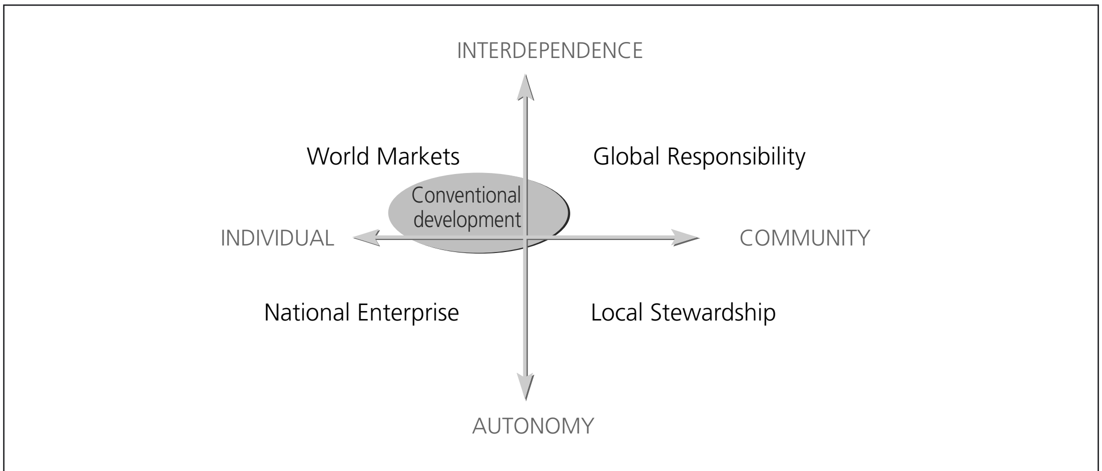
- Give more sense of how different trends and countertrends might unfold and interact, what the implications would be of variations from the standard account of these developments.
- Allow for some test of the robustness of policy and strategy conclusions across different paths of development, and possibly yield some guidance as to signals that we are on one or other path.
- Introduce substantially different "worldviews" concerning what drivers of change are and how they are related together, and allow for dialogue among proponents of different viewpoints as to the results of, or the requirements for, various events materializing.

UK foresight "environmental" scenarios

There are many studies involving multiple scenarios. Perhaps the best-known scenario analysis in the UK foresight programme is one designed initially to be able to deal with environmental issues, though it has been used in a much wider range of contexts. The discussion below draws on a summary of this work by Berkhout and Hentin (2002).

This study elaborated scenarios on the basis of two dimensions, concerning social and political values and the nature of governance (figure XXIII). The "values" dimension reflects underlying principles driving the choices made by consumers and policy-makers. At the "individual" end of the spectrum private consumption and personal freedom dominate. Governance is mainly limited to regulating markets and securing law and order. At the "community" end of the spectrum, more concern for the common good, the future, equity and participation is the norm. Civil society is strong and resources are allocated through more heavily regulated markets. The "governance" dimension captures structures of political and economic power. At the "interdependence" end of the spectrum power to govern is distributed away from the national state level. The "autonomy" end of the spectrum retains high levels of economic and political power at national (national enterprise) and regional (local stewardship) levels.

Figure XXIII. UK foresight "Environment" scenarios



Source: Miles, (2003).

Brief histories of the future (called "storylines" in this study) and a fairly elaborate tabular comparison of the four cells formed by these two dimensions are developed. Berkhout and Hentin summarize a wide range of studies and policy activities in which these scenarios were used, and they still have continuing resonance within such UK policy bodies as the Environment Agency. They also seem to have had some impact on scenarios developed in later projects—for instance, those developed in workshops by the FUTMAN project in 2002 http://europa.eu.int/comm/research /industrial_technologies/27-03-03_futman_en.html have considerable similarity to the ones described above.

World futures

A multiple scenario analysis that explicitly worked with "normative visions of the future" is the Freeman and Jahoda (1978) analysis of World Futures mentioned earlier. This is unusually explicit both in its normative orientation, and in its use of divergent worldviews as a tool in scenario analysis. Usually the theoretical standpoint of the researcher or scenario team is left obscure, and there are simple references to the "plausibility" of various future possibilities; but in this study it was asserted that plausibility is in part a function of worldview.

As for the normative element, two values informed the study: material welfare (people's basic requirements for food, shelter, clothing and security should be met) and equality (in the sense of reducing the grosser disparities between and within countries, that lead to vast differences in the life prospects of different people). This meant looking at the question of economic growth: what levels of economic growth are required to meet the needs of the human race? Are these sustainable? And then, are inequalities functional or inevitable components of the world system? How far can human needs be met in futures largely created by a minority of the world's inhabitants?

These values were built into four alternative "profiles of the future", where higher and lower levels of economic growth and of international equality, are realized over coming decades. Examples of such futures were located in the contemporary futures literature. Despite the pessimistic assumptions of some earlier studies, it was concluded that food, energy, and materials resource availability was not the major impediment to realization of any of the four profiles. Differences among earlier futures studies in part reflected Malthusian approaches—but other areas of dispute among social scientists and policy-makers and activists about how the world works were also important. Thus the Freeman/Jahoda study grouped worldviews into three major sets on the basis of viewpoints articulated in the social science literature—especially the macroeconomics and world development literature. It considered what possibilities exist for moving towards each profile if the world were actually to operate along the lines these suggest. The upshot was the generation of 12 histories and images of alternative futures, explicitly related to assumptions of fact and value. These were related together through tabular comparisons and more discursive accounts.

Twelve scenarios are considerably more than are generally recommended in multiple scenario analyses. (In this case it finds some justification in enabling users to pull out the normative assumptions behind specific futures studies as well as to contrast different routes that are liable to be advocated as ways of reaching a specific future.)

There are studies that present considerably more scenarios, but most commonly practitioners recommend the use of no more than three or four main scenarios in the output of an exercise (a few minor variations may also be covered). The idea is that this is the number that can most readily be absorbed by readers who have not been part of the scenario generation process.

The big challenge, then, is selecting three or four scenarios that can do a good job of explicating the range of alternatives that may be confronted—or of highlighting the paths of development of underlying drivers and other factors. (Variations and additional scenarios may be located in annexes or on the web for the particularly interested reader to pursue.) The task now is to use appropriate criteria for selection among these scenarios. Again, several criteria (not always easy to reconcile in practice) can be suggested:

- Avoid a "most likely" middle-of-the road scenario, since decision-makers are liable to treat this as the future to plan for.
- Be careful with scenarios that are liable to be too "way out" for the audience and thus liable to discredit the exercise. Either find ways of presenting them in sufficiently qualified form that their salient messages are apparent without raising hackles, substantiate them with effective argument; or find ways of incorporating these messages into other scenarios (or, indeed, other analyses).
- Attempt to select scenarios which encompass all or most of the issues arising from the wide range of scenarios developed in earlier phases of the study, and that also illustrate something of the range of variations that may emerge across key parameters.
- Grab attention with provocative and interesting speculations and examples.

Different scenario methods approach this problem in different ways. Commonly, as in the Freeman/Jahoda or Berkhout study, we begin with a set of profiles of the future that are derived from dichotomizing underlying dimensions. The trick, then, is to select such dimensions that either go to the heart of clusters of driving and shaping forces, or that can be conveniently used as pegs on which to hang contrasting sets of development.

Scenarios in foresight

Scenario analysis is a well-known method in futures studies in general—but has been far less prominent in foresight work. Consider the UK experience. In the first cycle of activity, individual panels were circulated with a stimulating scenario essay by Oliver Sparrow (he had been a scenario planner for Shell, whose experience in this field is legendary, see for instance, Mendonca, 2001). For Sparrow's current activities see the Challenge Forum, (http://www.chforum.org/ohgs.html)—but this was barely used, since it came out of the blue and did not seem particularly relevant to many of those to whom it was provided. Each panel was requested to develop alternative scenarios for its sphere of analysis, but this task was more or less submerged by the mass of other duties given the panels, and very cursory results were obtained. The question of scenarios was raised intermittently, however. For example, when discussing the Delphi results obtained in one panel (transport), one commentator pointed out that the pattern of answers suggested that quite distinct scenarios were implicitly being used to guide the responses of different respondents. (In principle, survey data can be analysed to yield different scenarios based on viewpoints articulated by different respondents, but this was not pursued here.)

Scenario workshop methods were promoted to business users of foresight in documentation produced for the national programme. A quite useful guidebook on conducting such a workshop was produced for consultants and industry associations. The suspicion is, however, that this was more the result of contracting out the work of preparing a small business foresight guide to a contractor whose expertise lay in scenario methods, than in a clear strategic decision.

The second round of UK foresight invested substantial resources into developing, and displaying on its website and video resources, a set of alternative future scenarios. The "environmental" scenarios are still featured (www.foresight.gov.uk) as all-purpose scenarios, and have been used surprisingly widely. The social scenario study was also widely circulated, and probably proved highly satisfactory to those industrial participants who wanted foresight to tell them about future consumer markets. But little systematic development of scenario approaches can be seen in the UK programme.

This does not seem to be an inherent feature of foresight exercises, but probably has more to do with the origins of the approach out of Japanese national programmes. Whereas the current Japanese effort is intended to develop multiple scenarios, this has not previously been the case—the emphasis has been more on building consensus in industrial-scientific networks around a vision of the future. Irvine and Martin's *Foresight in Science* (1984, London: Pinter) described a range of approaches to bringing long-term perspectives into research policy-making, putting much weight on the Japanese experience. Such approaches were widely applied to improving national government decision-making (especially in the area of S&T) from the mid-1990s on. Foresight involves thinking about emerging opportunities and challenges, trends and breaks in trends, and such factors—like familiar futures studies. Systematic methods are used to develop better insights and visions concerning future possibilities. But foresight differed from the majority of traditional futures studies in two ways (as described in the second edition of the *FOREN Practical Guide to Regional Foresight* available from www.foren.jrc.es, on which the following account is drawn).

1. Foresight is highly related to decision-making. It brings together key agents of change and sources of knowledge, in order to develop anticipatory strategic intelligence. Beyond the preparation of specific plans and lists of priorities, guiding strategic visions are elaborated. These can enable a shared sense of commitment (achieved, in part, through the networking processes described below), and should be more robust to changing circumstances than are particular plans or priorities. This strategic vision is not a Utopia: it must combine feasibility and desirability, and to be explicitly related to present-day decisions and actions.

2. Foresight stresses eliciting wide participation. This may be purely a technocratic effort, in which central decision-makers are using methods such as consultations and Delphis to access knowledge that is located at a variety of locations in the society. It may be more of a democratic effort, seeking to involve a wider spectrum of the population in decision-making (or at least, in decision influencing). And it may be oriented towards building more of a "foresight culture". Foresight is often explicitly intended to establish networks of knowledgeable agents, that possess improved anticipatory intelligence—and self-awareness or reflexivity, in the sense of enhanced awareness of the knowledge resources and strategic orientations of network members. Such networks should be able to respond better to emerging challenges; and one of the objectives of some foresight programmes has been to establish improved networks among firms, policy-makers, entrepreneurs, financiers and scientific and technical experts, with the aim of revitalising national innovation systems. Thus the application of interactive, participative methods of debate, analysis and study of such developments and needs, involving a wide variety of stakeholders (often going well beyond the narrow sets of experts employed in many traditional futures studies), does not just result in better reports and policies. It should also involve forging new social networks. Foresight programmes vary in their emphases here: some use networks merely to help develop their formal products (such as reports and lists of action points); others take network establishment to be an equally, or even more, important achievement in its own right.

The term "foresight" is applied to all sorts of activities—as is the fate of any popular term. Thus, the term "fully-fledged foresight" could be used to distinguish activities that combine long-term orientations with networking activities and strong links to planning and decision-making.

Scenario methods—especially the well-known scenario workshop approaches—can be highly relevant to the networking goals of foresight. The process of scenario construction in workshops can yield important benefits here, in terms of exchange of views about developments, strategies, and the like. However, the origins of foresight have meant that such methods have been used relatively rarely and unsystematically. This is changing, with, for example, the heavy emphasis on scenarios in Norwegian work and several other recent or ongoing studies. (See, for instance, the CD-ROM produced as a result of the EC/EFTA workshop in June 2002: The Norway 2030 Seminar and Workshop on foresight to Scenarios—Methodology and Models available from DG Research.) The interesting challenge is to reconcile the workshop-based development of scenarios with their wider use in a foresight process in which numerous panels and issue groups will be active.

Scenario generation—methods

Scenarios may be developed by an extremely wide-ranging set of methods. They may emerge from workshops or be prepared by small expert groups, derived from Delphi or other survey results or constructed on the basis of different worldviews. Practically any forecasting or foresight approach can be the occasion for a scenario generating exercise.

- Individuals presenting their informed speculations about the future ("genius forecasters") can use scenarios as a template for illustrating and enlivening their accounts.
- Expert panels can establish a framework of scenarios on the basis, for example, of literature review or conceptual analysis.
- Survey results can be analysed to determine if there are different clusters of views about the future that can be considered representative of different scenarios.
- Cross-impact and similar methods can be used to identify the most probable of all of the scenarios logically possible from a combination of variables (again from expert judgements—or in the case of Monte Carlo simulations, for instance, from repeated runs of a probabilistic computer model).
- Workshops may be used to construct or elaborate on scenarios in a process of intra-group dialogue.
- Online methods are being explored, as are techniques using computers to support face-to-face (F2F) workshops.

The focus of the remainder of this chapter is on scenario workshop methods. These methods are particularly relevant for foresight in that:

- They allow for sustained analysis of alternative futures that are relevant to the key decisions that are confronted, and allow for the generation of reasonably articulate and consistent visions of these futures.
- They can be used as the trigger for such inputs to planning as identification of priorities, setting of objectives and targets, defining useful indicators of progress, etc.
- They network people together and allow for the integration of the knowledge that they possess; furthermore, by involving key actors in scenario generation, they can mean that decision-makers have deeper understanding of the underlying processes and key strategies, and a sense of identification with the choice and elaboration of the scenarios.

Scenario workshops

Scenario workshops are frequently used to build or to elaborate on scenarios. The aim is usually not just to achieve a finished scenario as a product. There are also benefits from involving members of an organization or community in futures exercises or more specifically in a foresight process. Such workshops bring together a range of knowledgeable and experienced participants, usually stakeholders of one kind or another, within a structured framework of activities.

This framework allows the participants to:

- Exchange information, views and insights.

- Identify points of agreement, disagreement and uncertainty.
- Create new shared understandings.
- Develop action plans and other instruments so as to help mobilize future activity.

Since the scenarios produced in such workshops are a product of the participants' own interactions, they are, in the management jargon, more likely to have "ownership" of them. To deconstruct this, they should:

- Understand the logic much better than if presented the material in a standard report;
- Have deeper insight into the considerations that have gone into the scenarios;
- Be better-equipped to be "carriers" of the scenarios to the outside world.

The scenarios should also possess greater legitimacy than those produced by a smaller expert group or visionary guru, at least if the workshop has drawn upon a reasonable range of participants. Scenarios may be generated from scratch in the workshops, or developed, in at least a rough form, in an earlier scenario generation activity. Some workshops use "off the shelf" scenarios prepared in other work (possibly even published ones) as a starting point for the workshop activity.

Scenario workshops typically have periods of extensive exchange of ideas and debate about them, and periods where ideas are being written down and listed, where different lists are combined, and so on. The process usually involves much dialogue, and use of such instruments as whiteboards and flip charts, though computer-based ("groupware") tools are now beginning to be used effectively. Scenario workshops usually extend over at least one day, and may involve several dozen participants (with "break-out groups" of between 6 to 12 people exploring different scenarios in detail). The workshop will be conducted with inputs from at least one facilitator, and often other helpers will take notes, record material from flip charts, and deal with logistic issues as they arise. Typically such facilitators have acquired their skills through involvement in these and similar group activities; they may have received some training in workshop methods (from T-groups through management workshops to academic seminars), but to date there has been little analysis of the processes in terms of knowledge development, and the skills are typically the "task" and "emotional" skills of classic groupwork, but this is too many to work on a scenario in detail.

Before the workshop: design and background material

Before the scenario workshop is implemented, it has to be designed—in more than a rudimentary fashion. For example, an earlier scenario design workshop, drawing on a range of expert and interested parties, may be constituted to help:

- Identify participants for the scenario workshop—it is vital to include the right range of knowledge and expertise, and as far as possible key end-users of the results.
- Determine what background research might need to be conducted, or materials collated, to provide participants with some common informational resources.

- Define the workshop procedures (what scenario methodology is to be deployed; what areas of study within the domain of interest should be selected, what specific questions might be used in the workshop.)

It is typical for a scenario workshop to begin with participants reviewing some background material that has been prepared especially for it, or more generally for a larger foresight or futures exercise it is set within. This might be a SWOT analysis of the organization's position in the area of concern. The SWOT or benchmarking input may involve comparing the region, country or organization with relevant others in the various sub-domains. The comparison should be able to identify trends and dynamics, and the systemic elements of the domain. It should be prepared in such as way as to indicate what informants and available literature suggest might be possible. Other inputs might include statistics of research related to this area; relevant Delphi material; results of computer simulations and econometric analyses.

Some scenario workshops are kicked off with a set of background scenarios or other forecasts prepared by an expert team. This can provide one way of presenting the results of background studies in an absorbable way: a small set of scenarios dealing with the development of the domain. This provides the workshop participants with a base against which to frame their own preferred scenario. They may proceed to elaborate these, criticise them, or use them as a launchpad for constructing aspirational scenarios.

Case study 1: multiple scenarios

The Economic and Social Research Council (ESRC) commissioned Centre for Research into Innovation and Creativity (CRIC) and the Institute for Alternative Futures (IAF) to run a workshop in January 2002 to inform its decision-making process concerning priorities for social research on genomics, and the selection of a centre to conduct such research. A set of four scenarios were presented to the workshop participants, each outlined in a couple of pages of text. This used an approach developed by the IAF, to deploy four archetypal scenarios:

- A "best guess" extrapolation, or "official future" scenario.
- A hard times scenario.
- And two "structurally different" scenarios (at least one of these is to be visionary, marking a paradigm change or an aspirational future).

In the workshop, the four scenarios—featuring the application of genomics achieving very different degrees and patterns of success—were:

- *Genomics, Inc.* benefits primarily for the developed countries, the affluent, and corporations.
- *Genomics for All* genomics applications developed to increase equity and sustainability.

- *Broken Promises* genomics applications work poorly in general, failing for a variety of reasons.
- *Out of Control* genomics is an international and environmental destabilizing force.

An account of each was produced by the research team, and the scenarios document was one element of a package of documents supplied to participants (others included, for example, discussions of drivers of genomics applications and explication of the nature of the genomics revolution). A set of break-out groups focused on one or other of these scenarios. In line with the workshop objectives, these small groups considered the key contributions that social research might make in the event of the given future occurring. What would the critical demands for knowledge be? What sorts of pressure might social science be under?

Each group was requested to discuss its scenario, in particular, orienting its discussion around the questions:

- Assuming this scenario will occur, what is the optimal contribution of social science research can make (your three to five top priorities)?
- Signposts: What would indicate movement toward this particular scenario, expressed, for example, as headlines in the media?

