Technology ForeSight Initiative

TEXT BOOK

Foresight Methodologies

Training Module 2

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

economy environment employment

Foreword

UNIDO Regional Initiative on Technology Foresight for Central and Eastern Europe (CEE) and the Newly Independent States (NIS) aims at responding to the region need for a mid-and long-term development vision as well as for bringing a more technology-oriented focus into the relevant national and regional knowledge-based institutions. The regional initiative should be instrumental to provide assistance to economies in transitions for a more sustainable and innovative development aiming at fostering economical, environmental and social benefits at national and regional levels.

As a component dedicated to strengthening the capabilities in the region to conduct and apply foresight in the decision making process, UNIDO has established training programmes on technology foresight in selected institutions in the CEE/NIS. This action promotes training according to four modules, dedicated to: organizers (module 1), practitioners (module 2), decision makers (module 3) and corporate (module 4).

Training Module 2 should provide to participants an overview of the most used methodologies and practical experience on applying them in foresight exercise. The module dedicated to technology foresight practitioners.

The training module is intended to upgrade knowledge of the industrial policy and technology foresight practitioners from government staff, academia and corporations as to application of TF tools and methodologies for technological policy promotion, long-term development scenario formulation and strategic decision making in the region of CEE/NIS.

Acknowledgement

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Background analysis: trend extrapolation; analysis of framework; megatrend analysis*

Abstract

The three subject matters will be dealt with in the chapter successively. Time series-analysis and -extrapolation will be presented using different examples. Main focus is given to forecasts based on the theory of cause and effect. A short introduction into the theoretical foundations is followed by a case study as group work, developing a causal link system for a specific market in the durables consumption sector.

Megatrend analysis will be summarized from the autor's book: "Global Scenarios. Megatrends in Worldwide Dynamics".

Forecasting on the Basis of Time Series Analyses

Inherent Laws During the Course of Economic Activity

This very popular method is based on the fundamental assumption that 'inherent laws' are effective during the course of economic activity, which win through again and again and steer the development of economically relevant variables onto certain 'predestined' courses. This has led to the conclusion that, once these inherent laws are successfully quantified through analysis of past developments and expressed in the form of an appropriate activity formula, we will then automatically also be in a position of being able to visualize future development. Forecasts based on such basic concepts are essentially built on an analysis of past activity. The results of this analysis are considered valid also in future by means of an analogy conclusion. The mathematical-statistical tool required for this analysis is knowledge of time series analysis, or breakdown of a time series into its components (trend, typical seasonal but still short-term fluctuations, business cycle and irregular influences), as well as typifying the first three components.

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Most Important Areas of Application

Experience has shown that the fundamental hypothesis on which time series analysis is based, i.e., constancy of economic variables over time, does not apply to the economic cycle phenomenon. Therefore, time series analysis cannot be used for economic forecasts from the outset. The reason for this is the irregularity of cyclical fluctuations (which cannot be taken into account via forecasting). In contrast, the above mentioned hypothesis appears in most cases to be applicable to seasonal or thus far short-term cyclical fluctuations, as well as long-term developments (trends). Let us first look at short-term fluctuations having a distance into the future of less than one year and being subject to pronounced seasonal, monthly, weekly, daily or hourly rhythms. The constancy of such short-term patterns of activity is obvious. Therefore, forecasts based on typified models of activity determined via analysis of the past usually provide very good results (see Figures 1 and 2).

Longer-term developments of relevant economic variables, evident via trends, seem also to be subject to definite laws over the course of time. There are in fact numerous examples that seem to prove clearly that the developments of many variables are astoundingly regular in the long term insofar as they always fall on the trend again despite temporarily sustained short-term deviations. Even larger scale political and economic disturbances do not seem to be able to throw a long-term trend off its course. It is as if it possessed magnetic power. Therefore, it is understandable that quite a few forecasters are tempted to extend a basic trend, determined on the basis of the past, through one stroke of a feather, so to speak. And indeed, why should a trend that has been very impressive in its regularity for years, even decades, suddenly deviate from its course?

The probability that the inherent laws, apparent through the constancy in trend, always win through again in the end is often considered greater than the probability that the future could lead to a fundamental change in a previous basic trend. An example may be useful in illustrating this point. The development of US macroeconomic productivity (real gross domestic product per wage/salary earner) has shown a remarkably constant trend for more than 100 years, so it is not surprising that numerous economists see the influence of the innate and hardly changeable 'character' of the American economy as the reason behind this. By the way, similar ideas exist for other countries as well. For example, H. Kahn goes as far as saying that each country has 'its own' long-term course of development and that 'while it can depart from this course temporarily, it will always come back to it in the end'. Great Britain, whose growth rate had been hovering around 2% since 1860, achieved 3% growth after 1945. For British conditions this meant a considerable increase beyond the long-term benchmark, which was apparently only temporary. According to Kahn, Great Britain is and remains to be a 'two percent growth country'.

Typical Trends

It is generally accepted that there are different trends, the most important of which are shown schematically in Figure 3:

Linear Trend. It increases or decreases over time at constant absolute rates of change according to the basic formula:

$$Y = a + b X$$

where Y = the variable analyzed, a = the initial value of the trend (at x = 0), b = the absolute change of y per observation period, and X = the time unit (year, month, quarter, etc.), whereby x = 0 at the starting point and the time units are continuously updated (1, 2, 3, ... n).

Exponential Trend. This trend increases or decreases at constant percentage rates of growth (b), according to the formula:

$$\log Y = a + b \log X$$

On a logarithmic scale this trend is linear.

Parabolic Trend. It is consistent with the formula:

$$Y = a + b X + c X2$$

This trend has the tendency of initially increasing or decreasing only slightly and then more and more so with time. The reason for this is parameter c, which due to multiplication with the squared time unit adds an increasingly strong upward or downward 'slant' to the trend.

Logistic Curves, Growth Curves. This trend is usually S-shaped, i.e., moving from an initial phase into a dynamic phase in order to then enter into a new (stationary) equilibrium phase again in the end. It is consistent with the formula:

$$Y = a / 1 + ea-bX + b$$

Life Cycle Curves. They follow at first a growth curve trend. In a subsequent period the curve takes a downturn again. Its trend is consistent with the formula:

$$Y = a / 1 + ea-bX + ed-cX$$

Growth theory frequently operates with such depictions of trends. The difference between the logistic trend, moving towards saturation, and so-called 'life cycle curves' is that with the latter – similarly to nature – no new stationary (equilibrium) phase occurs, rather a downturn or waning of the variable in question. These curves are sections of frequency distributions, meaning that both approaches are closely connected or represent a transformation.

In all these cases forecasts are based on extrapolations of past trends. Therefore it is important to first determine the 'typical' trend. In this context the phrase 'trend of the best fit' is often used, i.e., the trend that best reflects the previous trend of the analyzed series of numbers and is able – to use the language of econometrists – to most precisely 'remodel' it. This trend is then extrapolated into the future by assuming that the relationships so expressed remain the same and continue to exist in the same form in the future.

Forecasts Based on the Theory of Cause and Effect

The Causal Theoretical Approach

It should be a basic principle that approaches based on the theory of cause and effect be used when preparing long-term macroeconomic projections. It is obvious that time (as a variable) is inadequate for explaining the development of a national economy. Therefore, pure extrapolation of developments over time will not provide sufficient information as a basis for planning, either for economic or corporate policy.

Nonetheless, such extrapolations are used relatively frequently in government and industry.

The term 'causal theoretical forecast' is used when investigated variables are put in a dependent relationship with their relevant determinants and are then predicted on the basis of this knowledge. This is done step by step:

- Firstly the factors determining the development of the variable investigated are established;
- Secondly, the influence in terms of degree and direction, of these determinants on the variable investigated are registered and recorded as quantitative behavioral and reaction coefficients, and
- Thirdly, a forecast is derived on the basis of the presumed (estimated) development of the determinants (exogenous variables) of the variable to be predicted.

Procedures based on this basic concept – shown in Figure 4 – range from simple behavioral equations to comprehensive econometric models. In behavioral equations the development of the variable to be predicted is attributed to the influence of a single dominant determinant, while with econometric models the variables to be predicted are seen as variables of an integrated system of mathematical equations. In so doing, the interdependencies between the relevant variables are recorded as behavioral and definition equations.

Procedures for forecasting individual variables are of interest primarily when directly deriving individual pieces of economic information. Nevertheless, other forecasts can also be developed, e.g., the propensity of private households to spend or the development of capital market rates. However, similar to a ready to go car being more than a heap of, undoubtedly useful, parts, a macroeconomic developments forecast consisting of a self-contained system projection is qualitatively very different from a collection of isolated, individually forecast variables. There are virtually no one-sided causal dependent relationships between macroeconomic variables, rather only interdependencies. For example, as has been mentioned previously, consumption depends on income, however income in turn also depends on the amount of consumer spending. Only when a self-contained system is predicted can these interdependencies be taken meaningfully into account. Many structural data can be determined on the basis of the fixed relationships of the System of National Accounts (SNA) system, which permits testing of individual forecasts for their significance. However, predicting an entire data system is a considerably more elaborate process than forecasting individual variables.

Irrespective of the complexity of the theoretical statement (model) used, such a forecast's structure essentially always remains the same. As shown in Figure 4, a causal theoretical forecast is always based on a theoretical concept that starts from certain ideas as to the economic variables relevant to forecasting and their interdependencies. On the basis of these fundamental theoretical ideas, a theoretical statement is derived in verbal or formal-mathematical form that describes the relevant functional relationships and relationships of effect. A simple example of such a theoretical statement (equation) containing only two variables (a determining explanatory (exogenous) variable and a determinate, dependent (endogenous) variable) is shown in the following example. Private consumption (C) depends on disposable personal income (Y) and the propensity to consume (c) (verbal definition) or per formal definition:

$$C = c * Y$$

Complicated models, which can contain up to a hundred or more variables, have more theoretical statements (equations) that are connected with each other in the model. Otherwise, they are structured according to the same principles as the simplest equations.