This process yielded a large number of specifications of opportunities for research. It was one of a number of approaches to the question of research priorities that were employed in the workshop. (Full reports of the workshop are provided on the CRIC (http://les1.man.ac.uk/cric) and IAF (www.altfutures.com) websites. The discussion here draws on text produced by Clem Bezold and colleagues.

Figure XXIV illustrates some examples of the contributions that social research might make in the different scenarios, and "signposts" that the scenarios were on the way to realization. The material was captured in real time by use of COUNCIL groupware—each participant was equipped with a laptop PC with wireless modem, and a technical expert managed the structuring and collation of material. A great deal of on-the-fly facilitation was required to synthesize the mass of detail that rapidly appeared.

The scenario analysis was one important step in the process used in this exercise, which took the participants through a number of exercises that led them to develop and prioritize urgent themes for social research in the genomics area. (The workshop also noted aspects of the organization of research that went beyond topics for study—for example the need to improve interdisciplinary training and working, and dialogue between social and natural scientists.)

Figure XXIV. Some outputs of genomics scenario workshop

- **Genomics, Inc.,** *Research contributions:* "impacts" of genomics on various sectors of society, the concepts of well-being, ethics and health service use of genomics, the new industrial structure and property rights, growing and new social divides. *Signposts* include continuing mergers, increasing divide between public and private sectors, and inequalities among individuals.
- **Broken Promises,** *Research contributions:* re-evaluation of the notion of progress; reflexive social science to research alternative lifestyles and product use; better understanding of political change; the reconceptualization of risk including the inevitability of "normal" disasters and the need to prepare for them. *Signposts* include Greens winning in an archetypically conservative UK town, a big biotech company such as Monsanto going bust, and Golden Rice burned in India because of unforeseen side-effects.
- **Out of Control,** *Research contributions:* the comparative advantage and disadvantage of states and their relations to MNCs, the nature of international organization. *Signposts* include China buying a big biotech company such as Monsanto, and protestors attacking Greenpeace.
- **Genomics for All,** *Research contributions:* applied research supporting the development of international institutions that can regulate bio weapons, and the identification of genomic products and applications that will support equity and sustainability. Comparative analysis of scientific and political change (e.g. comparing IT and genomics revolutions, undertaking historical research on international institutions), understanding how cultural creatives unite politically and affect corporations, developing value impact assessment for new technologies. *Signposts* as such were not developed by this break-out group, but discussion suggested some events that might be important here—for example, loss of US hegemony (and possibly the break-up of the country), negative mobilizing events stimulating change in trajectories of genomics use (examples included serious diseases associated with genomics innovation).

These lines of work were discussed in plenary sessions, which emphasised social science research stances and styles that are critical, visionary and historically informed; research to probe critical political and moral constructs (e.g. the meaning of development and well-being); innovation studies on global issues; global actors and changing industrial structures; and ecosystem impacts of genomics and public processing of ecological knowledge.

Source: Miles, (2003).

Case study 2: success scenarios

The "success scenario" method has been applied to issues of science and technology policy in the UK—the underlying principles can be applied in many other domains. The workshops described here focused on a more short-term future than usual for such approaches—five to ten years—on account of sponsor requirements, though inevitably longer-term prospects were also discussed.

> (ICT and biotechnology scenario reports are reported on the CRIC and DTI websites as ICT in the UK a scenario for success in 2005 and Biotechnology in the UK a scenario for success in 2005.

http://les1.man.ac.uk/cric

http://www.ost.gov.uk/policy/futures/ict/intro.htm

http://www.ost.gov.uk/policy/futures/biotechnology/scenario.htm

CRIC also presents the background analyses for these studies.

The nanotechnology scenario report is available on the DTI website, under the title: New Dimensions for Manufacturing: A UK Strategy for Nanotechnology, at http://www.dti.gov.uk/innovation/nanotechnologyreport.pdf).

The Office of Science and Technology commissioned CRIC, together with the National Physics Laboratory and the Institute of Nanotechnology, to run a workshop on UK prospects and potentials in the field of nanotechnology, in autumn 2001. In the OST Nanotechnology exercise there was no overall effort to sketch out scenarios in advance of the workshop, and break-out groups were again constituted around sub-domains of the technology field. There was some background information constituting a scenario or roadmap of the most probable technology path in each sub-domain.

The heart of the process is a scenario workshop. As outlined above, the design of the workshop has to be carefully prepared, members recruited, and background research prepared. The design process extended over time, with a series of meetings between the sponsor and the scenario team that were extremely important for "tuning" the design and making sure that the sponsor was fully behind the approaches being used in the workshop.

There are two elements to a success scenario. It combines:

- *Desirability*. The scenario captures a vision of what could be achieved or aspired to, by the sponsoring organization or a wider community that it represents.
- *Credibility*. The scenario is developed with the assistance of, and validated by, a sample of experts in the area, chosen to reflect a broad range of interests (and usually including both practitioners and researchers).

Each of these elements is informed by the background research, providing a common information base for the experts to work with in workshop and other settings. Developing success scenarios has a number of functions:

- The process of discussing research results, debating and agreeing upon goals and indicators, and identifying feasible actions is valuable for creating mutual understanding and sharing of knowledge. This can establish platforms for further interaction and efforts to put in place the actions proposed.
- The scenarios form a stretch target, to challenge those concerned to aim for excellence, to think beyond the boundaries of "business as usual".
- The development of indicators moves the scenarios beyond vague aspirations, and allows for clarity as to what precisely is being discussed and whether and how far goals are being achieved.

- Finally, action points are developed and priorities may be established, with the merit of having been derived from a participative process.

An interview programme was carried out to benchmark UK activity in various application areas against the experience in competitor countries. There was no effort at modelling or substantial statistical analysis, due to the relatively novelty of the technology, and similarly there is little by way of serious social science to draw upon that deals with nanotechnology. Six application areas where it was accepted that nanotechnology would have a major influence, were focused on, namely:

- Drug delivery.
- Informatics.
- Instrumentation, standards and metrology.
- Novel materials.
- Sensors and actuators.
- Tissue engineering and medical devices.

An effort was made to identify main trends, drivers, and the most probable future in terms of technology developments in each of these areas. Participants were allocated to areas and asked to ensure that they had read at least the appropriate part of the material.

There are many ways in which a success scenario workshop may be organized, but the approach used in these workshops involved, with minor variations, a sequence of stages such as described below. The various stages outlined below mainly involve activity in working groups, usually constituted to cover each of the areas already identified in the domain under investigation. Plenary sessions precede, follow, and sometimes intersperse these working group sessions. The nanotechnology workshop lasted for a day, the other two for two days (presentations on background topics preceded the workshop proper).

After various introductory matters have been tidied up—setting out the mission statement for the exercise, introducing each other, etc.—the work begins in earnest. A common starting point in scenario workshops, used in the model described here, is to examine "drivers and shapers"—factors that could be critical to influencing the course of events, promote one or other sort of development, and lead to distinctive futures.

In many scenario workshops the STEEPV approach—in which people are asked to identify factors and issues under the headings social, technological, economic, environmental, political, and value-based factors—is used. This can be a useful prompt and way of ensuring that a broad range of issues is considered; it is also a helpful classification framework. But in some cases the workshop itself may be asked to come up with a grouping of "shaping" factors at an early stage of its work.

The discussion of drivers is inherently interesting and its output can be useful decision-making intelligence. But the process is equally important. What typically goes on here is that participants become more familiar with working with the background material, and with working together. They deepen their understanding (and possibly critique) of the material as ideas are chewed over, conceptual frameworks given a first airing, etc. They develop common ground rules for working, language in which to express ideas, etc.

Typically the discussion will at least in part be conducted in subgroups who are requested to work systematically through a range of factors that are liable first, to drive, and then, to shape the development of the domain. They may be asked first to concentrate on drivers, and then on shapers of the area. They may be provided with lists of potential factors as part of the background material, and be asked to critique these, add new ones if appropriate, and—especially—to indicate how important each might be, and why.

This workshop relied on paper-based rather than computer-supported methods (though some participants were spontaneously making use of laptops and even digital cameras in the most recent workshop). The groups were provided with written instructions. A facilitator/note-taker for each group was even given suggested timings for each task. The discussions were captured on posters, which were attached to the walls to provide a record of development and material for other groups to inspect at intervals. The key technique is crystallizing the thinking about factors, within different subgroups (and for them to communicate among themselves) in the form of lists. The background information, participants' knowledge, and their conceptual frameworks are brought together in ways that challenge them to develop shared understandings.

The success scenario methodology provides an impetus for these processes. It does so by asking the workshop, and working groups within it dealing with specific subtopics, to consider what might be realistically achieved if the UK (in these studies) is to be successful in the technology and its application areas. This means, of course, asking just what success in each area might constitute. This is another topic where views may differ. There may be quite different views of relations between means and ends, causes and effects; and also very different emphases on such values as efficiency, equity, sustainability, etc.

The next task for each working group was to characterize the scenario that they have developed; succinctly describing it in terms of what success looks like, what the main drivers and shapers are, and how they might be called into play. Since the success scenarios need to be both credible and optimistic, this part of the exercise provides a chance for the groups to consider whether the different scenario elements are consistent. A number of prompts were provided to the groups, suggesting elements of the scenarios that it would be helpful to describe. These subjects form the basis of brief presentations to a plenary session. This provides an opportunity to contrast the different groups' scenarios, and see if they are consistent or divergent—and what this implies. Knowledge cycles are thus established again, within and between subgroups. In this session the working groups further characterize the success scenario by specifying concrete ideas about how to recognize that the success scenario was becoming a reality. Again, some preliminary ideas of the sorts of indicator that might be developed are provided to kick off the work. The groups are challenged to suggest plausible quantitative estimates of such indicators—to clarify points of agreement and disagreement, to provide tools for monitoring progress, and to suggest alternatives to the narrow set of indicators that are typically used to drive policies. Figure XXV reproduces the introduction to this task as provided in the nanotechnology workshop. Figure XXVI reproduces instructions drafted for the facilitators and chairs of the subgroups, to guide them in the tasks they were to undertake.

The final working group task now is to provide suggestions for steps that need to be taken to maximize the likelihood of the success scenarios. This work may be conducted within the original working groups. One approach here is to use a "carousel method", where stations are set up with wall posters dealing with specific types of action—typically different policy areas. For example, a broad categorization of areas used in the nanotechnology workshop was:

- Research.
- People.
- Facilities.
- Finance and taxation.
- Access to technology (and international collaboration).
- Regulatory issues.
- Other issues.

In the carousel method, each group proceeds round the posters in turn (but starting at a separate point). It is free to read and comment on other groups' suggestions when visiting a station that another group has previously visited. (An alternative approach is to form new working groups, dedicated to specific action areas. It is possible to envisage other ways in which this task may be organized.) As well as specifying actions, participants are asked to indicate who might be responsible for seeing them through.

The outputs of this phase of work need to be synthesized and prioritized, and plenary sessions are typically used to achieve this.

The output of scenario workshops

The results of such a process can take several forms. Typically a major activity will be the production of a published report, outlining the results of the scenario workshop (and often also presenting at least some of the background research, too). This "codified knowledge"—information really—may remain with the sponsor.

In fully fledged foresight such material should be used more widely. They should enter into the public domain (with necessary caveats). They can be used in the processes of other organizations, feed into the components of an ongoing foresight exercise, and may perhaps be used in successive workshops.

The workshop may define actions to be carried out, including some which participants themselves may be engaged in. This is central to the success scenario methodology. A major task will be to move other parties through the knowledge cycles, so that they can incorporate the thinking of the workshop in their own decision-making.

The workshops described above have proved useful in decision processes. There are several elements to this:

- Helping to bring a wider span of knowledge into the process, which can be viewed technocratically as increasing efficiency, or democratically as enabling wider participation.
- Providing a methodology for arriving at lists of priorities that decision-makers can rely on as more than the opinion of a few self-serving individuals. Of course, such lists are not translated automatically into policy actions—the decision-makers have their own judgement to exercise and choices to make, though there is now a reference point at which the decisions can be compared.
- These inputs may serve to provide sponsors with huge amounts of intelligence that they previously lacked. Or they may serve to confirm what the policy expert already believed, but legitimize this by validating the views by reference to a wider set of experts and stakeholders.

The studies described above have been utilized in funding decisions. They have helped provided intelligence, too, that can be used in debates between different decision-makers. (Thus the genomics exercise could be used within the sponsoring organization to raise awareness of the relevance of the topic more widely than just among those centrally concerned with the decision. The other exercises provided those responsible for science expenditure with a case to take to the Treasury, and with suggestions as to how financial authorities might be able to assess whether the investment was worthwhile—staving off the threat that indicators of success might be imposed from outside.)

In the cases summarized above, client involvement proved vital in the design and conduct of the scenario workshops. Without such involvement, the exercises would not have been adequately tailored to the decision-making needs of the sponsors. And participation in the activities helped ensure, as suggested above, that there were "champions" for the scenario work within the sponsoring organization who could take the messages of the study further. This could be seen as a matter of disseminating the products of the exercise further. Equally, it can be viewed as a matter of extending the process of the exercise. Design to allow both of these dimensions to be maximized is needed to make sure that scenarios effectively contribute to decision-making.

It can be anticipated that there will continue to be emphasis on scenario methods in foresight exercises. It is likely that there will be further development of methods, computer-assisted and otherwise, for both "outward-bound" and "inward-directed" scenarios. There will also be exploration of means and methods for representing and disseminating scenario results, and for enabling users to build these into various foresight processes.

Figure XXV. Task of developing a success scenario

What would constitute "success"?

Indicators

- ❑ Key products and applications.
- ❑ Impact of products on end-user performance.
- ❑ Local and global end-user markets—size and UK share.
- ❑ Industry structure—large firms, SMEs, spin-outs.
- ❑ Business model (e.g. high value added).
- ❑ Where are the UK companies in the supply chain?
- ❑ Effect on GDP/employment? And impact on inward investment?
- ❑ Our competitors, and how we compare.
- ❑ Where is the leading-edge research? Where does the UK stand?
- ❑ Other features.

How much change by 2006?

What enables change?

- ❑ Quality of research.
- ❑ Ownership of research.
- ❑ Availability of skilled people.
- ❑ Sources of finance.
- ❑ Instrumentation, standards.
- ❑ Infrastructure and manufacturing capabilities (e.g. fabrication facilities).
- ❑ Structure and organization of industry and markets.
- ❑ Regulatory environment.
- ❑ Policies for health services and other public sector markets.
- ❑ Intellectual property regimes.
- ❑ Other issues (please add your own).

How do we know we are beating the competition?

- ❑ Relative performance with other countries.
- ❑ UK research recognized by global firms as leading edge.
- ❑ UK firms assembling high value added patent portfolios.
- ❑ Venture capitalists and inward investors investing in UK start-ups.
- ❑ International collaborations.
- ❑ End users seeking/recognizing value of UK products (market share).
- ❑ Availability/size of facilities in the UK.
- ❑ Number of graduates and post-graduates in relevant disciplines.
- ❑ Other issues (please add your own).

Source: Miles, (2003).

Figure XXVI. Guidance material used in a success scenario workshop

Session 2A

Building a new scenario—the success scenario

The scenarios we have provided are intended to provide stimulus for you to consider what might be realistically achieved if the UK is to be successful in each area of nanotechnology applications. This means, of course, considering what success in each area might be. In order to move toward more concrete and credible analyses of this, we are asking the groups to work systematically through a range of factors that are liable first, to drive, and then, to shape the development of science and industry in the UK and beyond. In later sessions we will go on to consider relevant indicators and actions needed.

Here is a list of potential drivers:

- ❑ Basic research—new knowledge, incremental and radical developments
- ❑ Demand from intermediate and end-users; users' appreciation of opportunities presented by new knowledge
- ❑ Sources of finance for development of applications (e.g. venture capital, stockmarkets, government)
- ❑ Instrumentation, standards
- ❑ Structure and organization of industry and markets (e.g. relations between large and small firms, role of intermediaries)
- ❑ Entrepreneurial attitudes, visions, incentives (in research and business)
- ❑ Other issues (please add your own)

Question 1

We would like you to work through and comment on each of these drivers. Please use the flip chart to identify the issues that you consider most important for each, and how they impact on your application area—how far do they promote development of applications in your areas? Are there specific applications that are promoted especially? Please indicate, too, what each of these might look like by 2006—e.g. will the scenario be driven by large firms or SMEs?

For each driver:

1. Identify the most important issues.
2. Discuss how far the driver impacts on your application area—how important is it as a driver (indicate this on a scale from 1 (not important) to 5 (extremely important)
3. Identify specific applications promoted by this driver
4. What might this driver look like by 2006—would it be growing or decreasing in importance or its particular type of impact?

Question 2

When discussing these issues, please:

- consider if your application area has special features here (e.g. different application areas feature very different regulatory environments)
- consider whether the UK situation is shared by other countries, or if we have specific opportunities or problems

Further building the success scenario

To further move toward a more concrete vision of what success for the UK in each area might be, we are now asking you to work systematically through a range of factors that are liable first to shape the development of science and industry in the UK and beyond.

Here is a list of potential shapers:

- ❏ Regulatory environment—health and safety, environmental and food regulations, competition policy
- ❏ Policies for health services and other possible public sector markets
- ❏ Intellectual property regimes, knowledge of and support for using them
- ❏ Public attitudes to risk, to expertise, to technology
- ❏ Quality of life issues (e.g. UK as an attractive market, base for production and research, place to live)
- ❏ Availability of technical, disciplinary, and multidisciplinary skills, and of management capabilities
- ❏ Other issues (please add your own)

Question 1

We would like you to work through and comment on each of these shapers. Please use the flip chart to identify the issues that you consider most important, and how they impact on your application area—do they impede developments, or push them in particular directions, for example? Please indicate, too, what each of these might look like by 2006—e.g. will the scenario feature a large number of people trained in multidisciplinary team-working?

For each shaper:
1. What are the most important issues (rate them on a 1 to 5 scale)?
2. How will those issues impact on your application area?
3. What will this shaper look like by 2006?

Question 2

When discussing these issues, please:
- consider if your application area has special features here (e.g. different application areas feature very different regulatory environments)
- consider whether the UK situation is shared by other countries, or has specific opportunities or problems

Figure XXVI. *(continued)*

Summarizing the scenario

Here we would like you to characterize the scenario developed by your group. One way in which this can often be achieved is to propose a "name" for the scenario. Beyond this, how can we succinctly describe it—what does success look like? What are the main drivers and shapers, and how are they being called into play? Remember that the success scenarios need to be both credible and optimistic: this part of the exercise is a chance to see if the different elements of your scenario are consistent.

What would this scenario look like in practice? What is the industrial landscape, the patterns of supply and use of the application? Where is the action taking place? What could we hope for in terms of a UK presence? Please try to characterize the scenario in terms of such features as:

- ❑ What level of UK activity is there likely to be in this application area? How much would it have grown in value and employment terms from current levels?
- ❑ What sort of presence is this in world markets—what is the UK's market share?
- ❑ Inward investment in the application area: how much growth would we expect? From where, what sort of firms? To what level?
- ❑ What sorts of UK firms are involved—are the main actors large firms? How many start-ups could we expect in this area? How many SMEs involved in the supply chain?
- ❑ How big are the end-user markets, what sorts of purchasers are there, what is the impact on their performance?
- ❑ What would industrial funding of research in universities for relevant nanotechnology look like?

You will have more time this afternoon to address such questions further, but it will help to make a start on them now to characterize the scenario—and see how far members of the group are in agreement about optimistic prospects for such issues.

Please prepare a brief presentation on this, kicking off with the name of the scenario, and then describing it in ways that the other groups can rapidly grasp. This will provide us with an opportunity to contrast the different groups' scenarios, and see if they are consistent or divergent—and what this implies.

Session 5 Indicators for success

We asked you to begin to characterize the success scenario. Could you return to the bulleted questions there, and amplify your answers if that seems necessary. Please also give us some further concrete ideas about how you would be able to recognize that the success scenario was becoming a reality. The ideas below are "off the wall", but are intended to indicate, the sorts of things you might want to suggest:

- ❏ Share of UK research in EU collaborations in nanotechnology fields.
- ❏ Number of patents taken out by British innovators in application areas based on nanotechnology.
- ❏ There is considerable public enthusiasm for nanotechnology, as evidenced by recruitment for courses, media attention, etc.
- ❏ The NHS (as a market), NICE and the FSA become champions of nanotechnology applications.
- ❏ Growth of high-quality dedicated nanotechnology firms supported by more venture, capital, large firms and a strong science base.
- ❏ Harmonization of the European patent system and a credible, transparent European-wide regulatory framework in nanotechnology-related areas.
- ❏ Contribution of nanotechnology applications to major users reflected in relevant processes or products constituting xxx per cent of their outputs/new products.
- ❏ Growth in UK trade surplus, reflecting nanotechnology applications.

The big challenge, of course, is to suggest plausible quantitative estimates of such indicators. The closer you can come to suggesting not only indicators, but also ball-park figures, or ranges of figures, that might apply by 2006, the more valuable the exercise will be—not least to clarify where our points of agreement and disagreement are. Another benefit of this part of the exercise is that it can, hopefully, suggest alternatives to the narrow set of indicators that are currently used to drive policies for research.

Session 6 Critical success factors and actions

The task now is to provide suggestions for steps that need to be taken to maximize the likelihood of your success scenarios. Please do so by discussing them in your groups, and writing the points on the wall posters. We invite each group to proceed round the posters in turn—feel free to read and comment on other groups' suggestions. Please indicate on your suggestions if they are specific to certain application areas. If there is a suggestion that divides your group, it is probably best to write it up and indicate the lack of consensus. Please try to indicate who might be responsible for seeing particular actions through. You might also be able to indicate what sorts of systems, indicators, feedback, etc., they could be using to see if actions are having the desired effects.

Source: Miles, (2003).

5. CRITICAL TECHNOLOGIES

Identification of strategic research priorities having a high potential to contribute to a favourable economic development and to the fulfilment of social needs of the society, while optimally utilizing limited public funds, is the subject of numerous foresight studies. Various methods are applied to identify a limited set of national research priorities. Method of critical technologies is widely used in several countries, e.g. France, the United States and recently in the Czech Republic. The method consists in applying sets of criteria against which the “criticality” (importance) of a particular technology (research direction) can be measured.

This section summarizes the basics of the critical technologies method and provides an example of its recent application in the Czech Republic in 2001. The main objective of the Czech exercise was to select priorities for the new National Research programme, which it was planned to launch in January 2004.

Technologies representing the driving forces in national economic prosperity and security are regarded as critical to national interests. Due to the limits on R&D spending even in rich world economies, neither government nor industry can afford to invest in every possible field of research. For a better guidance in R&D spending and for defining priority research areas, a number of countries initiated national foresight exercises aimed at identifying national critical technologies (or national key research directions).

Different countries developed different approaches to identifying their lists of critical technologies. While most European countries and Japan developed more or less sophisticated foresight exercises, in the United States a much more straightforward effort was undertaken in the decade between 1989 and 1999. Four National Critical Technologies Reports have been produced so far using different methodologies (a special panel or industrial interviews conducted by an expert organization). The last (fourth) report was prepared by RAND in 1998 (Popper, Wagner, Larson, 1998).

In France, the Ministry of Industry initiated the last national exercise based on the critical-technologies principle in 1999. The exercise, “Technologies Clés 2005” (Key Technologies 2005) aimed at producing a list of about 100 technologies that could be considered to be critical (key) for French competitiveness (www.minefi.gouv.fr).

The Czech Government decided to sponsor the first national TF in 2001. The main objective of the exercise was to propose key research directions (critical technologies) that have a strong potential to contribute to a favourable economic development and to the fulfilment of societal needs while optimally using the public funds for research. The final report was published in 2002 (www.foresight.cz).

The above examples of the four countries do not represent an exhaustive list of those using the critical technologies method in foresight exercises. They should be understood as a demonstration of the method’s applicability in countries of different sizes and types of economy.

Critical technologies

In some languages, the word “critical” implies “catastrophe”, and therefore the wording “key technologies” is used instead. Despite the name, the meaning is always the same—technologies which have a strong potential to influence national competitiveness and quality of life. The method always involves an application of a specific set of criteria to measure “the criticality” of particular technologies.

What is a critical technology?

For a technology to be considered as critical, three criteria should be met (Bimber, Popper, 1994):

1. *Policy-relevant*—the produced list of technologies should indicate political interventions can be made to realize the results. Particular attention should be paid to the issues of R&D processes, commercialization, dissemination and utilization of results.
2. *Discriminating*—there should be a clear distinction between critical and non-critical technologies. It is not acceptable to include any advanced (popular) technology. Particular attention should be paid to the level of aggregation of different technologies to avoid hiding of non-critical technologies under the “critical headline”.
3. *Reproducible*—even those not directly participating in the exercise should be able to reconstruct the results using the procedures used to select the critical technologies. The used method should be transparent, robust and publicly accessible.

The term “critical technology” should not be mixed with other terms, such as:

- State-of-the-art technologies—these technologies may lack policy relevance and sometimes they may be included in the list only because the exercise managers may hesitate not to exclude “a popular” technology from the final list.
- Technologies for national self-sufficiency—with rising globalization there are many technologies (particularly in the case of smaller countries) that are important for a country but may be easily bought on the international market.

On the other hand there are other types of technologies that would fit the criteria of criticality, for instance, generic and pre-competitive technologies. They are potentially useful in many applications, the particular technology is then considered to be critical because invested resources are believed to lead to significant returns in various product applications.

Method of critical technologies

Objective

The main objective is to prepare a list of critical technologies with a clear indication of related policy actions that should enable the implementation of the results.

When is this method useful?

The method of critical technologies is particularly useful in situations when straightforward “discrete” recommendations for discussion at the political level are the prime objective. In practice, the method of critical technologies is particularly useful for setting national R&D priorities. Specific questions characterize the exercise:

- What are the key areas of R&D?
- What are the critical technologies (key research directions) that should be preferentially supported from (public) resources?
- What criteria should be applied to choose critical technologies?
- What are the most important measures that should be discussed at the policy level to enable implementation of the results?

There is a tendency to extend the objectives from a “simple” technology prioritization to a broader assessment of the national innovation system. The exercises conducted recently in the Czech Republic and in France are examples of that trend.

In principle, the method of critical technologies may also be used to identify “non-technology critical issues”, for instance social ones but no example of such an activity has so far been published.

What are potential weaknesses?

The main danger may be that a relatively narrow group of experts participate in the exercise. The method may further tend to focus exclusively on technologies without paying sufficient attention to other issues (e.g. socio-economic). On the other hand, there are examples of exercises based on the method of critical technologies designed and managed in such a way that both potential weaknesses are reasonably eliminated.

How to conduct the exercise

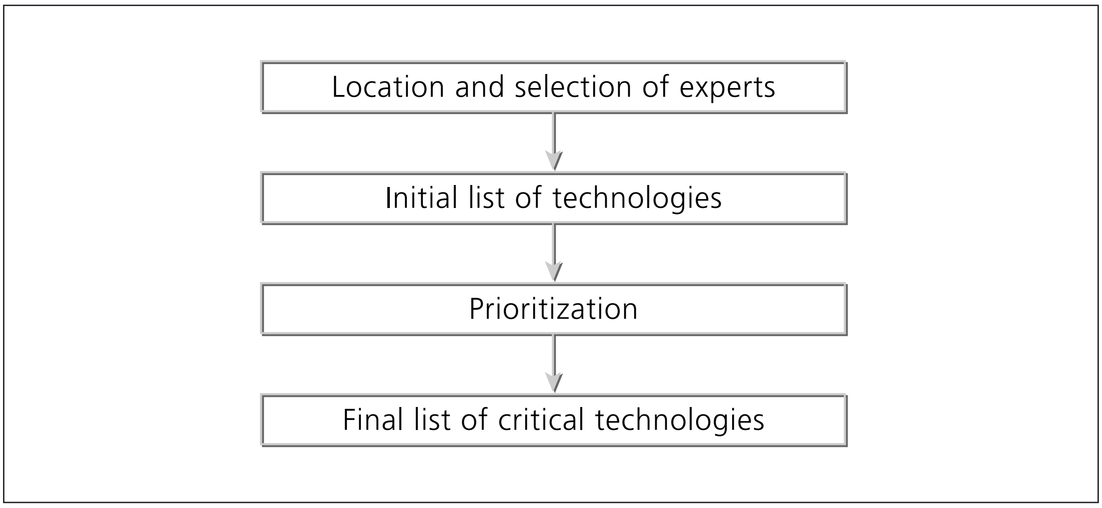
There is no single recipe which could be considered to be the only way to conduct a foresight exercise based on the method of critical technologies. The following paragraphs summarize some general suggestions that can be derived from foresight exercises conducted in the recent past. The case example in the following section provides a more detailed suggestion of how to conduct a foresight exercise using critical technologies. On the other hand, it is realistic to assume that case studies can provide only basic suggestions while a concrete methodology will always depend on the particular tasks and objectives of an exercise.

Structure of the exercise

Although a wide variety of approaches may be used for structuring the critical technology exercise, some typical steps are always involved (figure XXVII).

Individual steps of a more detailed structure of a critical technologies exercise are discussed in the case example (Czech foresight exercise).

Figure XXVII. Typical steps of critical technologies exercise



Source: Klusacek, (2003).

Location and selection of experts

Location and selection of experts is a key initial step of any TF. The method used for the location of experts is profoundly influenced by the extent of the consultation scheme (Loveridge, 1999). Two extremes—*(a)* narrow consultation, and *(b)* broad consultation are possible, although mixed approaches may be considered.

The narrow consultation scheme is typical for most "expert committee studies" conducted for instance in the US programmes of critical technologies. A relatively narrow group of experts is appointed by the exercise sponsor. The sponsor also prepares (initial) terms of reference. The expert committee uses primarily its own resources and scarcely seeks consulting capacities outside. The advantage is speed and relatively low operational costs. On the other hand, the opinions are hardly likely to be unbiased because special interests in a small group are very likely.

Broad consulting schemes include a central management group that coordinates and manages the whole exercise using external expertise gathered in panels, expert groups, or knowledge pools. The core group is responsible for finding and selecting the experts.

Initial list of technologies

The initial list of technologies can be derived from already existing lists (for instance from previous foresight studies) or it can be produced in brainstorming sessions or discussions in expert panels. Additionally, approaches such as bibliographic searches, expert studies, interviewing industrial experts, and environmental scanning, may be combined to develop a comprehensive list to examine.

Prioritization procedure

Prioritization is the most difficult and risky step of the exercise. The main objective sounds quite simple—to reduce the initial list of technologies to a list of critical technologies that are the most relevant against the set of applied criteria. However, since prioritization may discard a substantial number of technologies considered so far, there are suddenly “the winners” and “the losers”. It is at this point that strong lobbying usually takes place and it is one of the most important tasks for the team managing the exercise to keep the results protected from external pressures as much as possible.

In practice, a voting procedure is usually used to make a selection from the initial list of technologies. It should be noted that prioritization is not exclusively tied to the method of critical technologies. Practically all foresight techniques have to make a selection of priorities at a certain point. In some programmes, for instance in the case of the UK foresight exercise, in which a Delphi survey is used, objectives were formally defined. The prioritization procedure was looking to maximize the objectives. In the UK exercise prioritization was made by sorting the topics in descending order according to indices representing the objectives. The objectives chosen for the UK programme were the wealth creation and the quality of life. Figure XXVIII (Loveridge, 1999) illustrates both variables in detail. Delphi respondents indicated the influence they thought each Delphi topic would have on each objective by selecting the appropriate number. The result can then be depicted in a two dimensional graph with both objectives as variables for each of the topics considered.

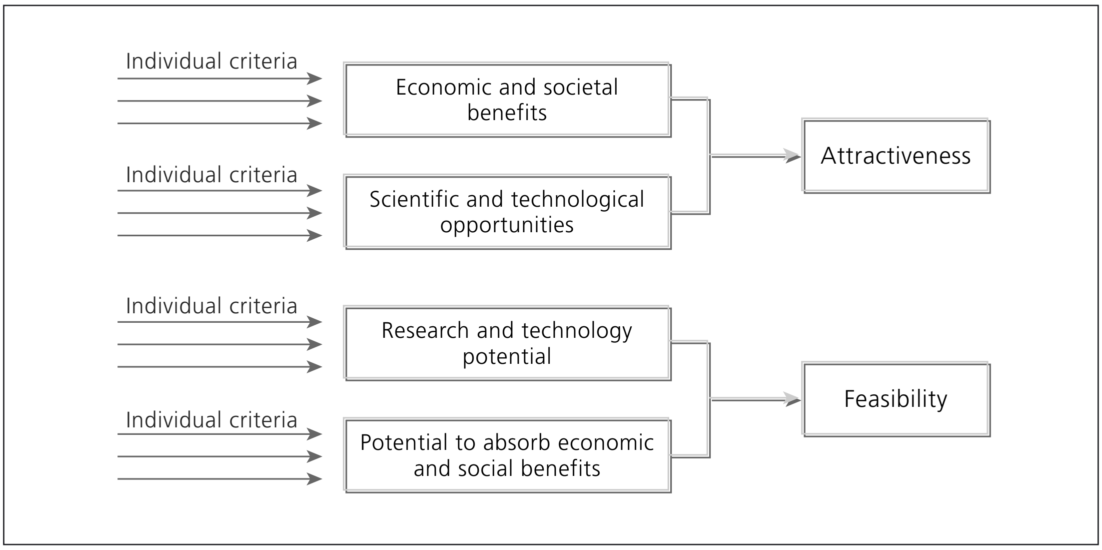
Figure XXVIII. The objective functions for the UK foresight programme

Impact	Choice number	Wealth creation	Quality of life
Harmful	1	Development might be socially beneficial but economically detrimental.	Development might be economically beneficial but socially detrimental.
Neutral	2	It is likely to have only marginal effect on the UK’s economy and on wealth creation.	It affects the population or the environment in a minor way.
Beneficial	3	Its realization is likely to have a significant influence on the UK economy and may lead to new forms of wealth creation.	It is beneficial to most of the population or the environment in a recognizable way.
Highly beneficial	4	It responds to a major market need or creates a revolutionary opportunity capable of market exploitation providing sustainable wealth creation.	It is likely to provide a major advancement in the quality of life for most people and a substantial improvement for a minority of people in fields such as health, culture and in the environment.

Source: Loveridge, (1999).

Another type of voting (prioritization) procedure follows the approach used by the Australian CSIRO (www.csiro.au) or by the United Nations University in the Millenium Project (www.millenium-project.org). In these cases, two parameters, attractiveness and feasibility (CSIRO) or importance and likelihood (Millenium Project) were used. A similar voting method using a set of parameters on importance and feasibility was used in the Czech foresight exercise. Again, the prioritized topics using this process need not to be necessarily obtained through a critical technology exercise but may have emerged from any type of a foresight process. The parameters attractiveness and feasibility are determined for each technology from the initial list. Technologies having a good score for both parameters are potential candidates for the final list of critical technologies. Both parameters have a complex character—they result from values of individual criteria that were assigned by voters to individual technologies from the initial list. The procedure leading to both parameters is schematically illustrated in figure XXIX.

Figure XXIX. Scheme of prioritization



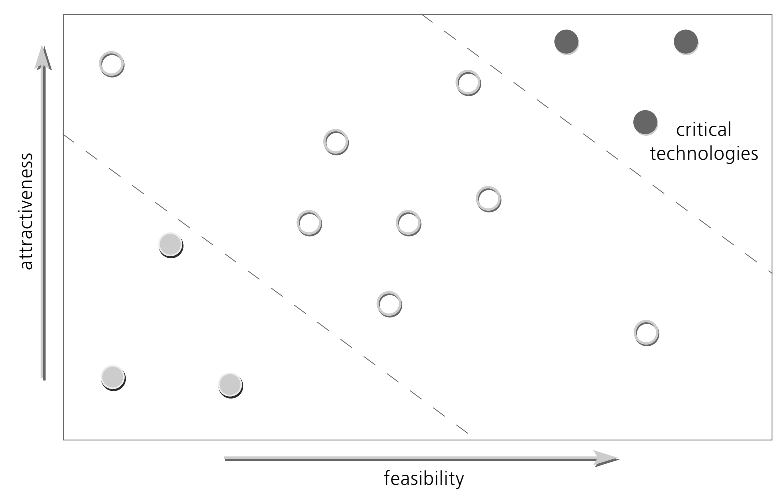
Source: Klusacek, (2003).

Individual criteria may differ in their form, they should usually express what benefits may be expected from the new technology (or what economic or societal needs may be satisfied). For instance the criteria of economic benefit may be formulated as "market growth", "contribution to productivity", and the criteria of societal benefit may be formulated as "importance for human health", "impact on material/energy effectiveness". Criteria of research and technology potential may include "probability of breakthrough discoveries", "demand by the application sector" or "competitiveness of a related industry".

Voters (e.g. members of panels) asses each of the technologies from the initial list against the agreed set of criteria by assigning a "mark" from a scale of 1 (low), ..., 5 (extremely high) to each of the criteria for each specific technology. Individual marks are then clustered following the scheme in figure XXIX according to two parameters—"attractiveness" and "feasibility". The situation may be further complicated using different weights for each criterion or attributing a different level of expertise to each of the voting experts. The total amount of data may be very large. Electronic voting procedures have been developed to make the voting and handling large amounts of data feasible. Such an approach will be illustrated using the case example of the Czech exercise.

Once the two parameters are compiled for each technology considered they may be represented graphically in a two-dimensional graph ranking the individual technologies. An example of such a presentation is given in figure XXX.

Figure XXX. Ranking of technologies in the plane of parameters "attractiveness" and "feasibility"



Source: Klusacek, (2003).

The points in the graph correspond to individual technologies. Black points in the upper right corner are strong candidates for "critical technologies", the points in the lower left corner correspond to less attractive technologies with low feasibility in the considered environment (national economy, industry). Special attention should be given to the point in the upper left corner—a technology of very high attractiveness but very low feasibility. If such a technology is really highly attractive and important then a group of experts should be asked to consider it as a good candidate for a key technology and to recommend support measures that could increase the feasibility. The results of voting should not be accepted automatically as the final outcome of prioritization. They should be thoroughly discussed in an expert group to confirm the results of voting and to identify possible pitfalls. It may happen that the group of experts suggests changes to the standing of some technologies moving them to a better (or a worse) position in the graph. However, in such a case the project managers should require a detailed justification, or the prioritization would lose its credibility.