For use in forecasts, these equations (models) have to be 'filled' with concrete numbers by means of available statistical data as well as results of statistical analyses. Statistical analyses are used for determining the interconnections and past behavioral functions relevant to each case. Using the above example, a quantified consumer function could look as follows:

$$Ct - Ct\text{-}1 = 0.8 * (Yt - Yt\text{-}1)$$

(= average propensity to consume: 80% of disposable personal income is being consumed)

or:

$$Ct = 0.8 * Yt$$

Marginal propensity to consume: a change in disposable personal income by 1 unit (CHF, CHF million, CHF billion) leads to a change in private consumption by 0.8 units.

or:

$$Ct\text{-}Ct\text{-}1/Ct\text{-}1 * 100 = 0.8 * Yt\text{-}Yt\text{-}1/Yt\text{-}1 * 100$$

Elasticity of private income: a 1% change in disposable personal income leads to a 0.8% change in private consumption.

Statistics provides the necessary test procedures for being able to assess to what extent quantitatively formulated descriptive statements are capable of capturing reality and what errors have to be estimated. Such errors arise when previous development is expressed by means of these descriptive statements. Data processing systems are, in turn, capable of greatly facilitating quantification of the descriptive statements (models) as well as testing their relevancy. Such numerically concretized descriptive statements (models) can be used both for analytical purposes (i.e., for testing theories empirically) and forecasting purposes.

Forecasts and Simulations

Causal theoretical approaches can be separated into actual forecasts and alternative simulations. Those forecasts that in the forecaster's eyes indicate the most likely future development (similarly to weather forecasts) can be regarded as actual forecasts. Of course, these forecasts are not unconditional ('this is how it will be'), rather are conditional ('this is how it will be, if ...'), i.e., they are based on hypotheses as to the future development of the relevant determinants of the variable to be forecast. However, forecasters ascribe the greatest probability of occurrence to such hypotheses, similarly to a meteorologist expecting that his/her hypotheses as to the shifts of weather fronts, future pressure and wind conditions, etc., will come true and so also his/her forecast. Market forecasts and short-term economic forecasts clearly belong in this category.

Alternative simulations assume that forecasts in the above-mentioned sense are not possible for the long term. This is because general conditions change, not only for national economies but e.g. for foreign trade, in ways that cannot be assessed objectively via probability or plausibility considerations. Therefore, it is essential to consider alternatives, i.e., to simulate various equally likely future situations – mostly with a view to their economic effects; to be dealt within this seminar at ‘scenario analyses’.

Judgments based on estimates are unavoidable when formulating actual forecasts. All explanatory, determining variables (i.e., disposable personal income in the above case) have to be predicted, unless they are determined endogenously in a model (i.e., from within the model). Nevertheless, a relatively large number of explanatory (exogenous) variables always remain in each equation or model. These variables have to be predicted by means of judgments based on estimates before it is possible to start working on the actual forecast. This is the fundamental difference between the forecasting and the analytical model. Although with the latter all explanatory variables are known and have to be used in the model ‘tel quel’ for empirical verification, their future development is unknown and so has to be predicted.

In addition, it has to be decided in a forecasting model the extent to which the reaction and behavioral coefficients from empirical analysis of the past will also be valid in the future, or whether they have to be revised. Such decisions also amount to a judgment based on estimates, in which not only theoretical knowledge but also the forecaster’s experience and intuition play an essential part.

The situation is similar with forecasting simulations. In our simple example the development of private consumption could be established on the basis of various propensities to consume, or changes in disposable personal income. In order to provide these simulations with some real forecasting value, the alternatively chosen hypotheses must not be purely hypothetical in nature (which would definitely be acceptable within the scope of analytical simulation models) but should be applied to reality as much as possible. Selecting them from a virtually unlimited variety of theoretical alternatives again requires an individual judgment based on estimates. This judgment is of particular significance insofar as the final user of forecasts cannot be presented with an entire package of, in part, diametrically opposed forecasts. If alternatives must be presented, then it is important to concentrate on a few, particularly important and realistic versions. Furthermore, only those variables and behavioral coefficients should be alternated whose future developments appear especially uncertain or which can be moved in various directions via political decisions.

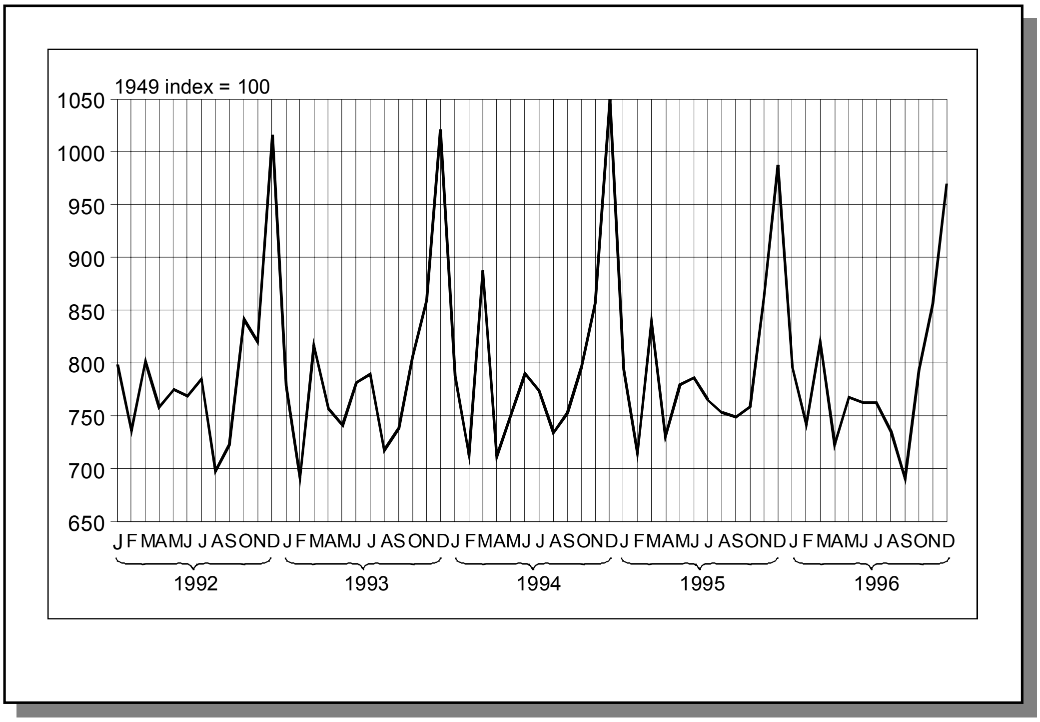
Central Importance of the Causal Chain (Relational Network)

As shown in Figure 4, a theoretical statement’s structure represents the first step, so to speak, of working with causal theoretical methods. The extreme importance of this step cannot be overemphasized. This step focuses on recognizing the relevant determinants for each of the market segments. It has to be determined at the same time which structural features characterize the subject of investigation. If applicable, it has to also be established whether key factors have to be taken into account that characterize especially the investigation subject and so make a specific forecasting approach imperative. We would like to illustrate this seemingly rather easy step by means of an equally simple forecasting problem. For this, we would like to use the example of car sales..

Megatrend Analysis

The basis for this approach is being laid out in the book: Graf, H.G.: Global Scenarios. Megatrends in Worldwide Dynamics, Verlag Rüegger, Zürich 2002, ISBN 3 7253 07210. See also the figures 5 to 10.

Figure 1: Turnover in Retail Trade: Total Turnover from 1992 to 1996 on a Monthly Basis (1949 Index = 100)



Source: Swiss Federal Statistical Office (Yearbook), various Volumes.

Figure 2: Daily Load Curve: Power Consumption of Households (in % of Daily Peak)