Final list of critical technologies

The final list of critical technologies is an essential part of the final report to the sponsor. It does not include the final decisions because they are the responsibility of policy-makers but it brings an important expert message that should create a good background for political decisions. The final list of critical technologies may be accompanied by "ID sheets" of identified critical technologies, specifying their main characteristics, application areas and critical problems to be addressed.

Case example—the Czech Republic

Background

The case of the foresight exercise conducted in the Czech Republic in 2001 is presented here. The method of critical technologies used in the Czech case resulted in a list of national research priorities for the new National Research programme (NRP). The case example may be modified (replicated) in other countries that may need to select their research priorities in order to optimally use limited public resources for research.

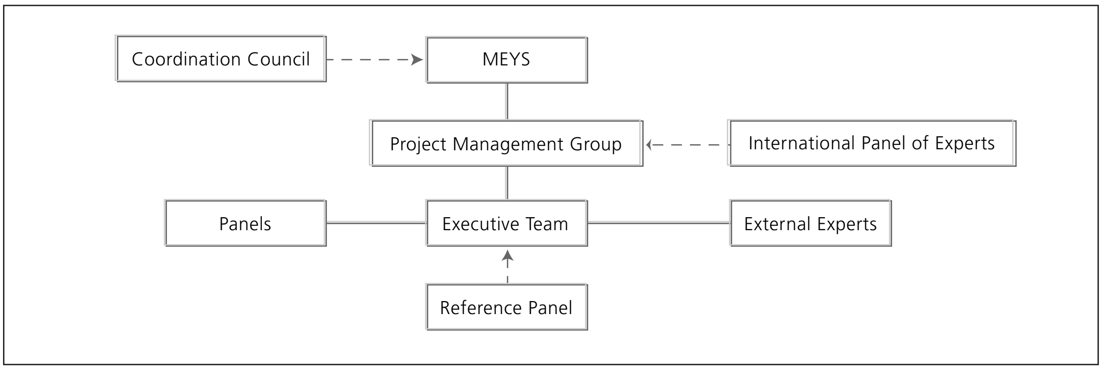
The objective of the exercise

The national R&D policy approved by the Czech Government in 2000 declared the need for the early identification of priorities for research funded from public resources using a proven methodology (or a combination of methodologies) of TF. The accomplishment of this task was the principal objective of the national TF exercise conducted in the Czech Republic in 2001. Additionally, the exercise suggested cross-cutting measures and it proposed a system of management principles and systemic instruments to make the new NRP operational.

The managerial, advisory and executive structure

The main project objectives could only be achieved through cooperation within a relatively complex structure in which all the important stakeholders were represen-

Figure XXXI. The structure of the Czech technology foresight project



Source: Klusacek, (2003).

ted. The basic structural elements of the Czech foresight project are illustrated in figure XXXI. The dashed arrows indicate an advisory role.

The Ministry of Education, Youth and Sports (MEYS) was the project's principal promoter and sponsor.

The Coordination Council consisted of top representatives of key stakeholders—Government Departments (Ministries), research organizations, industry, members of Parliament, business managers, social forecasters and NGOs. The Council was chaired by the Deputy Minister of the MEYS. The main task of the Council was to evaluate the project's progress, comment on its results, provide input on project modification and facilitate a broad consensus enabling the implementation of the project results.

The Project Management Group performed the executive management of the project. The Group was headed by the Project Manager who reported directly to the Ministry.

Expert panels consisted typically of 15 to 20 leading national experts in a particular field. In each panel experts from research (providers of a new technology) and industry (users of a new technology) were evenly represented. The main panel outcomes were justified proposals of priority areas of oriented research including recommended measures for their implementation.

The executive team organized and supported the activities of the expert panels, coordinated in-depth interviews of industrial managers and worked out a quantitative analysis of significance of individual business sectors to the Czech economy.

*External expert*s were leading national professionals in particular fields. They were invited to prepare a SWOT analysis of their sectors and to suggest priority areas of oriented research to match the needs identified in the analysis.

The International Panel of Experts was a group of prominent international experts in the area of TF. They provided their opinion on the project methodology and their view on the analysis and interpretation of the results.

The Reference Panel consisted of representatives of research institutions, industrial companies, associations of entrepreneurs and other organizations. The panel included a large number of people who were electronically contacted for their opinion on the interim project results. The opinion of the panel was considered in the formulation of the final version of project documents.

Location of experts

In order to conduct the foresight project, several hundred national experts were needed to participate in the panels and to perform independent analyses of the chosen sectors. In the first phase of the project, key national research institutions, universities, industrial companies, professional associations and other stakeholders were invited by MEYS to nominate experts for the foresight project. More than 500 names were submitted.

In the second step the nominees received a questionnaire with a brief description of the project objectives. The questionnaire was designed to elicit full contact details of respondents, the main areas of their professional involvement and their level of expertise in selected sectors. The respondents were also asked to recommend other experts suitable for participation in the project. The new nominees were requested to repeat the whole procedure—this so-called co-nomination procedure was also used in the UK foresight programme. Finally, names and characteristics of more than 800 candidates were collected.

Preparatory phase

Expert panels constituted the "creative backbone" of the project. At the beginning of the project the panels were provided with input information as a background for their work. The information consisted of three major components:

- Results of interviews of the application sphere. In-depth interviews of a representative sample of key companies from each sector (286 companies in total) were conducted to identify the demands of users for results of oriented research. A structured questionnaire was designed for this purpose. In-depth interviews were performed at face-to-face meetings with company managers responsible for R&D strategy. To ensure fully professional communication external experts were appointed to collect the data.
- Results of desk research. Thorough desk research was performed by the executive team to collect basic economic data and data on public research expenses in individual sectors. The information was completed with abridged versions of sectoral strategic documents as prepared by individual Ministries.
- Sectoral SWOT analyses. These analyses were prepared by leading national experts for particular sectors. The analyses included expected trends (scenarios) for the next 10 years.

Panels

Panels consisted typically of 15 to 20 leading national experts in a particular field. The chairman, assisted by the panel secretary who was also an expert in the particular field, chaired each panel. One of the basic prerequisites for the efficient work of panels was to bring together people with different backgrounds and experience to combine professionals from the "supply" and the "demand" sides. After complex discussions with representatives of the MEYS (the project sponsor), Coordination Council and other key stakeholders, 17 panels were established:

- Thirteen thematic panels:

    1. Agriculture and food
    2. Environment
    3. Health care and pharmaceutics
    4. Information society

5. Building industry, urbanism and housing
6. Materials and technology of their production
7. Discrete manufacturing
8. Instruments and devices
9. Machinery and equipment
10. Chemical products and processes
11. Transport systems
12. Energy and raw materials
13. Social transformation

- Cross-cutting panels:

14. Human resources for R&D
15. Integrated R&D
16. Regional and international cooperation in R&D

- One systemic panel:

17. Management and implementation of the NRP

Because of the scope of this section—to illustrate the use of the method of critical technologies—only the work and outputs of thematic panels will be described further.

Thematic panels' work and outputs

First, the panels performed SWOT analyses of their respective sectors. The results of the SWOT analyses were compared with the analyses previously elaborated by external experts. With the use of brainstorming, panels were asked to identify important research directions (IRDs). This was followed by discussion in each panel. The IRDs were assumed to have a potential to support exploitation of the opportunities or to suppress the threats as identified in the SWOT analysis for each application sector while maximally using the strengths of the corresponding research base and/or the relevant industry.

The number of IRDs identified by each panel varied from 15 to 64. In total, 612 IRDs were identified across the 13 thematic panels using this approach. As the foresight exercise aimed at determining a rather short list of national research priorities, further reduction of IRDs was the next task for thematic panels.

The first reduction was made during discussions on the suggested 612 IRDs in panels. After formal rearrangements and elimination of IRDs by panels there were still almost

600 of IRDs. Further reduction was carried out using a prioritization procedure developed especially for the purpose of this foresight project. The procedure followed the approach used by the Australian CSIRO (Commonwealth Scientific and Industrial Research Organisation) (www.csiro.au).

During the prioritization procedure panel members evaluated each of the IRDs suggested by their panel against two parameters—“importance” and “feasibility”. Both parameters were obtained through assessment of individual IRDs against a set of 35 criteria (figure XXXII). The original set of criteria suggested by the Management Group was much shorter with the intention to reduce it even further. However, there was much debate, with little room for compromise, particularly in the Coordination Council. Criteria were grouped into six clusters, which were aggregated into two parameters (coordinates) “importance” and “feasibility”. Due to the high number of criteria and IRDs and the number of voting panel members, a set of almost 300,000 data points was produced. The only feasible way of managing and evaluating such an amount of data consisted in using an electronic “voting procedure” developed specifically for this project and accessible to panel members (through a personal password) via the Internet on a web site dedicated to this national foresight project. The opportunity to vote was open for about one month. A remarkable number of panel members (91 per cent) voted. The resulting data was electronically processed and used for the first identification of reduced lists of IRDs. These lists were further refined after a thorough discussion on the voting results in each panel.

A typical result of voting is illustrated in figure XXXIII (panel Information Society). Individual points correspond to the particular IRDs. The upper right corner includes “key research directions”. Panels were allowed to change the standing of some IRDs in a few particular cases, however, in such instances, the project management required a detailed justification.

The voting procedure and the following discussion in thematic panels led to 163 key

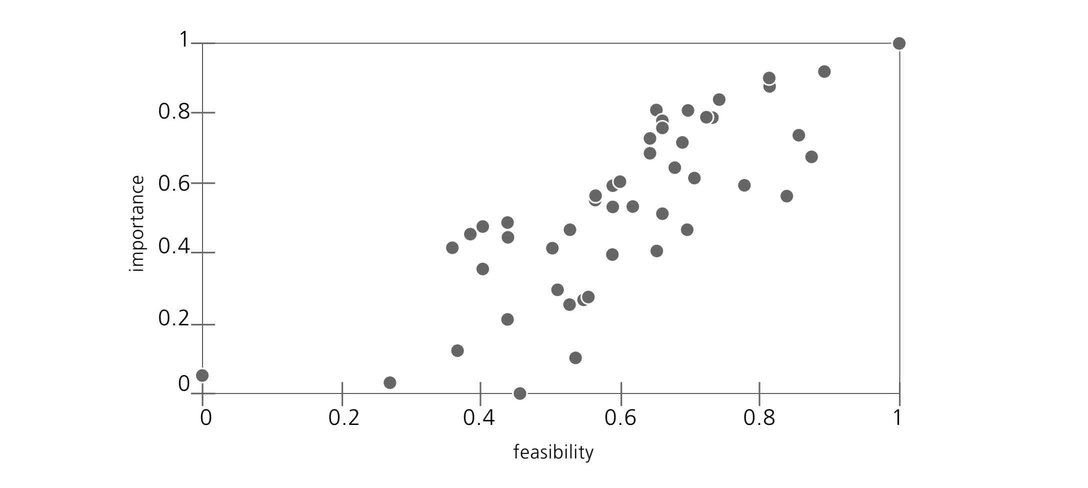
Figure XXXII. Criteria for selection of key research directions (critical technologies) in the Czech foresight exercise (2001)

IMPORTANCE				FEASIBILITY	
Economic, social and environmental importance			Research and technological opportunities	Application potential (absorption potential of the application sector)	Research and technology potential (production potential of R&D)
Economic importance	Social importance	Environmental importance			
Importance for GDP	Importance for human health	Impact on material effectiveness	Ability of the research direction to produce new technologies	Competitiveness of the application sector(s)	Current state of the art of the research field
Importance for export	Importance for the safety of the society	Impact on energy effectiveness	Probability of "breakthrough discoveries"	Support in administration/state policy and regulation	Probability of a positive development of the research field
Impact on productivity	Impact/influence on the quality of life	Environmental-friendly effect	Probability of creation of new application possibilities related to the research direction	Availability of results in the world market	Level of the necessary R&D infrastructure
Market size	Influence on the creation of job opportunities	Potential of replacing un-renewable energy sources by renewable ones	Possibility of combining the research direction with other research directions	Demand of the application sector	Financial requirements of the research direction
Strategic importance for the Czech Republic internationally		Natural and productive space saving effect	Possibility of applying the results of the research direction in various applications	Influence on the creation and growth potential of small- and medium-sized enterprises	Probability of financing from various sources
		Effect on transport requirements	Probability of a synergic effect with other research directions		Level of education in related fields
			Probability of involvement in international cooperation		Current quality of human resources
			Importance for meeting untackled needs of the society		
5	4	6	8	5	7

Each criteria is to be assigned a mark from a scale of 1 to 5: 1=low, 2=medium, 3=high, 4=very high, 5=extremely high.
NOTE: For the shaded criteria the mark is reversed, i.e. 1=extremely high, 2=very high, 3=high, 4=medium, 5=low.

Source: Klusacek, (2003).

Figure XXXIII. Results of voting—panel information society



Source: Klusacek, (2003).

research directions (KRDs), some of which resulted from aggregating the original IRDs. The aggregation was possible because the original IRDs were very detailed and they sometimes covered only a narrow area of research. The leading principles of aggregation were thematic complementarities and links between IRDs. Some aggregations were made between IRDs suggested by different thematic panels as a result of communication between panels. The inter-panel communication addressed some cross-cutting issues, however, most of the cross-cutting issues in this foresight exercise were identified in the subsequent work of the working group. The working group also carried out the second prioritization, i.e. further reduction of the KRDs selected by panels.

The results of the panels' work were summarized in their final reports. The reports contain comprehensive SWOT analyses of respective application sectors, anticipated trends (brief scenarios), detailed description of the procedure leading to the set of IRDs and description of the following prioritization procedure. Each panel submitted the most important research directions as a list of KRDs (163 KRDs across the 13 panels), which were ranked consistently with their significance to the respective application sector. Additionally, most of the panels identified "emerging technologies" and "market niches" in their area of expertise. Some panels presented additional recommendations for the development of their particular R&D area and/or industry. Panels also prepared "ID sheets" of identified KRDs specifying their main characteristics, application areas and critical problems to be addressed.

Working group

A working group (WG) was established for the final phase of the project. The WG consisted of 17 panel chairpersons (13 for thematic panels, 3 for cross-cutting panels and 1 for the panel management and implementation of the NRP). Additionally, 1 person represented the pharmaceutical part of the panel (health care and pharmaceutics). The main reason for including panel members in the WG was the link to the previous stages and findings of the foresight exercise. The WG further included 8 members of the Coordination Council—representatives of the sponsor, the R&D Council of the Czech Government and other key stakeholders. The main rationale for including these members was the recognition that as the exercise moved closer to the implementation stage, more "political" actors engaged in the project were necessary.

The main task of the WG consisted in further selective reduction of the 163 KRDs produced by the panels. This step was necessary because the new NPR should define national priorities and the research involved should thus receive preferential financing. It was estimated that no more than 100 KRDs should constitute the final output of the foresight exercise. The WG analysed the set of 163 KRDs suggested by the panels. After identifying the cross-cutting issues and an extensive debate between representatives of the panels the WG further reduced the total number of KRDs to the final 90 KRDs. The final list of KRDs is available with additional information on the Czech foresight exercise at www.foresight.cz.

Summary

The method of critical technologies is very suitable for assessing various technologies (or research directions) when selection of priorities is the major task of the foresight exercise. The outcomes of the exercise do not constitute final decisions but they formulate important recommendations by experts to policy-makers. The method may tend to focus its attention on technology aspects while social dimensions may be neglected. A careful management of the exercise as well as a sophisticated design of priority criteria considering social aspects may satisfactorily solve the problem.

6. TECHNOLOGY ROADMAPPING

Technology-driven innovation is of increasing importance to industry and countries, as a means of achieving the economic, social and environmental goals that lie at the heart of sustainable development. The effective management of technology is becoming more challenging as the cost, complexity and pace of technology change increase in a globally competitive market. The management of technology for business and national benefit requires effective processes and systems to be put in place to ensure that investment in R&D, facilities and skills is aligned with market and industry needs, now and in the future.

The technology roadmapping method is used widely in industry to support technology strategy and planning. The approach was originally developed by Motorola more than 25 years ago, to support integrated product-technology planning. Since then the technique has been adapted and applied in a wide variety of industrial contexts at the company and sector levels (for example, the International Semiconductor and UK Foresight Vehicle technology roadmaps). Technology roadmaps can take many forms, but generally comprise multi-layered time-based charts that enable technology developments to be aligned with market trends and drivers.

This section provides an overview to the technology roadmapping approach, starting with an introduction to the topic of technology management. Roadmapping is a very flexible approach, and the various aims that it can support are reviewed, together with the different formats that roadmaps take and the principles for customizing the method. Also important is the process that is required to develop a good roadmap, and this chapter describes a method for rapid initiation of roadmapping in the business strategy, together with some of the characteristics of good roadmaps and the systems needed for supporting their application. Case examples are included to illustrate how the approach can be applied at the sector level, based on collaborative workshops.

Much of this section focuses on the management of technology from the perspective of the manager at the firm level, where many of the techniques have evolved, but it should be recognized that the principles and approaches discussed can also be applied at the sector or national level.

Technology and the management of technology

There are many published definitions of "technology" (for example, Floyd, 1997, Whipp, 1991, Steele, 1989). Examination of these definitions highlights a number of factors that characterize technology, which can be considered as a specific type of knowledge (although this knowledge may be embodied within a physical artefact, such as a machine, component, system or product). The key characteristic of technology that distinguishes it from more general knowledge types is that it is applied, focusing on the "know-how" of the organization. While technology is usually associated with science and engineering ('hard" technology), the processes which enable its effective application are also important—for example new product development and innovation processes, together with organizational structures and supporting knowledge networks ("soft" aspects of technology).

Treating technology as a type of knowledge is helpful, as knowledge management concepts can be useful for more effectively managing technology (for example, Stata, 1989, Nonaka, 1991, Leonard-Barton, 1995). For instance, technological knowledge generally comprises both explicit and tacit knowledge. Explicit technological knowledge is that which has been articulated (for example in a report, procedure or user guide), together with the physical manifestations of technology (equipment). Tacit technological knowledge is that which cannot be easily articulated, and which relies on training and experience (such as welding or design skills).

Similarly to "technology", there are many definitions of "technology management" in the literature (for example, Roussel et al., 1991, Gaynor, 1996). For the purposes of this section the following definition is adopted, proposed by the European Institute of Technology Management (EITM) (EITM is a collaboration between a number of European universities: see http://wwwmmd.eng.cam.ac.uk/ctm/eitm/index.html).

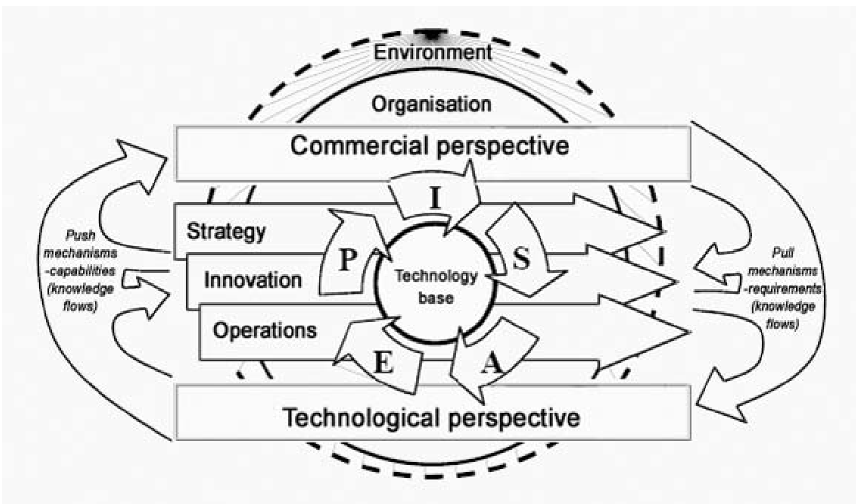
"Technology management addresses the effective identification, selection, acquisition, development, exploitation and protection of technologies (product, process and infrastructural) needed to maintain (and grow) a market position and business performance in accordance with the company's objectives".