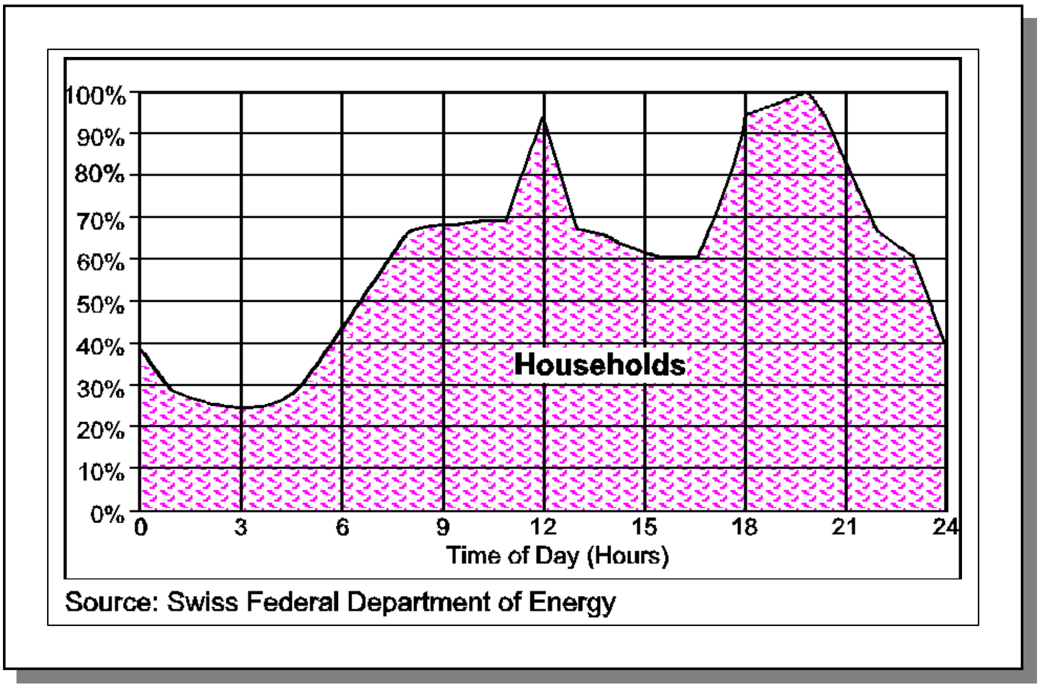


Figure 3: Statistic Curve Lines

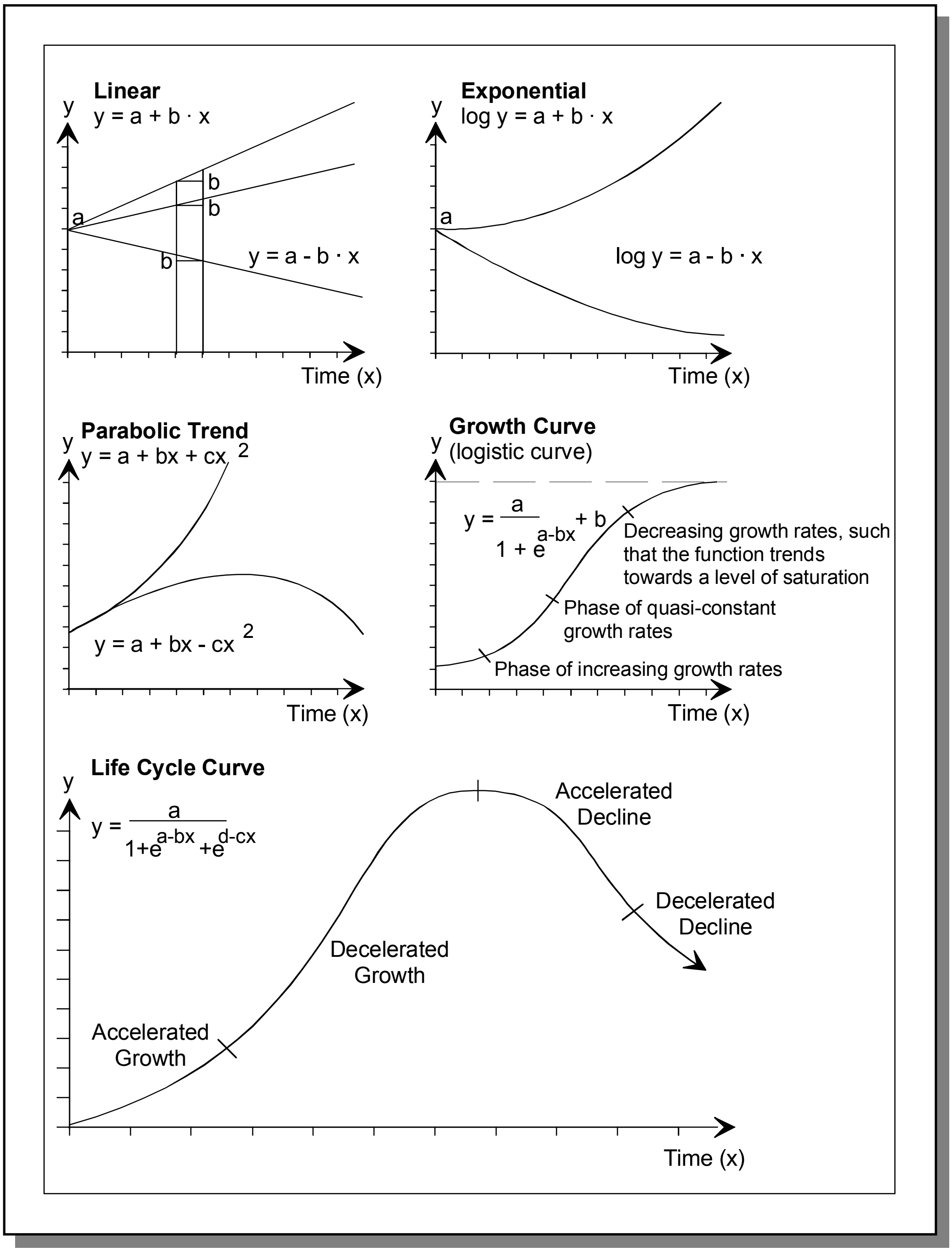
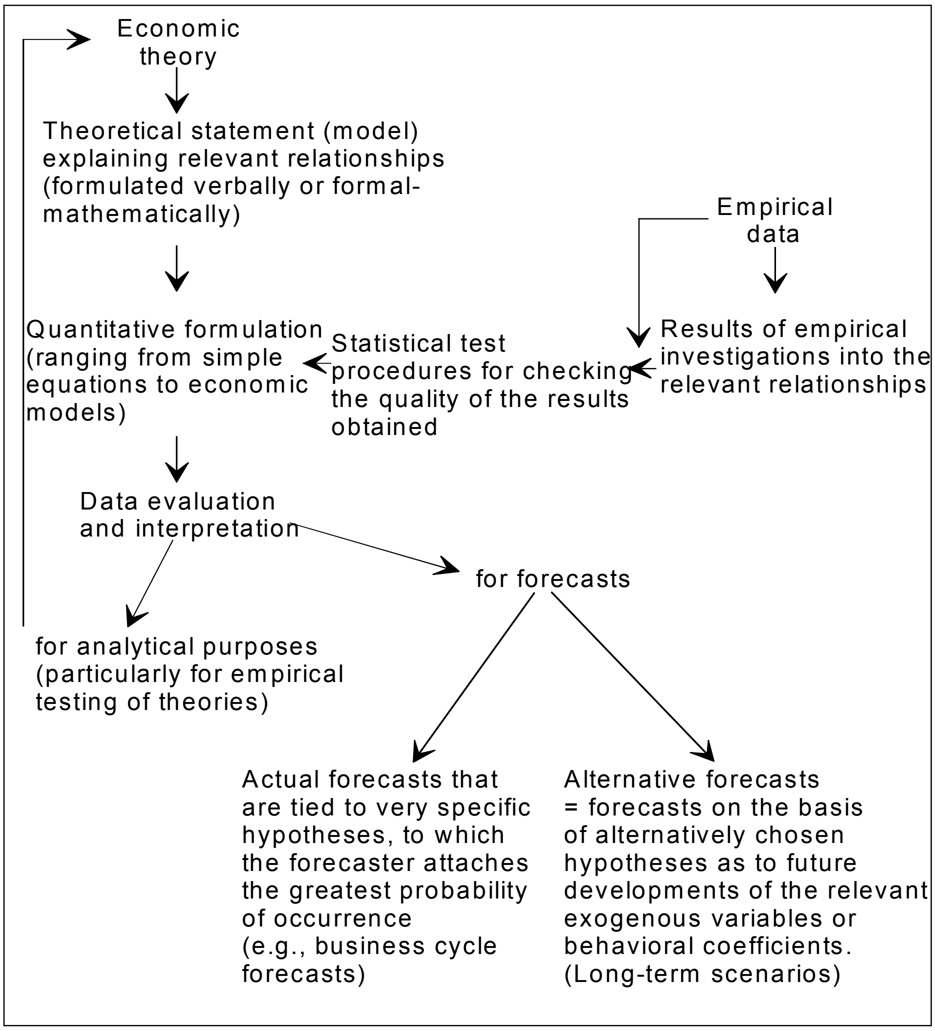


Figure 4: Structure of a Forecast Based on the Theory of Cause and Effect



Source: Kneschaurek, F. (Unternehmung und Volkswirtschaft), p. 322

Figure 5: What might change in future?

- Global environment
  - Vulnerability
  - Structural change
  - Liberalization of markets
- Demographics
  - Growth, ageing
  - Ethnical and social imbalances
  - Urbanization
- Security
  - Fundamentalism
  - Terrorism
- Customers
  - Sophistication of demand
  - Product safety
- Technology and competition
  - Information and communication
  - Deconstruction of value-added chains
  - Mobility
  - Bio-technologies
- Distribution and supply
  - New standards
  - Substitution, new value-added layers
- Sector specific trends
  - Processes, specialization
- Corporate identity
  - Vision, mission
  - Ownership and hierarchies
  - Defining business activities
  - Market position

Figure 6:

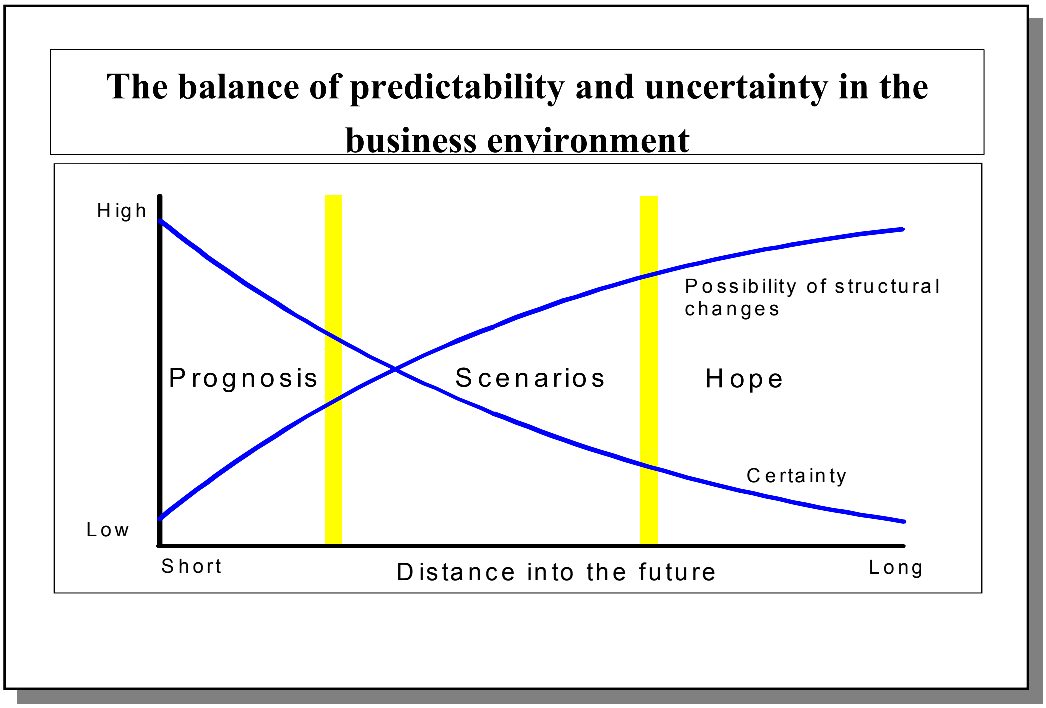


Figure 7:

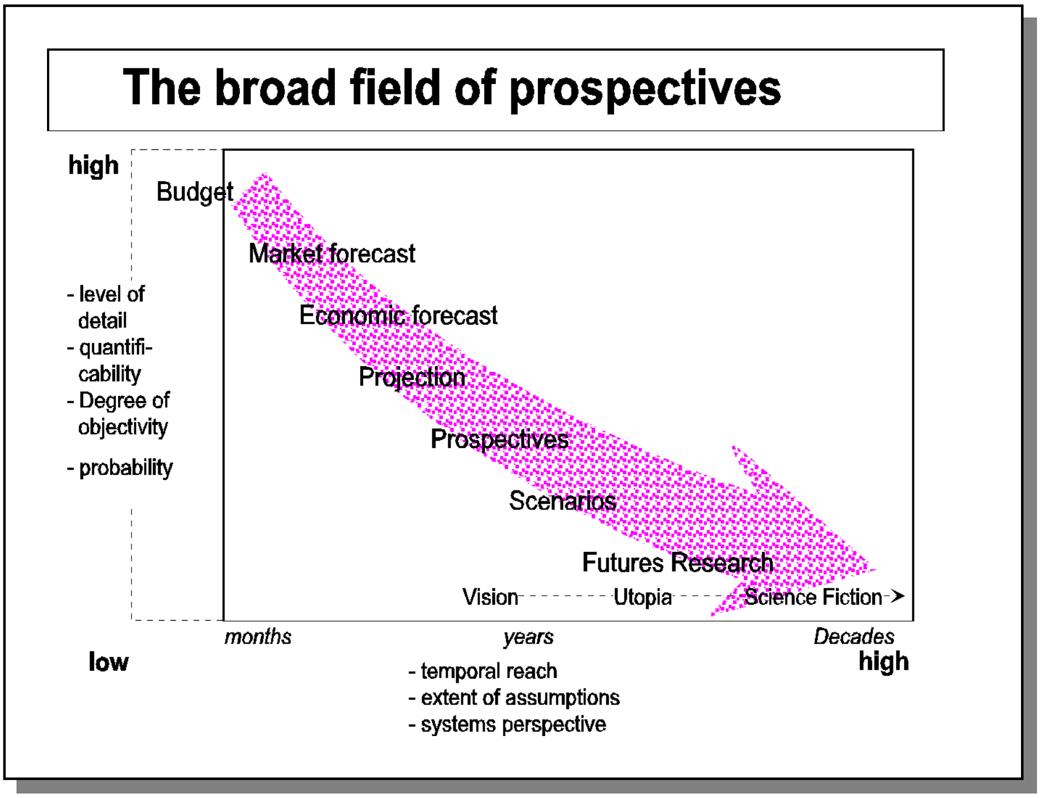


Figure 8:

The Challenges in 6 Dimensions

- Demographic Development
- Social Fundamentals
- Political Framework
- Technological Progress
- Ecological Sustainability
- Economic Trends

Figure 9:

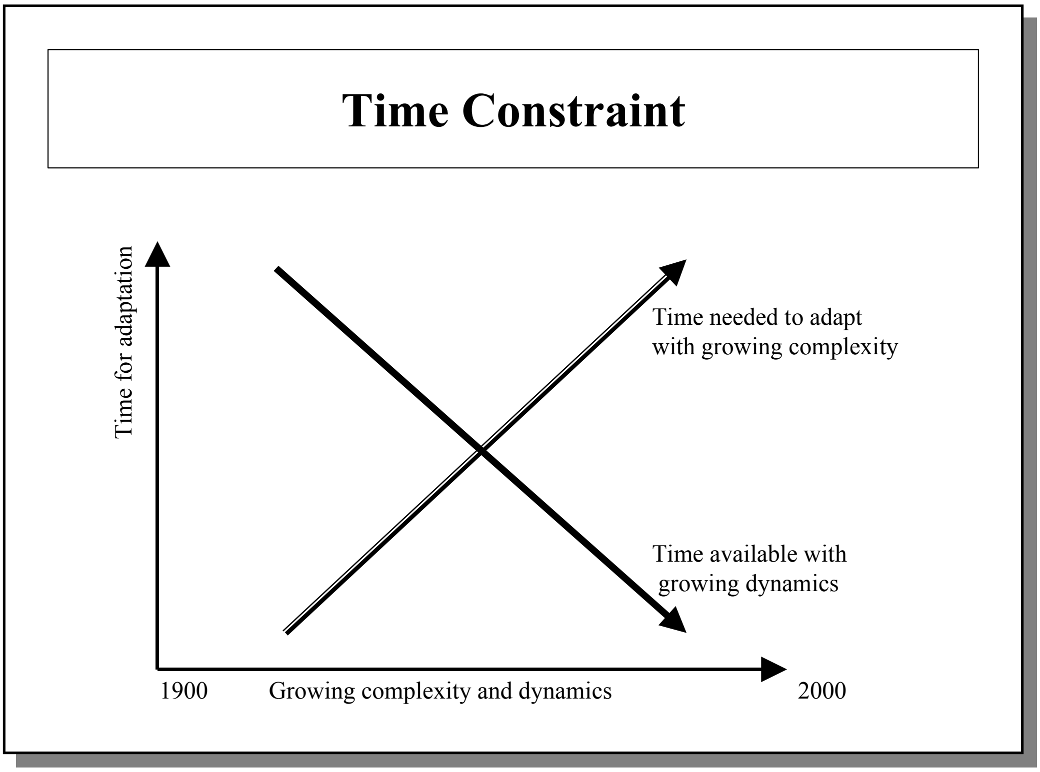
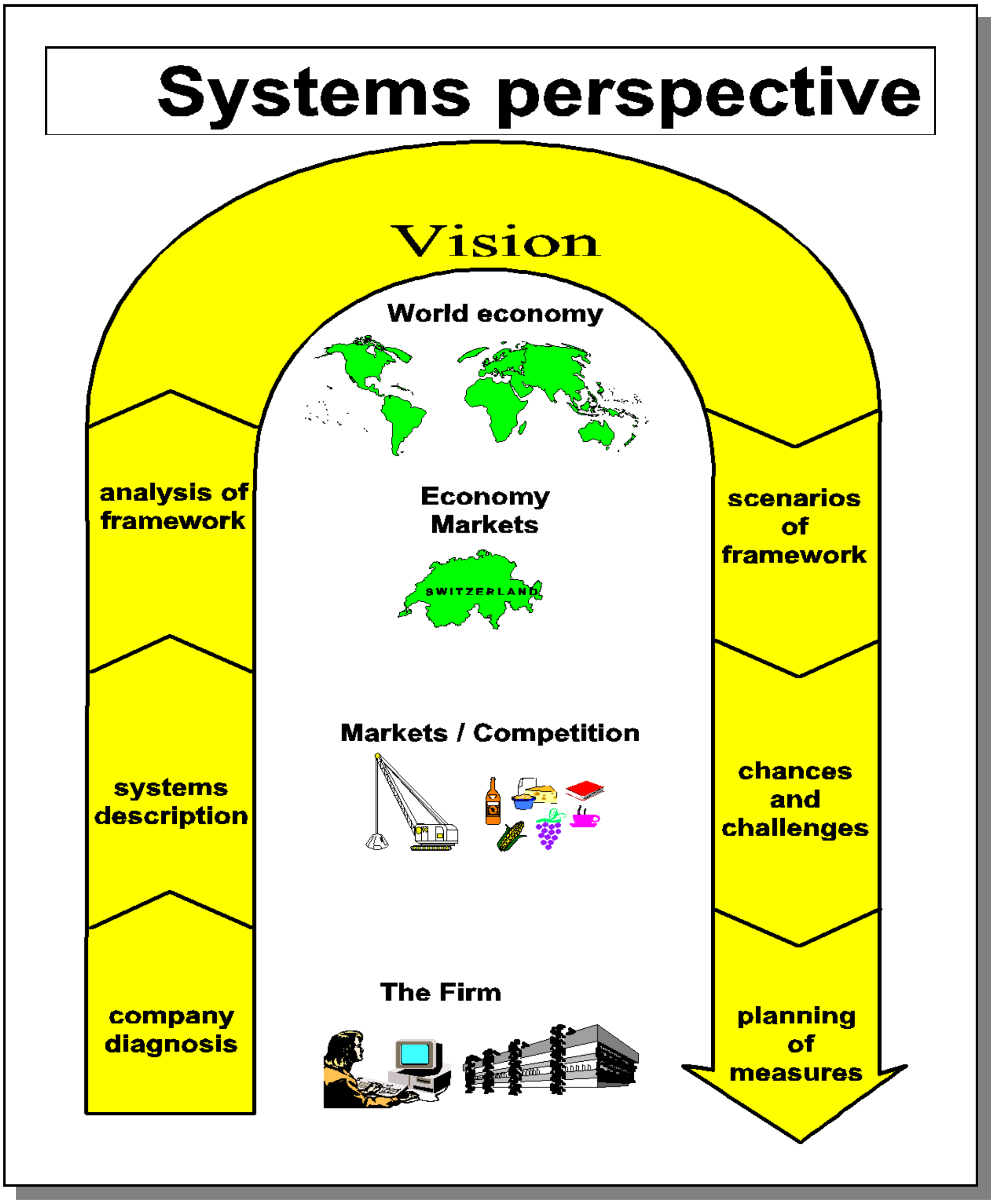


Figure 10: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Strategic Framework for Scoping Technology Foresight*

Abstract

There are many different ways to conduct Foresight exercises. This implies a number of strategic decision points in the design and delivery of Foresight. It is important to recognise these choices from the outset through a *process* called **scoping**. The chapter presents 12 elements around which Foresight can be scoped. 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. The chapter also presents opportunities and problems associated with mixing different methods.