This definition highlights two important technology management themes:

- Establishing and maintaining the linkages between technological resources and company objectives is of vital importance and represents a continuing challenge for many firms. This requires effective communication and knowledge management, supported by appropriate tools and processes. Of particular importance is the dialogue and understanding that needs to be established between the commercial and technological functions in the business.
- Effective technology management requires a number of management processes and the EITM definition includes the five processes proposed by Gregory (1995): identification, selection, acquisition, exploitation and protection of technology. These processes are not always very visible in firms, and are typically distributed within other business processes, such as strategy, innovation and operations.

Technology management addresses the processes needed to maintain a stream of products and services to the market. It deals with all aspects of integrating technological issues into business decision-making, and is directly relevant to a number of business processes, including strategy development, innovation and new product development, and operations management. Healthy technology management requires establishing appropriate knowledge flows between commercial and technological perspectives in the firm, to achieve a balance between market "pull" and technology "push". The nature of these knowledge flows depends on both the internal and external context, including factors such as business aims, market dynamics, organizational culture, etc. These concepts are illustrated in figure XXXIV, showing technology management processes (identification, selection, acquisition, exploitation and protection), business processes (strategy, innovation and operations), highlighting the dialogue that is needed between the commercial and technological functions in the business to support effective technology management.

Figure XXXIV. Technology management framework



Source: Probert et al., (2003).

Technology roadmaps

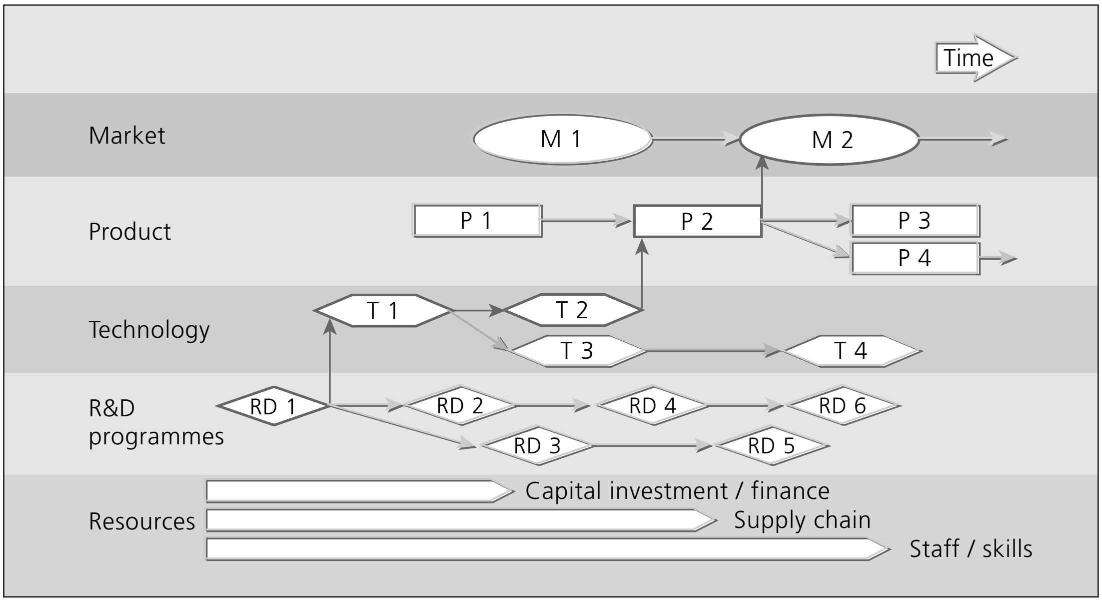
Technology roadmapping represents a powerful technique for supporting technology management and planning in the firm. Roadmapping has been widely adopted in industry (Willyard and McClees, 1987, Barker and Smith, 1995, Bray and Garcia, 1997, EIRMA, 1997, Groenveld, 1997, Strauss et al., 1998, Albright and Kappel, 2003, McMillan, 2003). More recently roadmaps have been used to support national and sector "foresight" initiatives: for example:

- The Semiconductor Industry Association (SIA) (http://public.itrs.net/files/1999_SIA_Roadmap/Home.htm) (Kostoff and Schaller, 2001).
- Aluminum industry (http://www.oit.doe.gov/aluminum/).
- UK Foresight Vehicle (http://www.foresightvehicle.org.uk/) technology roadmaps (Phaal, 2002).

An Internet search using the term "technology roadmap" will produce thousands of links, mostly relating to sector level initiatives, many of which are available for downloading (although there is considerable activity at the company level, this is seldom published for reasons of confidentiality).

Roadmaps can take various forms, but the most common approach is encapsulated in the generic form proposed by EIRMA (1997) (figure XXXV), showing how technology can be aligned to product and service developments, business strategy, and market opportunities.

Figure XXXV. Schematic technology roadmap

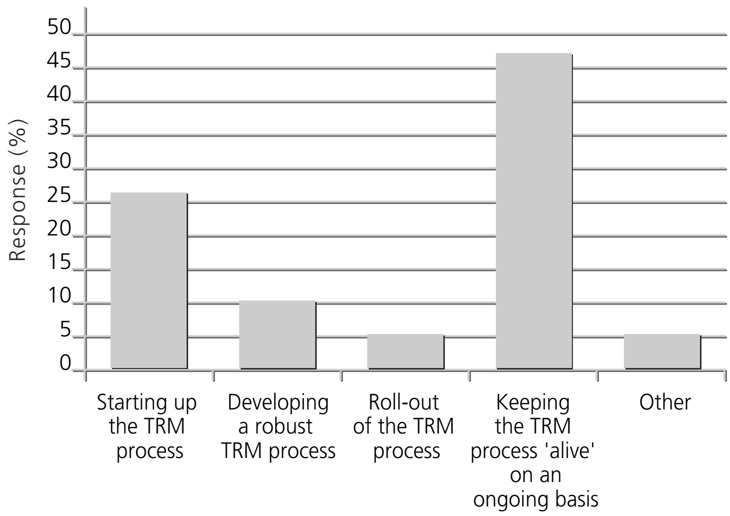


Source: Phaal, (2003).

The generic roadmap is a time-based chart, comprising a number of layers that typically include both commercial and technological perspectives. The roadmap enables the evolution of markets, products and technologies to be explored, together with the linkages between the various perspectives.

A survey of 2,000 UK manufacturing firms (Phaal et al., 2000) indicates that about 10 per cent of companies (mostly large) have applied the technology roadmapping approach, with approximately 80 per cent of those companies either using the technique more than once, or on an ongoing basis. However, application of the TRM approach presents considerable challenges to firms, as the roadmap itself, while fairly simple in structure and concept, represents the final distilled outputs from a strategy and planning process. Key challenges reported by survey respondents included keeping the roadmapping process "alive" on an ongoing basis (50 per cent), starting up the TRM process (30 per cent), and developing a robust TRM process (20 per cent)—figure XXXVI.

Figure XXXVI. Key technology roadmapping challenges



Source: Phaal, (2003).

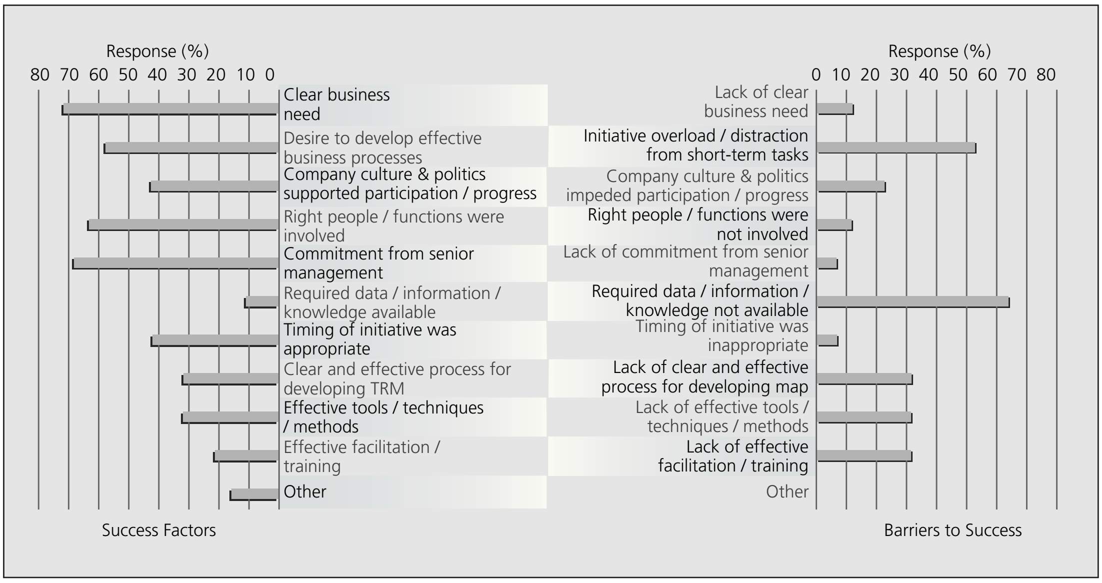
One of the reasons why organizations struggle with the application of roadmapping is that there are many specific forms of roadmap, which often have to be tailored to the specific needs of the firm and its business context. In addition, there is little practical support available and companies typically re-invent the process, although there have been some efforts to share experience. For instance, EIRMA (1997), Bray and Garcia (1997), Groenveld (1997), Strauss et al., (1998) and DoE (2000) summarize key technology roadmapping process steps. These authors indicate that the development of an effective roadmapping process within an organization is reliant on significant vision and commitment for what is an iterative, and initially exploratory, process. More recently, a number of guidance notes have been published that relate to the

application of the technology roadmapping approach at the sector level. In Australia (Australian guide to developing technology roadmaps—technology planning for business competitiveness, August 2001
http://industry.gov.au/library/content_library/13_technology_road_mapping.pdf)
and Canada (Industry Canada—Technology roadmapping—a strategy for success, including a guide for government employees:
http://strategis.ic.gc.ca/epic/internet/ intrm-crt.nsf/vwGeneratedInterE/Home.)

These documents provide useful guidance on the principles and practice of technology roadmapping, and are a useful input to the design of a roadmapping process or activity. Many of the sector-level technology roadmaps that have been published on the Internet. al.so provide useful guidance and examples. However, examination of these documents also reveals the variety of approaches that can be taken, which can be attributed to the flexibility of the roadmapping concept. In general it is necessary to customize the roadmapping approach to suit the particular circumstances for which it is intended.

Other factors that contribute to (and hinder) successful technology roadmapping are shown in figure XXXVII, based on results from the survey described above. Factors that are particularly important for successful roadmapping (greater than 50 per cent response) include a clearly articulated business need, the desire to develop effective business processes, having the right people involved and commitment from senior management. Factors that particularly hinder successful roadmapping include initiative overload, distraction from short-term tasks and required data, information and knowledge not being available.

Figure XXXVII. Roadmapping success factors and barriers to success



Source: Phaal, (2003).

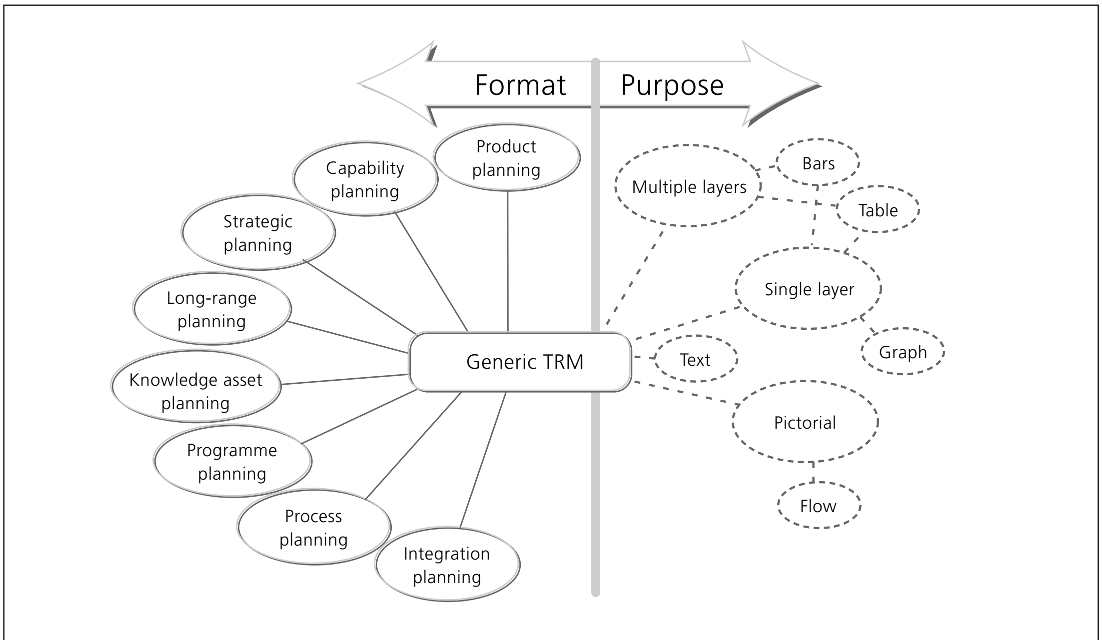
This section presents an overview of the technology roadmapping technique, including the range of aims that the approach can support, and the various formats that roadmaps take. A process for the rapid initiation of roadmapping in the firm is presented (T-Plan), together with the general requirements for supporting the process in the firm.

Technology roadmapping approaches

Purpose

The technology roadmapping approach is very flexible, and the terms “product” or “business” roadmapping may be more appropriate for many of its potential uses. Examination of a set of approximately 40 roadmaps has revealed a range of different aims, clustered into the following eight broad areas, based on observed structure and content (Phaal et al., 2001a) (figure XXXVIII).

Figure XXXVIII. Characterization of roadmaps: purpose and format

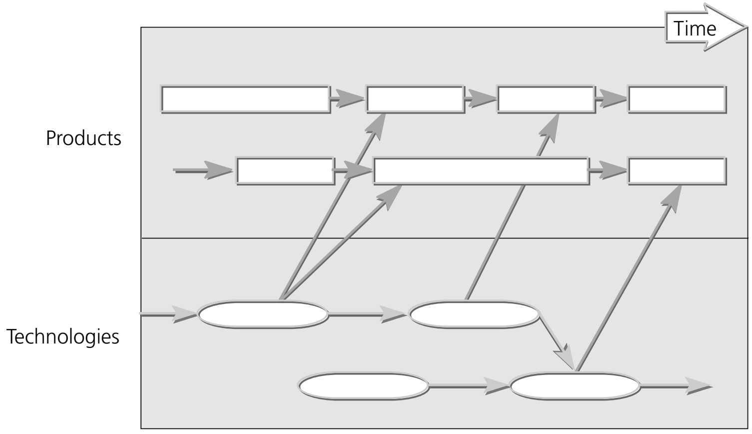


Source: Phaal, (2003).

1. Product planning

Description: This is by far the most common type of technology roadmap, relating to the insertion of technology into manufactured products, often including more than one generation of product.

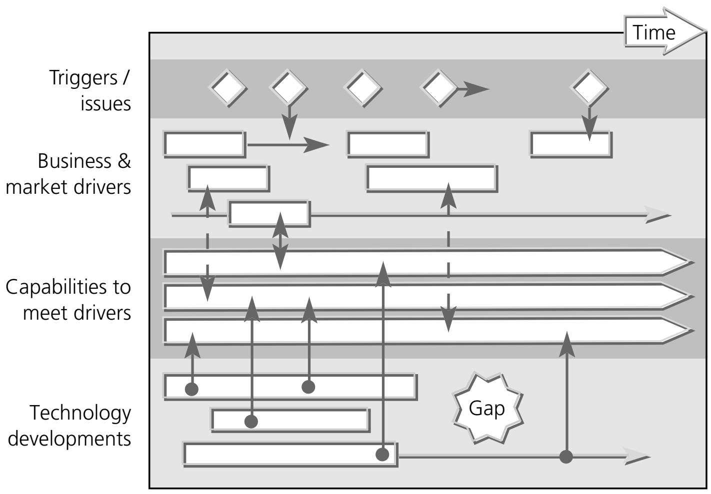
Example: A Philips roadmap, where the approach has been widely adopted (Groenveld, 1997). The example shows how roadmaps are used to link planned technology and product developments.



2. Service/capability planning

Description: Similar to type 1 (product planning), but more suited to service-based enterprises, focusing on how technology supports organizational capabilities.

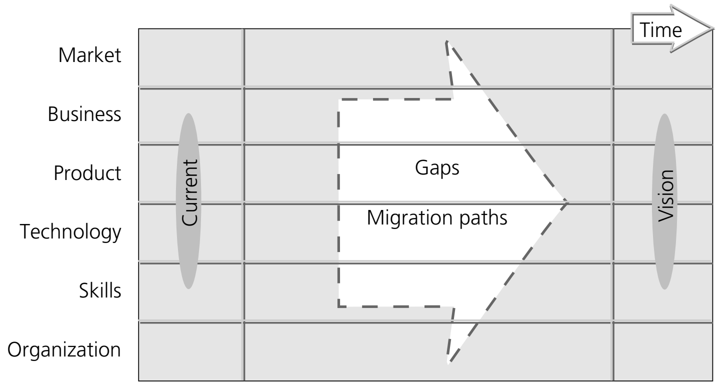
Example: A Post Office roadmap/T-Plan7 application (Brown, 2001), used to investigate the impact of technology developments on the business. This roadmap focuses on organizational capabilities as the bridge between technology and the business, rather than products.



3. Strategic planning

Description: Includes a strategic dimension, in terms of supporting the evaluation of different opportunities or threats, typically at the business level.

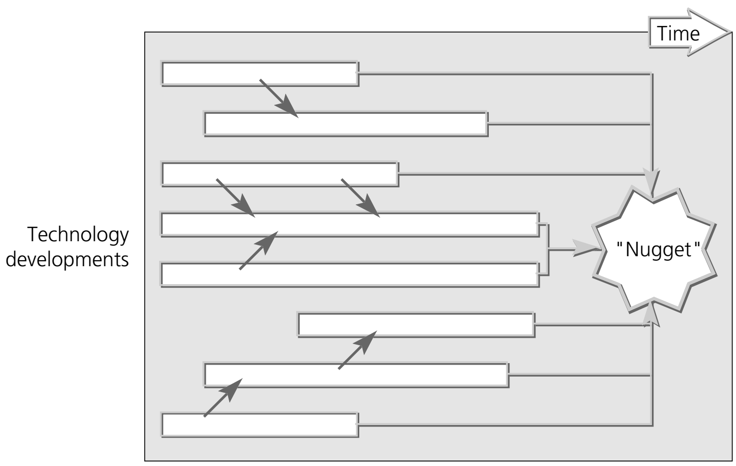
Example: A roadmap format developed using T-plan to support strategic business planning. The roadmap focuses on the development of a vision of the future business, in terms of markets, business, products, technologies, skills, culture, etc. Gaps are identified, by comparing the future vision with the current position, and strategic options explored to bridge the gaps.



4. Long-range planning

Description: Extends the planning time horizon, and is often performed at the sector or national level ("foresight").

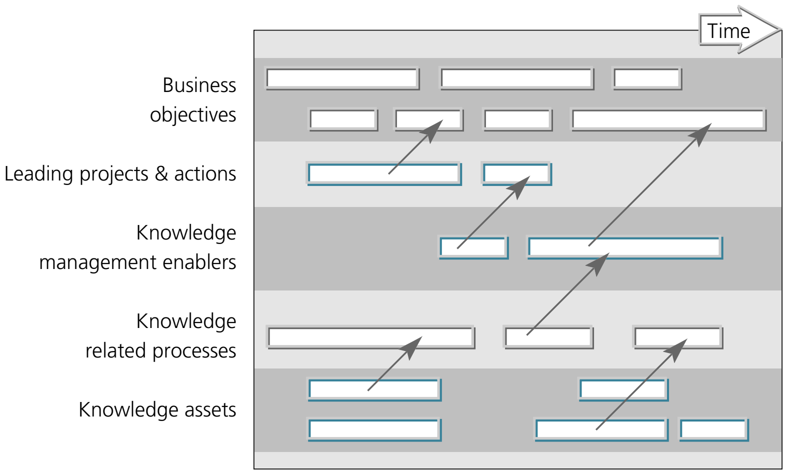
Example: A roadmap developed within the US Integrated Manufacturing Technology Roadmapping (IMTR) Initiative (one of a series). This example focuses on information systems, showing how technology developments are likely to converge towards the "information driven seamless enterprise" (a "nugget"), (IMTR, 1999), integrated manufacturing technology roadmapping (IMTR) project—information systems for the manufacturing enterprise, http://imti21.org/).



5. *Knowledge asset planning*

Description: Aligning knowledge assets and knowledge management initiatives with business objectives.

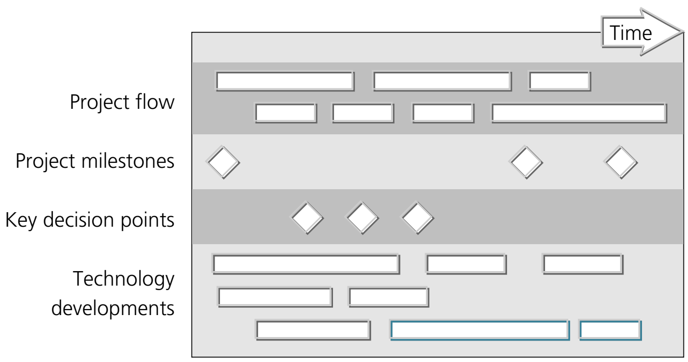
Example: This form of roadmap has been developed by the Artificial Intelligence Applications Unit at the University of Edinburgh (Macintosh et al., 1998), enabling organizations to visualize their critical knowledge assets, and the linkages to the skills, technologies and competences required to meet future market demands.



6. *Programme planning*

Description: Implementation of strategy, and more directly relates to project planning (for example, R&D programmes).

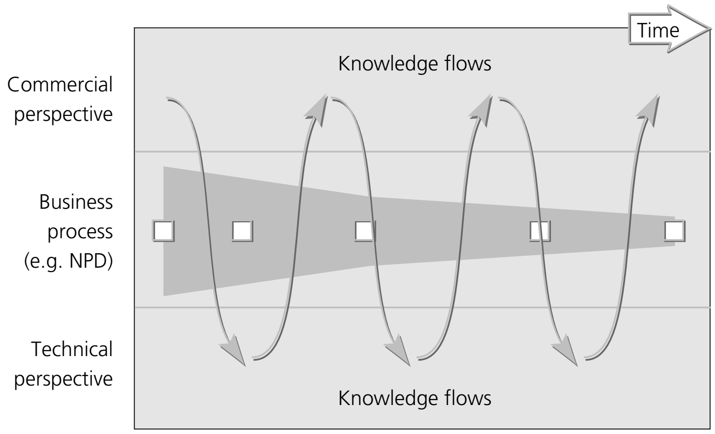
Example: A NASA roadmap (one of many) for the Origins programme, used to explore how the universe and life within it has developed. This particular roadmap focuses on the management of the development programme for the Next Generation Space Telescope (NGST), showing the relationships between technology development and programme phases and milestones.



7. Process planning

Description: Supports the management of knowledge, focusing on a particular process area (for example, new product development).

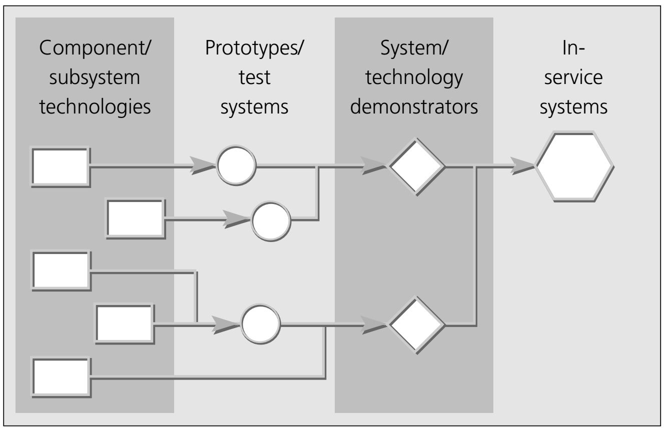
Example: A type of technology roadmap, developed using T-Plan to support product planning, focusing on the knowledge flows that are needed to facilitate effective new product development and introduction, incorporating both technical and commercial perspectives.



8. Integration planning

Description: Integration and/or evolution of technology, in terms of how different technologies combine within products and systems, or to form new technologies (often without showing the time dimension explicitly).

Example: A NASA roadmap (Origins programme—see No. 6), relating to the management of the development programme for the NGST, focusing on "technology flow", showing how technology feeds into test and demonstration systems, to support scientific missions (NASA, 1997), Origins technology roadmap, http://origins.jpl.nasa.gov/library/techroadmap/roadmapidx.htm).



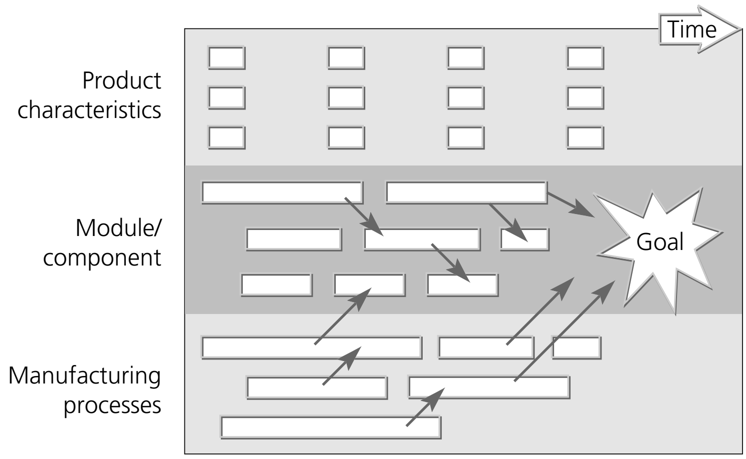
Format

Another factor that contributes to the variety of roadmaps that have been observed is the graphic format that has been selected for communicating the roadmap, with the following eight graphic types identified, based on observed structure (Phaal et al., 2001a):

(a) Multiple layers

Description: The most common format of technology roadmap comprises a number of layers, such as technology, product and market. The roadmap allows the evolution within each layer to be explored, together with the inter-layer dependencies, facilitating the integration of technology into products, services and business systems.

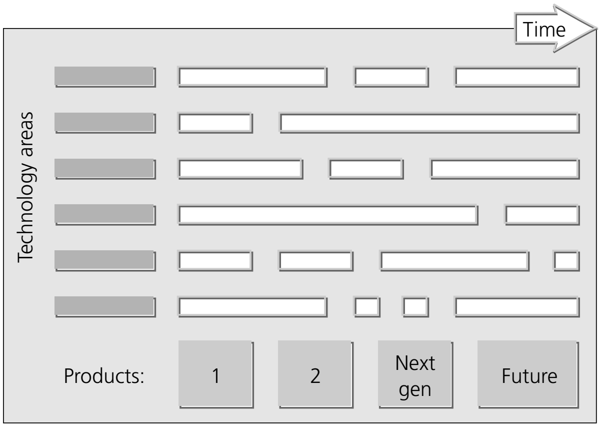
Example: A Philips roadmap (Groenveld, 1997), showing how product and process technologies integrate to support the development of functionality in future products.



(b) Bars

Description: Many roadmaps are expressed in the form of a set of "bars", for each layer or sub-layer. This has the advantage of simplifying and unifying the required outputs, which facilitates communication, integration of roadmaps, and the development of software to support roadmapping.

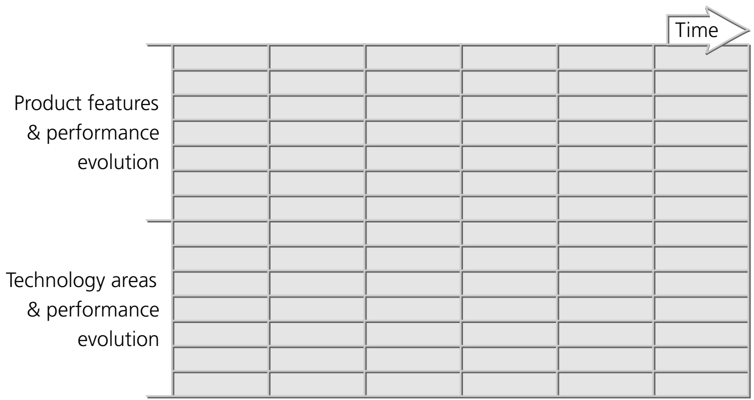
Example: The "classic" Motorola roadmap (Willyard and McClees, 1987), showing the evolution of car radio product features and technologies. Motorola has subsequently developed roadmapping to new levels, with roadmaps now forming part of corporate knowledge and business management systems, supported by software and integrated decision support systems (Bergelt, 2000).



(c) Tables

Description: In some cases, entire roadmaps, or layers within the roadmap, are expressed as tables (i.e. time vs. performance). This type of approach is particularly suited to situations where performance can be readily quantified, or if activities are clustered in specific time periods.

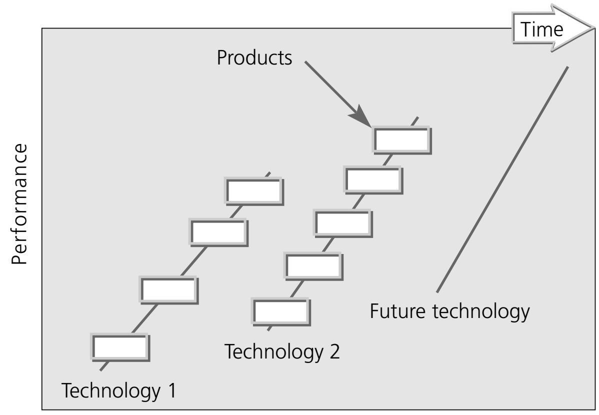
Example: A tabulated roadmap (EIRMA, 1997), including both product and technology performance dimensions.



(d) Graphs

Description: Where product or technology performance can be quantified, a roadmap can be expressed as a simple graph or plot—typically one for each sub-layer. This type of graph is sometimes called an "experience curve", and is closely related to technology "S-curves".

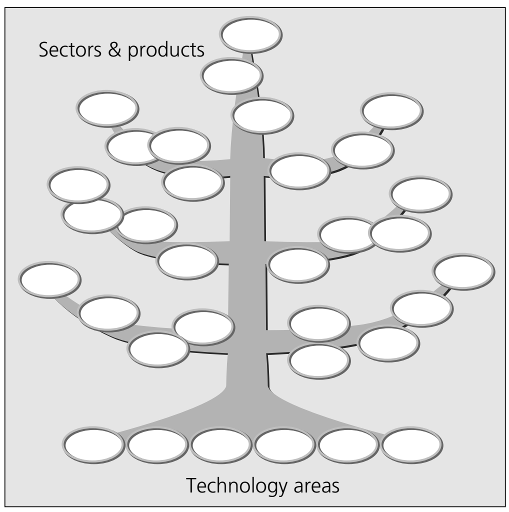
Example: A roadmap showing how a set products and technologies co-evolve (EIRMA, 1997).



(e) Pictorial representations

Description: Some roadmaps use more creative pictorial representations to communicate technology integration and plans. Sometimes metaphors are used to support the objective (e.g. a "tree").

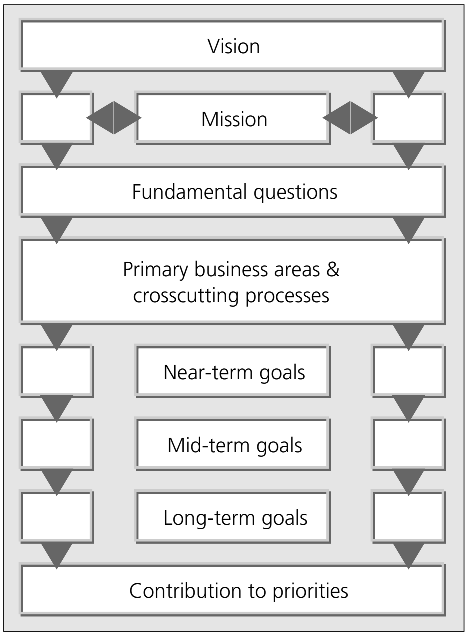
Example: A Sharp roadmap, relating to the development of products and product families, based on a set of liquid crystal display technologies. (ITRI, 1995, Electronic Manufacturing and Packaging in Japan, JTEC Panel Report, http://itri.loyola.edu/ep/).



(f) Flow charts

Description: A particular type of pictorial representation is the flow chart, which is typically used to relate objectives, actions and outcomes.

Example: A NASA roadmap, showing how the organization's vision can be related to its mission, fundamental scientific questions, primary business areas, near-, mid- and long-term goals, and contribution to US national priorities. (NASA (1998), Technology plan—roadmap, http://technologyplan.nasa.gov/)



(g) Single layer

Description: This form is a subset of type "a", focusing on a single layer of the multiple layer roadmap. While less complex, the disadvantage of this type is that the linkages between the layers are not generally shown.

Example: The Motorola roadmap (Willyard and McClees, 1987), type "b" above, is an example of a single layer roadmap, focusing on the technological evolution associated with a product and its features.

(h) Text

Description: Some roadmaps are entirely or mostly text-based, describing the same issues that are included in more conventional graphical roadmaps (which often have text-based reports associated with them).

Example: The Agfa "white papers" support understanding of the technological and market trends that will influence the sector (Agfa white papers, 1999, http://www.agfa1to1.com/whitepapers.html)

The range of roadmap types observed may be partially attributed to a lack of clear and accepted standards or protocols for their construction. However, it is considered that this also reflects the need to adapt the approach to suit the situation, in terms of business purpose, existing sources of information, available resources and desired use (the message being communicated). Roadmaps do not always fit neatly within the categories identified above and can contain elements of more than one type, in terms of both purpose and format, resulting in hybrid forms.

Technology roadmapping process

The T-Plan "fast-start" approach has been developed as part of a three-year applied research programme, where more than 35 roadmaps were developed in collaboration with a variety of company types in several industry sectors (figure XXXIX). A management guide has been written to support the application of the T-Plan approach (Phaal et al., 2001b), which aims to:

1. Support the start-up of company-specific TRM processes.
2. Establish key linkages between technology resources and business drivers.
3. Identify important gaps in market, product and technology intelligence.
4. Develop a "first-cut" technology roadmap.
5. Support technology strategy and planning initiatives in the firm.
6. Support communication between technical and commercial functions.

Figure XXXIX. Applications of T-plan fast-start TRM process

Sector/Product	Focus/Aims
Industrial coding (3 applications)	Product planning
Postal services (10 applications)	Integration of R&D into business: business planning
Security/access systems	Product planning
Software	Product planning
Surface coatings	New product development process
Medical packaging (2 applications)	Business reconfiguration
Automotive sub-systems	Service development and planning
Power transmission	Business opportunities for new technology
Railway infrastructure (3 applications)	Capital investment planning and technology insertion
National security infrastructure	Research programme planning
Building environmental controls	New product/service opportunity: business reconfiguration
Road transport	Defining national research agenda: network development
Technical consulting (6 applications)	New service development
Automotive/aerospace	Corporate synergy
Academic (2 applications)	Strategic planning
Bio-catalysis	Research planning; network development
Satellite navigation	Research planning; network development
Food processing	Research planning; network development
Pneumatic systems	Innovation strategy

Figure XXXIX. *(continued)*

Sector/Product	Focus/Aims
Emerging technologies	Research priorities
Automotive	Innovation opportunities
Retail (2 applications)	Business strategy and product planning
Off road vehicles	Global production strategy

Source: Keenan, (2003).

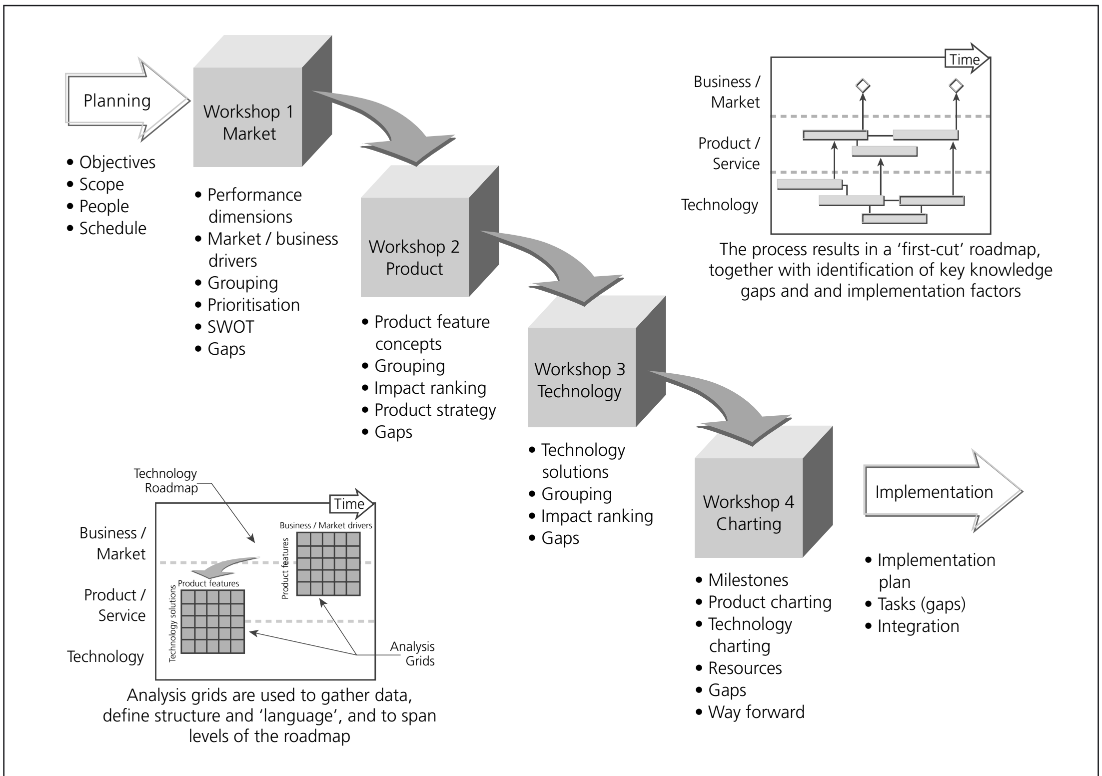
The T-plan process that has been developed to support the rapid initiation of roadmapping in the business comprises two main parts:

- Standard approach, for supporting product planning (Phaal et al., 2000).
- Customized approach, which includes guidance on the broader application of the method, incorporating many of the techniques included in the standard approach.