Introduction

Much of this volume is given over to presenting and elucidating specific methods commonly associated with technology Foresight exercises – scenarios, Delphi, expert panels, critical technologies, etc. Often hidden and forgotten is consideration of the methods associated with organising and managing a technology Foresight exercise, yet these are crucial to the success of Foresight. For example, how are participants identified and engaged in a technology Foresight 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 technology Foresight exercise in a process known as "scoping". In this chapter, we will explain the process of scoping and its constituent elements. Accordingly, the chapter is divided into two main sections. The first deals with the process of scoping technology Foresight – 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 technology Foresight 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 technology Foresight options.

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The Scoping Process

Deciding on what you want to achieve from technology Foresight, 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 we have called “scoping”. In this section, we provide a definition of scoping, summarise its benefits, set out how and when it could be done, and suggest who should be involved.

What do we mean by “scoping”?

By the term “scoping”, we refer to those processes of research and deliberation that contribute to the shape and timing of a given technology Foresight activity. Technology Foresight can come in many shapes and sizes, and can be conducted over a long or shorter time period. Deciding 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 technology Foresight 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, something we will do in this chapter.

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, 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 technology Foresight involves three main tasks:

1. Gathering **background information** – technology Foresight should not be undertaken without research into past and ongoing activities of a similar nature. Organisers 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.

2. **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 technology Foresight exercises, some of who may come from overseas. But the target audience of a technology Foresight 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.

3. **Articulating and presenting options** – once background information has been gathered and views elicited, options for technology Foresight 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 technology Foresight, highlight examples from other countries, regions, organisations, etc. (whichever is most comparable), and describe a set of possible options for technology Foresight. The scoping elements described in Section 2 of this paper provide one possible framework for constructing these different options. We would recommend that 3-4 different exercise "blueprints" are 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 naturally by technology Foresight champions, mostly in the form of reading about exercises in other places and 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. Our interest in this chapter is with the formal scoping *process*, of which the informal is a part. As we have suggested above, such a process 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 the case frequently. Instead, scoping often constitutes a sort of intelligence gathering to see whether technology Foresight is appropriate. The decision may be taken not to proceed with a technology Foresight 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 conducting of an exercise. In some instances, this may even be formalised into periodic reviews that set the future course of an exercise at key stages.

Who is normally involved in scoping?

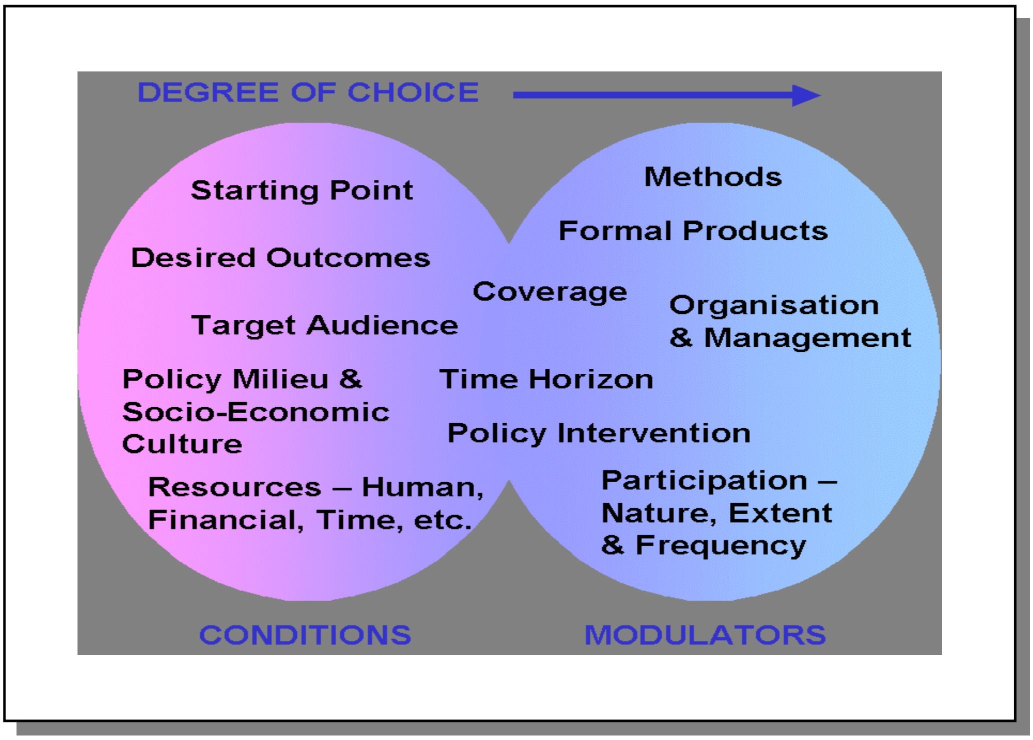
Whether the aim is to set up a process-based or a product-based Foresight activity, one of the main features of Foresight activities must be the active involvement of the various stakeholders from initiation and throughout all the stages of the activity. This is a core factor differentiating Foresight from more narrow futures and planning approaches, and is an important determining factor in Foresight's organisation 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!).

The Scoping Elements

Below, we present twelve elements around which Foresight can be scoped. 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 1. The elements on the left-hand side, the so-called "conditioners", are usually (though not always) pre-determined 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 technology Foresight exercise is to be conducted. On the right-hand side are the "modulators". These (usually) offer much greater scope for variation and include the methods to be used, the degree of participation, and the organisational structure of the exercise. Each of these elements is now discussed in detail below.

Figure 1: The twelve scoping elements of technology Foresight



Starting point

Given the pervasiveness of technology in all our lives and the impacts of technological change on our cultures and societies, technology Foresight can be undertaken at almost any location of decision making. Up until now, it has been most prominent at the national level, with national governments in many parts of the world organising wide-ranging exercises that cover several technologies. Such exercises are typically located in science ministries, research councils and/or academies of science. Technology Foresight has also been used by international organisations, 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 technology Foresight activities in Latin America. More recently, the sub-national 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. Sub-national regions where technology Foresight 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 technology Foresight, with exercises on areas like agriculture, the automotive industry, and aerospace having taken place since the late-1990s.

The starting point for technology Foresight 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 technology Foresight, 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 technology Foresight 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 technology Foresight has a large effect on its scope and shape, even here there is considerable room for choice.

Policy milieu and socio-economic culture

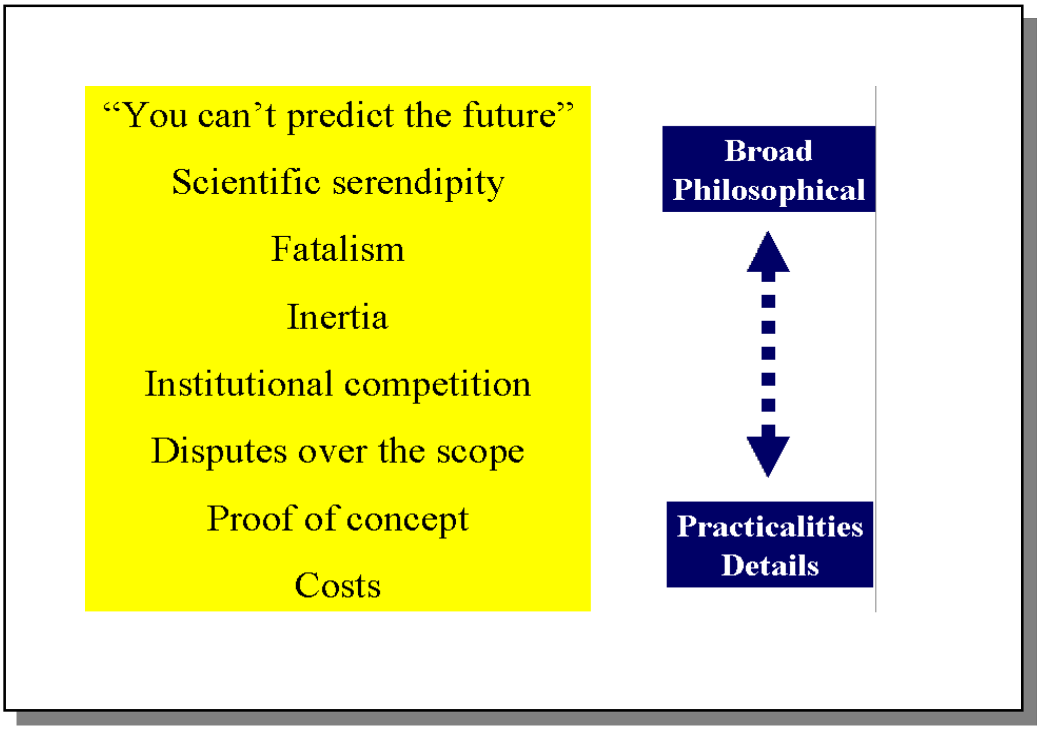
Technology Foresight does not take place in a political, techno, or socio-economic vacuum. Rather, as we have noted above, it is positioned within an institutional setting. The term ‘institution' in everyday language refers to distinct bounded organisations that are easily identified. But such institutions 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 technology Foresight exercise. For example, it may be that a particular economic sector or policy area is characterised by extensive conflict between stakeholders – what implications does this have for technology Foresight in such an area? Similarly, other areas may be characterised by cosy relations amongst key stakeholders that might breed a certain degree of complacency. Again, what are the implications for technology Foresight in such a situation? To give a brief answer, in areas of conflict, technology Foresight 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 technology Foresight include (a) cultures of collaboration; (b) the presence or otherwise of a forward-looking tradition; and (c) 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 technology Foresight 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.

Several further barriers to initiating technology Foresight might be anticipated, as shown in Figure 2. 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 2: Some of the barriers facing technology Foresight



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 technology Foresight is also flawed:

1. Technology Foresight has never been used to prioritise all of the scientific enterprise of a nation state. 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 organisations of science.

2. 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.

3. Something that is often missed by proponents of the serendipity argument is the fact that technology Foresight 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.

4. Finally, who is to say that the science supported as a result of priorities emerging from a technology Foresight exercise will not result in similar widespread applications as the laser? We suspect that the real issue underlying the serendipity argument is one of control – who sets the direction of what scientists do, the scientists themselves or society? In fact, technology Foresight 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 nation states, 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 organised 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 technology Foresight – institutional competition – has been observed by the authors in nation states 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 technology Foresight. Such competition can lead to open conflict and eventually to nothing being done, as has happened in one Central European country over the last 3-4 years. It is difficult to advise on such situations in a generalist way, but it is something that proponents of technology Foresight 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 organising 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 technology Foresight. 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 technology Foresight's "proof of concept". By this, we refer to the evidence base that demonstrates the effectiveness of technology Foresight. We will say more on this below. For now, we note that little evaluation of technology Foresight has been conducted that demonstrates its effectiveness. Moreover, the processes of technology Foresight remain poorly understood. Evidence of Foresight's worth is therefore largely anecdotal and focused 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 the authors are aware of planned technology Foresight exercises that were either scaled back or postponed due to the unavailability of necessary financial resources. When scoping technology Foresight, 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 technology Foresight 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 technology Foresight. 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 consultation as to the aims and activities of technology Foresight. 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 organisations and/or areas characterised by similar problems and objectives.

The communication tools used will depend upon the target audience for the technology Foresight 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 organisations (especially the sponsor) and communities involved. Rationales for technology Foresight will tend to emphasise 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 organisations 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 organisation, country, etc. - but the political competence to deal with the issues may or may not reside in that organisation 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 maximised.

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 technology Foresight 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 organisations 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 technology Foresight is new to many exercise sponsors and managers and they are unsure of what to expect.

Resources

The resources needed for technology Foresight 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. We will now briefly deal with each of these in turn:

- **Financial resources** – the cost of a technology Foresight exercise depends primarily upon the nature and scale of involvement of participants and its duration. We address each of these issues below, but 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 (see Table 1). As for costs, little indicative financial data exists on Foresight exercises in general. Core, and usually centralised financial costs are most likely to result from such elements as (a) the running of a project management team; (b) the organisation 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.

Table 1: Examples of sponsors of national technology Foresight 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

- **Time** – this is nearly always a resource in short supply in technology Foresight. 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 technology Foresight exercises take 1-2 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 organisational 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, technology Foresight is unlikely to get off the ground, let alone 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 a 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** – technology Foresight 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, technology Foresight 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 technology Foresight 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 organisation 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 generalist 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-organised 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 technology Foresight. 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 technology Foresight 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 recognised from the outset that it is impractical to set out to cover all possible themes and/or sectors in any given technology Foresight 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 organisational decisions. Lobbying by interest groups is another influence. A review of national technology Foresight 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 Technology 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.

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 10-15 years, although it may be as long as 30+ or as short as 5 years (see Table 2). 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 organisations, cultures, etc. for the future.

Table 2: 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

Methods

As this volume is given over to summarising some of the main methods used in technology Foresight exercises, we will not cover these here. Instead, we will briefly consider how methods can be used together, both in parallel and in sequence, to constitute a coherent exercise. To do this effectively, we need to (a) outline the key steps in a technology Foresight 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. We will therefore set out some of the key steps in technology Foresight and then suggest possible methods that might prove useful.

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, organisation and management, implementation, etc. As we have already discussed these wider tasks in other parts of this chapter, we will largely omit them here. Instead, we will focus only on the core futures methods.

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, synthesised, 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 visualisation and presentation of results is also especially important at this stage.

Once anticipated and/or desirable futures have been visualised, strategies of avoidance and/or realisation 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 technology Foresight 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 technology Foresight 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 organisation (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 organisation might be required. What is important is to recruit gifted individuals who are prepared to learn and share, and not just present their organisation's official positions.

Methods for locating such individuals involve search through databases and web resources, or seeking advice from other informed people. *Representative* approaches can involve asking scholarly, professional and industry organisations 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.

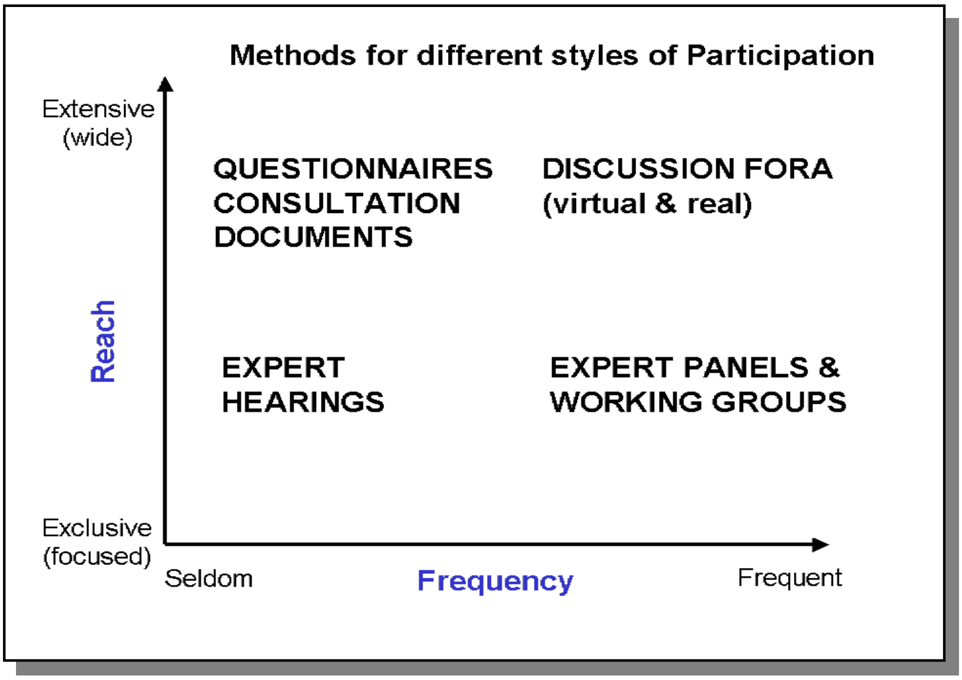
The more formal methods are important for reaching beyond the "usual suspects", but approaches such as co-nomination are time-consuming. Any methods can be limited by the choice of initial informed sources, so it is important to cast the net widely here. If the area under consideration is large, many 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' (see Figure 3). 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.

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.

Figure 3:



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.

Organisation 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 organisational 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, mobilise 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 Committee 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; and
- 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 organised 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; and
- 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 organisation.) 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 materialise. 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: technology Foresight 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 technology Foresight 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 – which 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 technology Foresight.

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.

Table 3: Some types of output from Foresight

	Formal outputs	Informal outputs
Material for long-term reference and dissemination activities beyond those organisations 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 organisations directly involved	Workshops, newsletters, press articles, web sites	Visions developed in workshops, results & evaluation circulating within networks
Networking	Institutionalisation of networks e.g. through formation of permanent organisations 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

Table 3 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.

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 that 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 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 need to be some modification of these expectations, too.

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 of 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.**

Summary

This chapter has sought to introduce some key elements for scoping technology Foresight that can be used at national, regional or company/organisation levels. These scoping elements have already been employed widely in Foresight exercises across Europe and underpin recent European guidelines on the use of Foresight. We have also sought to raise awareness of Foresight's limitations, arguing that expectations should be realistic. Planned appropriately, and with sufficient political support, technology Foresight 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.

Technology Foresight 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 recognised 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 technology Foresight. The simple imitation of issues and methods (not to mention the uncritical "borrowing" of results) from elsewhere is liable to be counterproductive. 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 organisation. 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.

Brainstorming: a creative problem-solving method*

Abstract

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 the present chapter, 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

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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 and so on.

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 stimulus. 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 that 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. Of course, 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 produced.

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 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 20-30 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 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;

(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 humourous 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", and so forth, 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, 10-20 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 advertisement 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?