Standard process (integrated product-technology planning)

The standard T-plan process comprises four facilitated workshops—the first three focusing on the three key layers of the roadmap (market/business, product/service, and technology), with the final workshop bringing the layers together on a time-basis to construct the chart (figure XL).

Figure XL. T-plan: standard process steps, showing linked analysis grids



Source: Phaal, (2003).

Also important are the parallel management activities, including planning and facilitation of workshops, process coordination, and follow-up actions. Simple linked analysis grids are used to identify and assess the relationships between the various layers and sub-layers in the roadmap.

Customizing the process

Technology roadmapping is an inherently flexible technique, in terms of:

- The wide range of aims that roadmapping can contribute towards.
- The time frame covered by the roadmap (past and future).
- The structure of the roadmap, in terms of layers and sub-layers, which can be adapted to fit the particular application.
- The process that is followed to develop and maintain the roadmap/s.
- The graphical format that is selected to present information and communicate the roadmap.
- The set of existing processes, tools and information sources in the firm which the roadmap and roadmapping process need to integrate with.

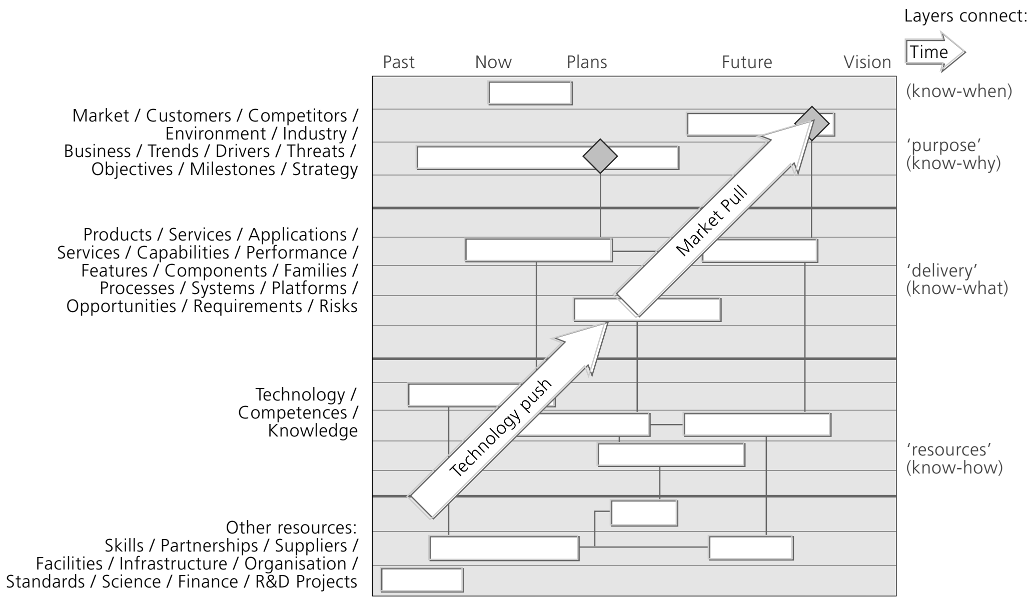
Application of the T-Plan approach in a wide range of organizational and strategic contexts has enabled the flexibility of the roadmapping method to be explored. The approach can (and should) be customized to suit the particular application, in terms of roadmap architecture and the process for developing the roadmap.

The generalized roadmap shown in figure XLI, based on observations of many roadmaps, illustrates the different layers and sub-layers that can be used to define the roadmap structure, which can be tailored to fit the particular context. The multi-layered generic architecture allows key aspects of knowledge about the business to be captured, structured and shared, strategic issues to be identified, and actions agreed. Alignment of "know-why" (purpose), "know-what" (delivery), "know-how" (resources) and "know-when" (time) allows a balance between market pull and technology push to be achieved.

Customization needs to be considered during the planning phase, at the heart of which is a design activity, where both the roadmap architecture and roadmapping process need to be considered in parallel. As with all design activities, the process is creative, iterative and non-linear in nature. The following checklist is used in T-Plan applications as a basis for focusing discussion, which continues until the parties agree a plan that makes sense to all involved:

- *Context*—the nature of the issue that triggered interest in roadmapping needs to be explored and articulated, together with any constraints that will affect the approach adopted, including the following considerations:
  - *Scope:* defining the boundaries of the domain of interest (i.e. what is being considered, and what is not).
  - *Focus:* the focal issue that is driving the need to roadmap.

Figure XLI. Generalized technology roadmap architecture



Source: Phaal, (2003).

- *Aims:* the set of goals and objectives that it is hoped to achieve with roadmapping, in the long- and short-term. As well as the overt business aims, organizational goals are also typically included, such as the desire to improve communication and to understand how the roadmapping approach can be used to support ongoing strategic activities in the firm.
- *Resources:* the level of resource that the organization is willing to contribute, in terms of people, effort and money.

• *Architecture*—the structure of the roadmap, in terms of:

- *Time frame:* the chronological aspects of the roadmap (horizontal axis), in terms of the planning horizon and key milestones, and also whether past events and activities should be included.
- *Layers:* the structure of the vertical axis of the roadmap, in terms of broad layers and sub-layers, which is closely related to how the business is structured and viewed (physically and conceptually).

• *Process*—the staged set of activities needed to build roadmap content, make decisions, identify and agree actions and maintain the roadmap in the future. The process includes a "macro" level, in terms of the broad steps needed in the short-, medium- and long-term, as well as a "micro" level, associated with the short-term and in particular the agenda that will guide the workshop/s.

• *Participants*—the people who need to be involved in the process and workshop/s, with the knowledge and expertise necessary to develop a well-founded and credible roadmap. Typically a multifunctional team is needed, representing both commercial and technical perspectives. The number of participants involved in the workshop/s depends on the specific context, and during the development and application of T-Plan workshop groups ranged in size from 5 to 35 participants. The agenda and facilitation approach adopted will vary depending on group size, with the need to break into sub-groups (with plenary feedback) if the group size exceeds about 10.

- *Workshop venue and scheduling*—a suitable date and venue is needed for the workshop/s, large enough to allow participatory roadmapping activity by the group/s.
- *Information sources*—it is important that the roadmapping activity takes account of available information, although there is a practical limit as to the quantity of data that can be accommodated in a workshop environment. Relevant information should be assessed prior to the workshop, and consideration given to what information should be supplied to participants prior to the workshop, handed out at the workshop, built into the roadmap template, or incorporated after the workshop in the context of an ongoing roadmapping process.
- *Preparatory work*—activities that need to be performed prior to the workshop/s need to be identified and agreed, such as inviting participants, booking an appropriate venue, preparing briefing documents and facilitation materials.

Taking the process further

The development of an initial roadmap is the first, but very important, step on the way towards implementing roadmapping in a more complete and beneficial way, if that is deemed appropriate. The key benefit of the fast-start T-Plan approach, apart from the direct business benefits that arise from its application, is that the value of the method can be assessed quickly and economically. The learning that is gained by this initial application provides confidence about how best to take the process forward within the organization.

While some organizations choose to use the method for particular situations on a one-off basis, others have taken roadmapping forward to form a significant part of their strategy and planning processes. Roadmapping can become the focal, integrating device for carrying the business strategy and planning process forward, bringing together the market/commercial and technological knowledge in the organization (figure XLII). Key issues include deciding where the boundaries of the roadmapping process should lie, to technology roadmapping what extent the method should be adopted, and how to integrate it with other systems and processes.

There are two key challenges to overcome if roadmapping is to be adopted widely within a company:

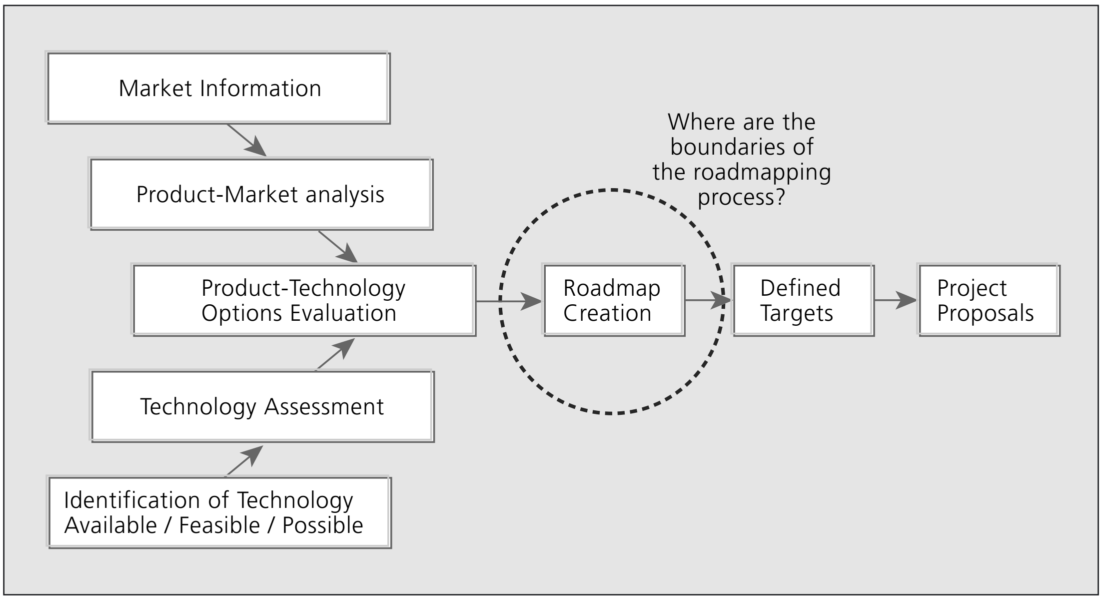
- *Keeping the roadmap alive:* the full value of roadmapping can be gained only if the information that it contains is current and kept up-to-date as events unfold. In practice, this means updating the roadmap on a periodic basis, at least once a year, or perhaps linked to budget or strategy cycles. The initial first-cut roadmap produced by the T-Plan process must be captured, stored, communicated, researched and updated, which requires careful consideration of the process and systems needed to facilitate this.

— *Roll-out:* once the first roadmap is developed in an organization, it may be desired to facilitate the adoption of the method in other parts of the organization. Essentially there are two approaches to rolling-out the method:

— *Top-down,* where the requirement for roadmaps is prescribed by senior management—the particular format may or may not be specified.

— *Bottom-up ("organic"),* where the benefits of using the method are communicated and support provided for application of the method where a potential fit with a business issue/problem is identified.

Figure XLII. Roadmaps integrate commercial and technological knowledge



Source: EIRMA, (1997), Phaal, (2003).

In either case senior management support is important, in terms of enthusiasm for use of the method, but also in terms of ensuring that resources are made available (budget, time and facilitation), workshops scheduled and barriers removed.

A further issue to consider if the roadmapping method is to be used on an ongoing and more widespread basis is that of software for supporting the development, storage, dissemination and upkeep of roadmaps. Simple word processing, spreadsheet and graphics packages are suitable for the initial development of a roadmap, but more sophisticated software would be beneficial if the process is to be taken forward.

(Some dedicated technology roadmapping software systems are: Geneva Vision Strategist developed by The Learning Trust (an enterprise solution used by Motorola and other large organizations): http://www.learningtrust.com; and Graphical Modelling System (GMS) developed by the US Office of Naval Research (ONR): http://www.onr.navy.mil/gms/gms.asp).

Software that is developed to support roadmapping should aim to provide the following types of functions:

- The multi-layer roadmap structure is recommended as the primary way of working with roadmapping data, owing to its simplicity and flexibility. Roadmapping objects (bars, linkages, annotations, etc.) can be defined in terms of their position in the layers, and on a time basis. The layered structure allows for a hierarchy of roadmaps to be developed, at any level of "granularity" in the firm.
- Software should define a common architecture for building roadmaps in the firm, enabling data sharing and linkage, which requires specification of appropriate protocols and templates.
- The software should support management of the data that is associated with the roadmap, including data mining ("drill-down") and analysis, together with methods for managing the complexity of the data for the user (e.g. multiple perspectives on the data, critical paths, linkages, etc.). Inclusion of additional management "tools", such as the analysis grids used in the T-Plan method and portfolio project selection matrices is desirable.
- The software should be as customizable as possible, in terms of setting up the layered structure, definition of roadmapping objects, choice of graphical representation, and inclusion of annotations, notes and supplementary information.
- One of the strengths of the roadmapping approach is its support for integration of information, processes and methods in the firm, and the supporting software should reflect this, proving facilities for importing and exporting data, together with linkages to other business and management information systems. In its broadest sense, the roadmapping process and supporting software can form a central element of knowledge and information management systems in the firm.
- The software should cater for both "novice" and advanced users. The software should be able to "grow" with the company as its use of roadmapping expands and matures. The software should provide support for the development of individual roadmaps, as well as support for enterprise-wide roadmapping (scalability). The software should support multi-user, distributed participation in the development of roadmaps, which require input from various perspectives in the firm. Roadmap elements should be dynamically linked (within roadmaps and between roadmaps), so that the effects of changes to roadmaps can be readily determined.
- Software should fit in with the human process that is a key benefit of the technique; the development of good roadmaps typically requires multifunctional workshops. There is scope for creative approaches to the development of effective software-user interfaces, such as the use of electronic whiteboard and brainstorming technology. The role of software is to support the roadmapping process, and users should not expect that software alone will result in good roadmaps.

Case example—Foresight Vehicle technology roadmap

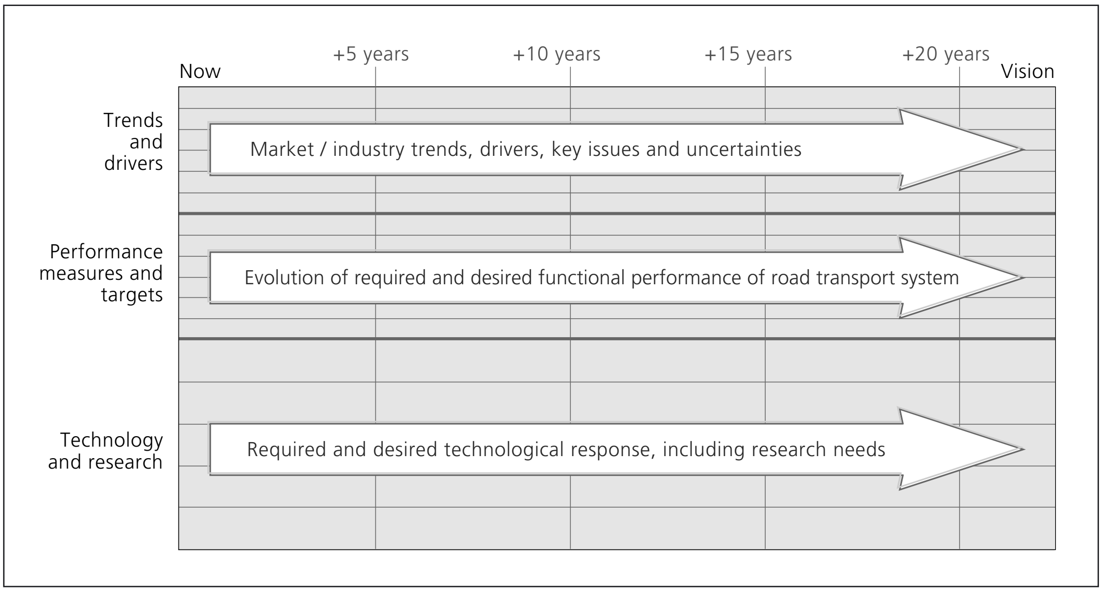
An Internet search using the term “technology roadmap” will provide many examples of sector-level roadmaps, which are a useful resource for those embarking on a technology roadmapping initiative, providing input data and also in terms of the approaches that have been adopted in terms of roadmapping processes and roadmap architectures. The Foresight Vehicle technology roadmap example below illustrates one possible approach.

The Foresight Vehicle (http://www.foresightvehicle.org.uk/) an industry-academic network that is supported by the UK Department of Trade and Industry (DTI), Engineering and Physical Sciences Research Council (EPSRC) and other government departments. The goal is to stimulate applied research that will contribute to the economic, social and environmental goals of industry and government in the UK, focused on the automotive sector (and road vehicles in particular). The foresight Vehicle consortium has been active for more than five years, involving more than 400 organizations and sponsoring collaborative research worth more than £80 million.

A technology roadmapping initiative was undertaken in 2001-2002 (Phaal, 2002) to stimulate the network (drawing in new members), with the specific aim of defining the research challenges for the next round of funding. The process, which resulted in publication of version 1.0 of the roadmap (available to download from the Foresight Vehicle web site), involved a total of 10 workshops over a period of 10 months, with more than 130 participants from 60 organizations. The technology roadmap architecture is shown in figure XLIII, and the roadmapping process is illustrated in figure XLIV.

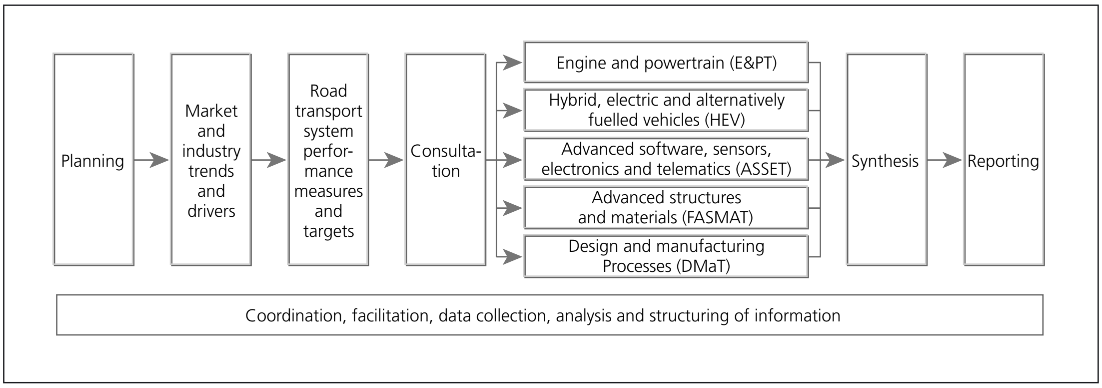
A systems approach was adopted (figure XLV), recognizing that the road vehicle forms part of a much larger system, which needs to account for the social, economic and

Figure XLIII. Foresight Vehicle technology roadmap architecture



Source: Phaal, (2003).

Figure XLIV. Foresight Vehicle technology roadmap process

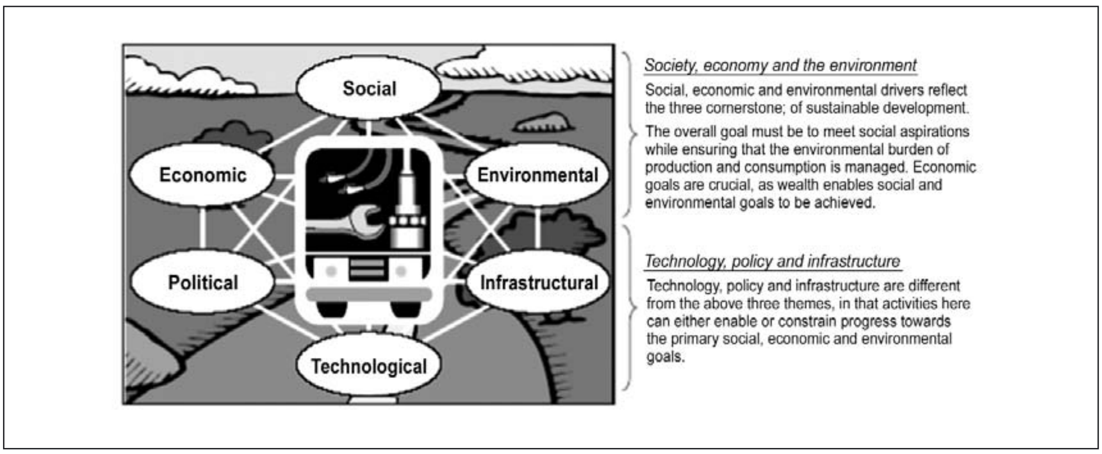


Source: Phaal, (2003).

environmental goals that form the three cornerstones of sustainable development, and reflecting the political, technological and infrastructural systems that can either enable or hinder progress towards these goals. These six themes ("STEEPI") were used to structure the top two layers of the roadmap, in terms of the trends and drivers, and also the road transport system. The technology layer of the roadmap was structured in terms of the five Technology Group areas that form the core activities of the Foresight Vehicle consortium (figure XLII).

The Foresight Vehicle technology roadmap is intended to act as a resource of the many different stakeholders involved in the network, including companies, universities and government. For this reason the report was written in such a way as to minimize bias and "interpretation", presenting the information that had been gathered during workshops and subsequent Internet-based research in an objective fashion. A total of 28 "rich picture" roadmaps form the core of the report (appendices), associated with the various sub-layers of the roadmap, with the main body of the report comprising a successive series of higher level summaries of the detailed content in the appendices, including text, tables and simplified graphics. For these reasons it may be more appropriate to

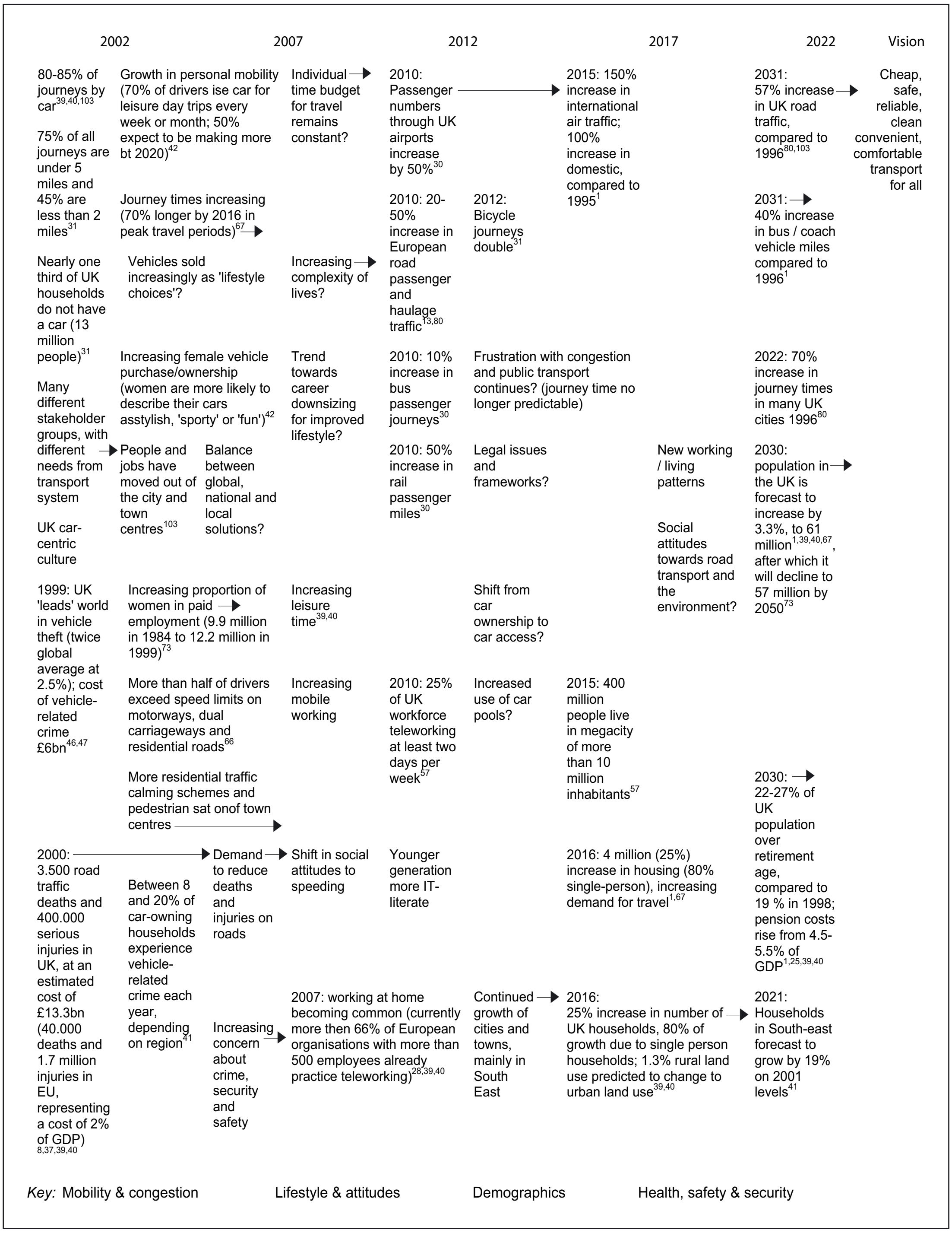
Figure XLV. Foresight Vehicle systems view



Source: Phaal, (2003).

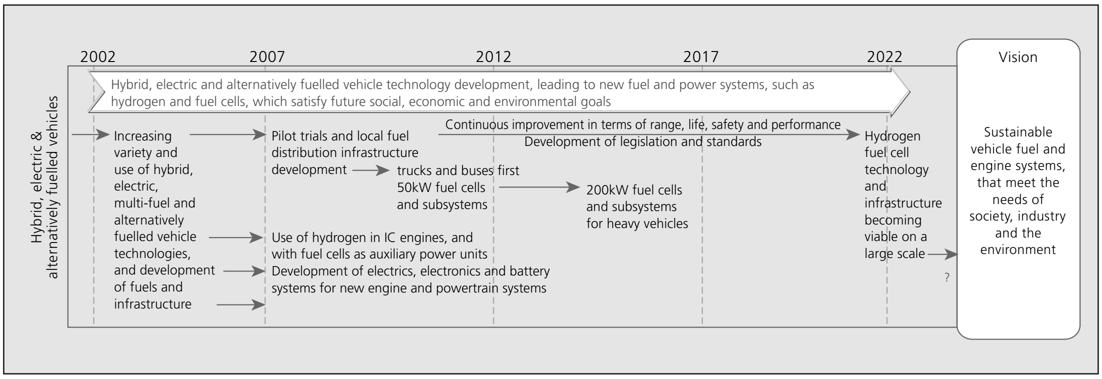
term this a technology “landscape” rather than a “roadmap”. The approach adopted is illustrated in figure XLVI and figure XLVII, showing one of the 28 “rich picture” roadmaps (for the social trends and drivers theme), and also one of the summary graphical roadmaps (for the hybrid, electric and alternatively fuelled technology theme).

Figure XLVI. Social trends and drivers “rich picture” roadmap



Source: Phaal, (2003).

Figure XLVII. Summary graphical roadmap for hybrid, electric and alternatively fuelled vehicle technology



Source: Phaal, (2003).

Summary

Technology roadmaps clearly have great potential for supporting the development and implementation of business, product and technology strategy, providing companies have the information, process and tools to produce them. The following general characteristics of technology roadmaps have been identified:

- Many of the benefits of roadmapping are derived from the roadmapping process, rather than the roadmap itself. The process brings together people from different parts of the business, providing an opportunity for sharing information and perspectives. The main benefit of the first roadmap that is developed is likely to be the communication that is associated with the process, and a common framework for thinking about strategic planning in the business. Several iterations may be required before the full benefits of the approach are achieved, with the roadmap having the potential to drive the strategic planning process.

- The generic roadmapping approach has great potential for supporting business strategy and planning beyond its product and technology planning origins. It should be recognized that it is not a "black box" methodology, that each application is a learning experience, and that a flexible approach, adapted to the particular circumstances being considered.

- Roadmaps should be expressed in a graphical form, which is the most effective means of supporting communication. However, the graphical representation is a highly synthesized and condensed form, and the roadmap should be supported by appropriate documentation.

- Roadmaps should be multi-layered, reflecting the integration of technology, product and commercial perspectives in the firm. The roadmapping process provides a very effective means for supporting communication across functional boundaries in the organization. The structure that is adopted for defining the layers and sub-layers of the roadmap is important, and reflects fundamental aspects of the business and issues being considered. Typically these layers relate to key knowledge-related dimensions in the business, such as "know-why", "know-what", "know-how", "know-when", "know-who", and "know-where".

- Roadmaps should explicitly show the time dimension, which is important for ensuring that technological, product, service, business and market developments are synchronized effectively. Roadmaps provide a means of charting a migration path between the current state of the business (for each layer), and the long-term vision, together with the linkages between the layers.
- Software has an important role to play in supporting the application of roadmapping in the enterprise. However, software alone cannot deliver good roadmaps, and needs to be integrated with the human aspects of roadmapping. A key benefit of roadmapping is the sharing of knowledge and the development of a common vision of where the company is going.

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This module is mostly based around papers presented at a series of courses arranged by UNIDO as part of a programme for Central and Eastern Europe and the Newly Independent States. Each paper of these papers is available in full on the UNIDO web site http://www.unido.org. The module also contains some additional material.

The UNIDO papers are:

1. *Overview of Methods used in Foresight,* Ian Miles and Michael Keenan, the Technology Foresight for Organisers Training Course, Ankara, December 2003.
2. *Delphi Method,* Kerstin Cuhls from the Foresight Methodologies Text Book, Training Module 2.
3. *Brainstorming and Creativity,* Halka Balackova, from the Foresight Methodologies Text Book, Training Module 2.
4. *Critical Technologies,* Karel Klusacek, from the Foresight Methodologies Text Book, Training Module 2.
5. *Scenario Planning,* Ian Miles, from the Foresight Methodologies Text Book, Training Module 2.
6. *Technology Roadmapping,* Robert Phaal, from the Foresight Methodologies Text Book, Training Module 2.
7. *The Most Commonly Applied Methodologies in Technology Foresight,* Jesús Arapé Morales, Regional Conference on Technology Foresight for Central and Eastern Europe and the Newly Independent States, Vienna, April 2001.

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1. *The Future is Ours: Foreseeing, Managing and Creating the Future,* Graham May, Adamantine/Greenleaf 1996.

2. *Cross-impact analysis for identification of key drivers,* Rafael Popper, excerpt taken from Miles, I. and Keenan, M. "*Handbook on Knowledge Society foresight*", Dublin: European Foundation, 2003.

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Futures Research Methodology

A CD with 27 chapters devoted to different futures methods, available from the American Council for the United Nations University at *http://www.acunu.org.*

Forecasting Principles

http://hops/wharton.upenn.edu/forecast.

Future Tool Kit

http://www.futuretoolkit.com.

Technology Futures Inc

The use of futures methods in relation to five different approaches to the Futures Skills *http://www.tfi.com/rescon/five_views.html.*

Local Government Association (England) Futures Toolkit

http://www.lga.gov.uk/Documents/toolkit/futures per cent20methods.pdf.

How to build scenarios

http://www.wired.com/wired/scenarios/build.html.

REVIEW QUESTIONS

1. What are the benefits of using formal methods in a foresight exercise? What factors would you take into account in selecting appropriate methods?
2. How do exploratory and normative approaches differ?
3. Why is it important to be clear about the assumptions on which methods used in foresight are based?
4. What would you need to consider in setting up an environmental scan?
5. How might you use a SWOT analysis in a foresight exercise?
6. What are the advantages and disadvantages for foresight of extrapolative methods?
7. Why might creative methods have a role to play in foresight?
8. Which of the methods outlined do you think would be most useful in a foresight exercise?
9. What are the distinguishing features of the Delphi method?
10. In what circumstances is Delphi a suitable method in foresight?
11. Outline the steps you would take in carrying out a Delphi exercise?
12. Brainstorming is based on two principles or preconditions. What are they?
13. What preparations would you make for a brainstorming session?
14. Outline the rules which make brainstorming sessions most useful.
15. How would you run a brainstorming session?
16. In what circumstances in foresight would you use brainstorming?
17. In what circumstances in a foresight exercise might you use a single scenario?
18. Outline the potential benefits of scenarios in foresight. Why would you use multiple scenarios?
19. What benefits are to be gained from "ownership" of scenarios?
20. What preparatory steps should be taken before running a scenario workshop?
21. Why might you use the success scenario approach?
22. Which types of scenario would be most useful in a foresight exercise? How would you organize a scenario process using one of these types?
23. How would you define critical or key technologies?
24. What steps would you take in running a critical technologies project?
25. What is a roadmap? Outline the issues to be considered in preparing a roadmap.

Review question 1

Making the foresight process more systematic.

Increasing the transparency of inputs, processes, and outputs.

Constituting "hybrid forums" for interaction and communication between various system actors.

Aiding the visualization of possible and/or desirable futures.

Resources.

Breadth and depth of participation.

Combination of methods.

Outputs required.

Data requirements.

Methodological competence.

Review question 2

Exploratory methods are "outward bound". They begin with the present as the starting point, and move forward to the future.

Normative methods are, in contrast, "inward bound". They start with a preliminary view of a possible (often a desirable) future or set of futures that are of particular interest. They then work backwards.

Review question 3

Clarifying assumptions helps select appropriate methods.

Review question 4

Sources to scan.

Should it be passive, active or directed.

Quality of the data.

Review question 5

To identify the strengths, weaknesses, opportunities and threats in a given situation.

Review question 6

Usually statistical and therefore can appear to be "scientific".

Can be used to identify trends.

No guarantee that the trends will continue.

Review question 7

Because foresight is not solely predictive but aims to influence the future.

Review question 8

Choice will depend on the situation of the exercise that should be carefully considered.

Review question 9

Delphi is an expert survey in two or more "rounds".

Starting from the second round, feedback is given (about the results of previous rounds).

The same experts assess the same matters once more—influenced by the opinions of the other experts.

Review question 10

Long-term issues where extrapolation is of little use and expert judgement can provide a useful guide.

Review question 11

What should be the breadth of the study?

How many and which fields should be included?

How will the study be organized? Who manages the process?

Who will be invited to participate (active or non-active)?

What results can be expected?

What questions are to be asked?

How is the questionnaire to be designed?

What kind of analysis is required?

How do you intend to implement the results?

Will there be follow-up activities (public relations, publications, workshops, presentations, conferences, etc.)?

Review question 12

The theory of association.

Needs to be conducted in a relaxed atmosphere.

Review question 13

What is the purpose of the brainstorming session and what is the topic?

How many people and which people should be involved?

When and where will the session take place?

Review question 14

No criticism of judgement.

Free expression.

Quantity rather than quality of ideas.

Record ideas.

Evaluation later.

Review question 15

Explain objectives.

Explain rules.

Warm up before the main session.

Record all suggestions.

Facilitate ideas.

Remember to thank participants.

Review question 16

Where creative thinking is needed.

Review question 17

To present an ideal vision, or to highlight the major trends in a best-guess future.

Review question 18

Especially the well-known scenario workshop approaches—can be highly relevant to the networking goals of foresight. The process of scenario construction in workshops can yield important benefits here, in terms of exchange of views about developments, strategies, and the like.

Review question 19

Understand the logic much better than if the material is presented in a standard report.

Have deeper insight into the considerations that have gone into the scenarios.

Be better-equipped to be "carriers" of the scenarios to the outside world.

Review question 20

Identify participants for the scenario workshop.

Determine what background research might need to be conducted, or materials collated, to provide participants with some common informational resources.

Define the workshop procedures.

Review question 21

Where there is a clear desirable future and a route to it can be developed.

Review question 22

Single—where there is a need to explore the impact of a particular future

Multiple—to explore alternative futures skills

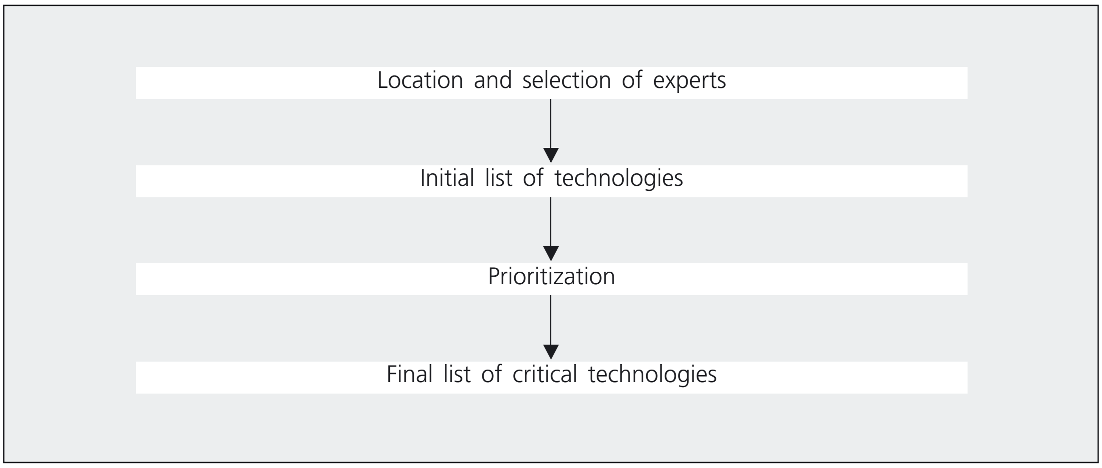
Success—to establish a route to achieve a desirable future

Arrange a scenario workshop with leading experts

Review question 23

Technologies which have a strong potential to influence national competitiveness and quality of life

Review question 24



Review question 25

A roadmap is a time-based chart, comprising a number of layers that typically include both commercial and technological perspectives. The roadmap enables the evolution of markets, products and technologies to be explored, together with the linkages between the various perspectives.

- Context
  - Scope
  - Focus
  - Aims
  - Resources
- Architecture—the structure of the roadmap, in terms of:
  - Timeframe
  - Layers
- Process
- Participants
- Workshop venue and scheduling
- Information sources
- Preparatory work

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