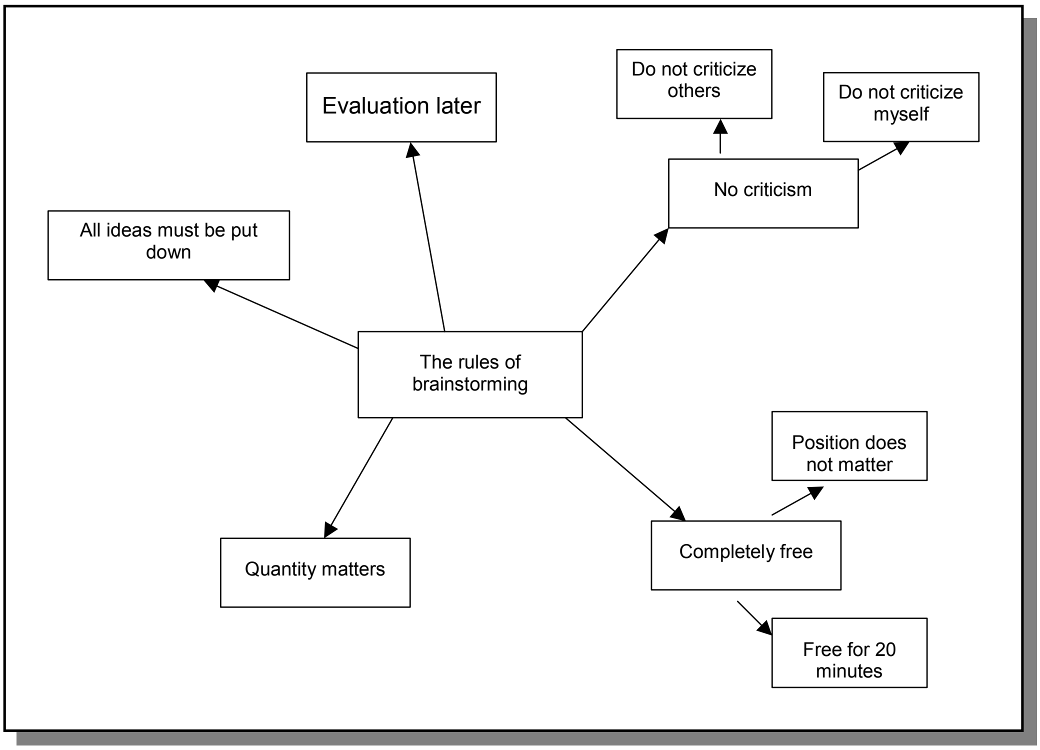
Additional creative methods

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) 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 systems 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” (see figure). 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
Example of a simple mind map: the rules of brainstorming



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.

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Using Expert and Stakeholder Panels in Technology Foresight – Principles and Practice*

Introduction / Abstract

Any review of technology Foresight 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 12-20 individuals who are given 3-18 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 organisation and management of expert panels is considered to be routine and unproblematic. Yet, years of advising technology Foresight programme managers in many parts of the world has demonstrated to the author and his PREST colleagues that the organisation and management of expert panels is far from routine and unproblematic. For example, practical and conceptual issues surrounding panel composition and the conduct of panel work are regularly raised. We therefore believe it timely that some guidelines be set down on the use of expert and stakeholder panels in technology Foresight.

We begin the chapter with a description of what a Foresight panel might look like and explain why such groups are deployed in technology Foresight. We then move on to some of the practical issues associated with using panels to include: specification of a panel's mandate; challenge of identifying and assembling panel members; how to get started and how to organise a panel's work; generating consensus and priorities; and reporting and dissemination. The chapter is rounded off with some summary conclusions.

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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 12-15 individuals and is mandated (usually by a 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 organisation) 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 12-15 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 technology Foresight 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 technology Foresight exercise.

Why use Panels in technology Foresight?

Technology Foresight 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 technology Foresight 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 organise;
- The ease with which panels can complement other methods used in technology Foresight. 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 technology Foresight exercise through the profile of panel members and the visibility of expert/stakeholder panels; and
- 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 panels as 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 timeframe. 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 scoping process is described elsewhere in this volume and will not be covered here. All we will say here is that 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:

1. **Proposals** covering what the panel will do, why they will do it, and who (which experts/stakeholders) should be involved; and

2. **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 panels 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 panels' terms of reference document should draw heavily on the proposal, but will be directed at guiding the panels in their tasks. An example of a terms of reference used in the first UK Technology Foresight Programme in 1994 is provided as an annex at the end of this chapter. It is a short and succinct document that is divided into four parts:

1. Background, which provides some background on the UK Technology Foresight Programme and the purpose of the terms of reference document;

2. Description of each of the three phases of the programme, setting out (i) what needs to be achieved, (ii) how the panel should go about its work, and (iii) a series of milestones;

3. Description of the way in which the panels' work fits into the overall Programme; and

4. 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 panels. Similar terms of reference have been used in other technology Foresight 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 panels:

1. **Composition** – what mix of knowledge is required to address the panel remit?

2. **Balance** – what mix of views / positions / value judgements / scientific disciplines should be represented on the panel to ensure even-handed analysis and conclusions?

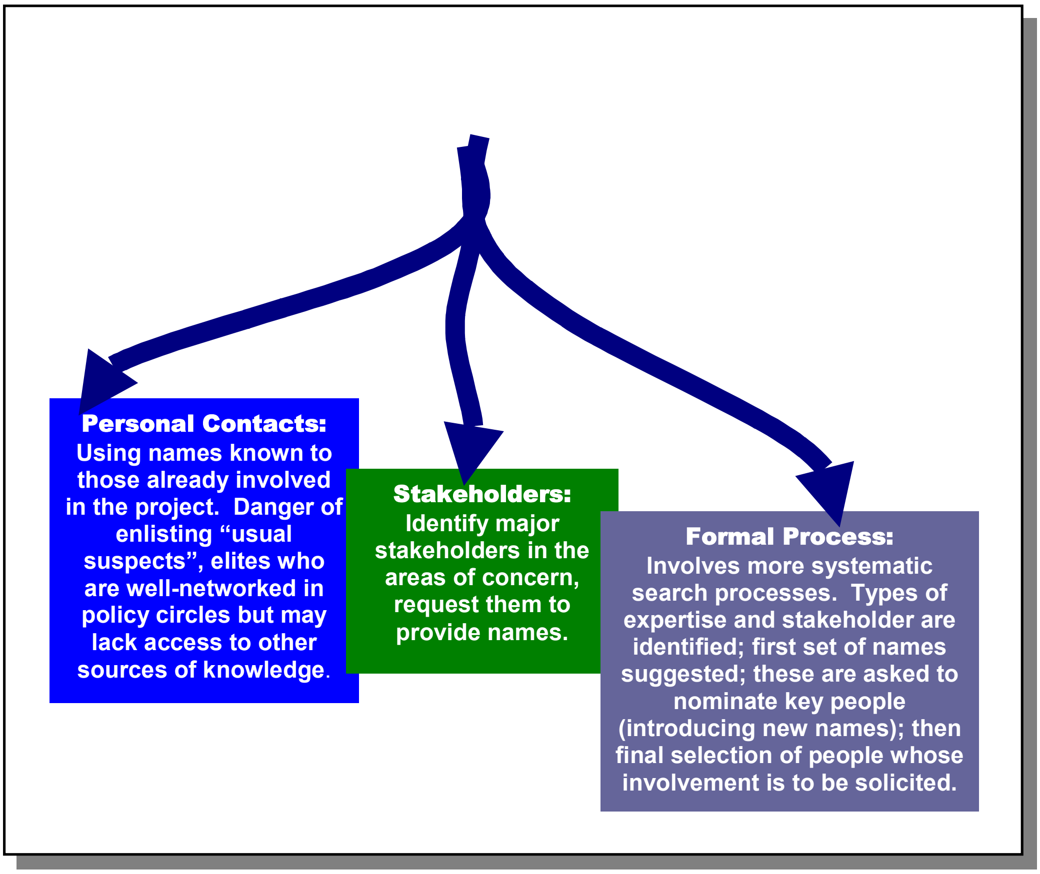
These are major concerns in technology Foresight, since panels must be perceived to be technically qualified and even-handed if the exercise is to achieve authority, credibility and legitimacy. It must, however, be acknowledged that panel members will bring their own interests and biases to the table 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, &c. 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 technology Foresight 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 technology Foresight 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 organisational 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, &c., 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 the figure below, 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.

Three ways of recruiting members & participants



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 we have 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 organisations 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 Technology Foresight 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.

Clearly, having people on panels that are acceptable to organisations 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 solely composed of an elite of 'usual suspects'. Technology Foresight 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 technology Foresight 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 Technology Foresight Programme was the first to use co-nomination in 1993. 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% was achieved across the two iterations of the questionnaire, with 1400 returned forms generating an additional 5200 new names for the exercise. Of these, 17% 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 thirteen out of the fifteen 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 Hungary, Czech Republic, South Africa, and Austria.

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 summarised, 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 of workshops and other consultation fora.

A special mention should be given to the choice of panel chairperson. Two main criteria are typically used for selecting such people in technology Foresight – 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 technology Foresight 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 common to most technology Foresight exercises), and political skills for dealing with sponsor and stakeholder organisations.

A further concern when organising technology Foresight 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 6-8 to cover the whole S&T base – whilst others may appoint 15-20 for the same purpose. The decision on the number of panels to appoint has resource implications, e.g. financial costs, exercise management tasks, &c. The fewer the panels, then 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.

Table: 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
UK1 (1995)	15	Sector/Technology
UK 2 (2000)	15	Sector/Society

A related issue concerns the number of panel members to appoint to each panel. Most Foresight exercises have opted for 12-25 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 co-ordination 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 technology Foresight 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 Technology Foresight 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 organisation 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 technology Foresight, e.g. for the running of scenario sessions, the writing of Delphi topic statements, &c. Such skills may reside in the organisation managing the exercise, although often this is not 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, &c.
- Travel costs and other communications (telephone, document courier, &c.) also need to be factored for. 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 technology Foresight 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 organisations 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 organise 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 technology Foresight 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 technology Foresight 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 in the box 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 2-3 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, 2-3 hours will need to be set aside to formulate the overall approach to the task. In many technology Foresight 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 set. 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, &c.)? 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 technology Foresight 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 technology Foresight 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 technology Foresight 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 (a) the future, and (b) 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 (a) the long-term (short-termism is a common weakness in panels and workshops) and (b) 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 other chapters of this volume 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 organisation.

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 easily digest.

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, &c.

We have already mentioned that panels can carry out their work through various organisational 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 2-5 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 technology Foresight 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 anonymised. 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 4-6 months, depending upon the duration of an exercise – whilst analyses prepared for or by the panels, e.g. SWOT analyses, literature reviews, &c. could also be made publicly available. In this way, the evidence base (and assumptions) upon which a panel is working can be scrutinised. Such reporting may also be used as an opportunity to consult with wider communities of actors. Thus, in many technology Foresight 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 technology Foresight is to nurture deliberation amongst a group of recognised 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 technology Foresight exercises, panels may not be required to reach consensus or to identify priorities, let alone 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 prioritise large lists of topics, for example, in critical technology exercises, voting procedures are commonly used. Voting is nowadays done online, as in the Czech Technology Foresight 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 organisations. This means that they are highly political in nature. For this reason, many technology Foresight exercises chose 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 organised to consider the implications of panels' analyses and priorities.

There are technology Foresight exercises where panels do make policy and investment recommendations. There are, however, risks with this approach, since the potential for upsetting organisations is great. To minimise 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 on. 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 10-15 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. Tying 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 as an attractive way as possible. Before being published, panel reports should be peer reviewed to check for (i) factual or analytical errors, (ii) coherence in analysis that shows convincingly how priorities and recommendations were arrived at, and (iii) 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 the box below. Draft reports are also normally sent to the sponsor for review.

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?

Prioritisation: 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, &c.?

(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)?

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 on 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 chapter has sought to explicate some of the issues surrounding the use of expert and stakeholder panels in technology Foresight. 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 chapter 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 organising 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 chapter has been unable to address all issues associated with the use of expert panels in technology Foresight, 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, in 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 Technology Foresight 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 relations with the Chief Scientific Adviser, Office of Science and Technology (OST), and the Technology Foresight Steering Group.

PHASE 1: INITIAL FORESIGHT WORK (APRIL – 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 <u>by the end of May 1994</u>. The Steering Group and the

OST will liase 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 10-20 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 which 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 30-50 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 Organisations 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 on 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;

    d. each panel should have received the second round of responses from consultees in the Delphi process by the end of October; and

    e. 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 of advice from the Technology Foresight 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 on 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 Departments. 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 Vice-Chairman, and:

    (i) A Technical secretary who will provide executive support to the work of the panel (for example the panels' meetings, drafting and circulating papers, taking forward action outside meetings in consultation with the Chairman;

    (ii) 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;

    (iii) One or more Assessors from the Steering Group.

17. Additionally, the OST will provide each panel with information about Foresight work which 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 organise their work.

Annex B:

Framework for final reports from Technology Foresight 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, &c.

2.2 The Panel and its Programme of Work
Including, for example, working techniques, consultation methods (including Delphi questionnaires, regional workshops and written submissions), relations with other sectors, drawing other expertise into the programme, &c.

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 which 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 [say 6] of priority opportunities or barriers to progress which reserve particular attention because of their high level of impact.

5. Recommendations for Implementation.

5.1 *<u>Practical</u> 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 Foresight in the XYZ Sector.*

6. Conclusions.

Brief observations about the Technology Foresight Programme, the priorities and recommendations.

References, list of appendices and list of separate publications.

Scenario Planning*

Abstract

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 paper 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 mobilise 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?

Introduction: Scenarios

Definitions

The term “scenario” has many uses. A google search using the term will come up with many hits before we get anywhere close to the origins of the word in theatrical scene-setting. We immediately find large volumes of usage referring to computer-related

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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 our 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.

Scenarios are used in this paper 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% as opposed to 5% growth rates). However, the sense used here is one in which we go 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 on (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 we shall examine some of the main varieties of scenario in use in Foresight work today.

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"). We can find whole books, for example, that present a view of a future without a great deal of explication of how we got from here to there - when I was reviewing Gerard O'Neill's 2081 two decades ago, I was struck by how perfectly the technological elements of this visionary future all worked 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 emphasise 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 which 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% or y%? 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% 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 - I prefer to term these two orientations “outward-bound” and “inner-directed”, respectively. It is unlikely that decades of usage will be shifted overnight, however.

Both orientations can be used in scenario analyses as suggested above. I have found variations of each to 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 given the range of possibilities explicated in the previous work.

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".[1] 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 organisation-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.

[1] From the book's dust jacket. In this unregulated future we can all be tracked all the time by position monitoring equipment, and the life of many inhabitants of developing countries does not display much opportunity to exercise freedom… Carping aside, the study does provide both rich detail of a techno-optimistic vision with partisan but generally well-informed discussion of the technological challenges involved.

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, e.g.:

- 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 nations and regions). There are vignettes describing everyday life or other case studies, which help to bring the scenarios to life. There are suggestions of unrealised developments ("hopes and fears") which 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 & 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 $2bn 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) with 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 characterisation 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, emphasising 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 cleanup"; "…world-wide, broadband network of networks based on fibre optics…communication satellites, cellular and microwave will be ancillary. Throughout the advanced nations…face-to-face…[etc.]… communication will be available to any place at any time from anywhere.") Others involve socio-economic factors ("World population will be about 8.4 billion people"; "…world-wide 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"; "Privatisation 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.

UK2010

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. 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).[2] 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).

[2] For a discussion of the three cycles of the UK Foresight Programme see Miles (2003).

The three "scenarios" here presented 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 revolutionise 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 these 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

But 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:

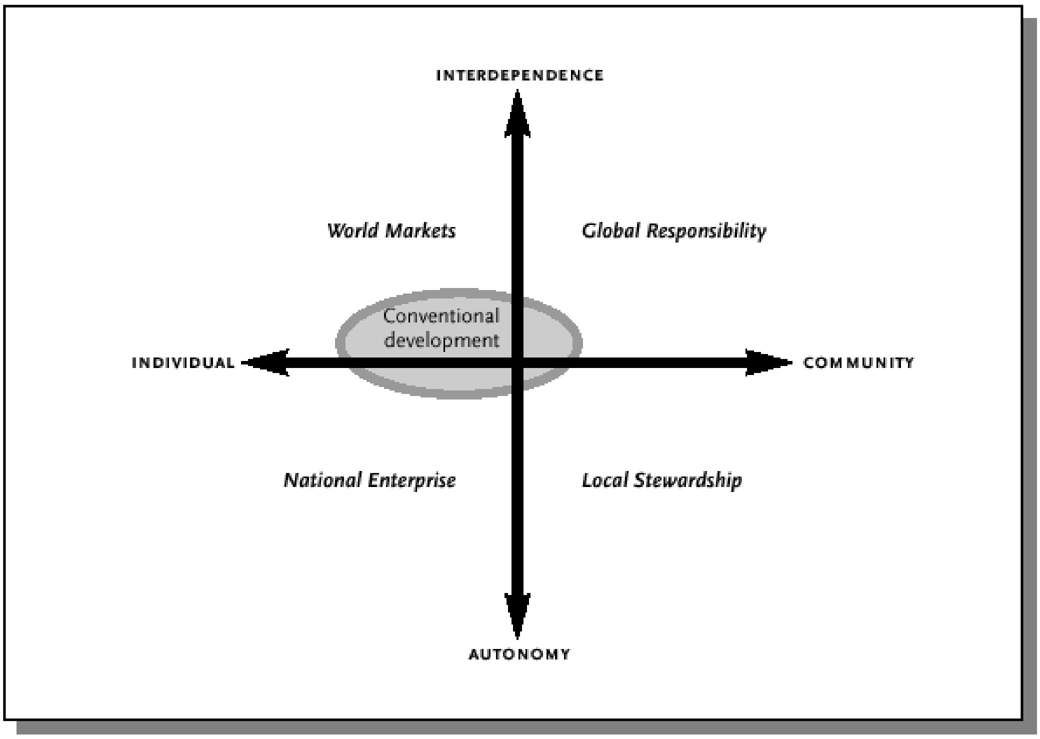
- Challenge received wisdom by demonstrating the plausibility of several diverse futures.
- Give more sense of how different trends and countertrends might unfold and interact, what the implications would be of variations from the standard account of these developments.
- Allow for some test of the robustness 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 materialising.

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** (see the Figure 1 below). 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 1: UK Foresight "Environment" Scenarios



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 summarise a wide range of studies and policy activities in which these scenarios were used, and the present author can testify to their 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[3] 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 we simply have 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 nations, 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 realised 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 realisation 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 policymakers 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 twelve 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 appendices or on the web for the particularly

[3] See http://europa.eu.int/comm/research /industrial_technologies/ 27-03-03_futman_en.html

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 dichotomising 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[4] - 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 my 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.

As we have seen, the second round of UK Foresight invested substantial resources into developing, and displaying on its website and video resources, a set of alternative

[4] 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

future scenarios. The "environmental" scenarios are still featured on 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 we see little systematic development of scenario approaches 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 policymaking, 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 we have described in the second edition of the FOREN Practical Guide to Regional Foresight (available from www.foren.jrc.es), on which the following account draws.

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, policymakers, 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, we use the term "Fully-Fledged Foresight" to distinguish activities which 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.[5] 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

Scenario 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 paper 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.

[5] 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.

- 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 organisation 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 mobilise 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.

In scenario workshops we 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 say 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 organisation's position in the area of concern. The SWOT or benchmarking input may involve comparing the region, country or organisation with relevant others in the various subdomains. 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 ESRC (Economic and Social Research Council) commissioned 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, who 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 destabilising 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:

a. Assuming this scenario will occur, what is the optimal contribution of social science research can make (your 3 to 5 top priorities)?

b. 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.[6]

Box 2 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 realisation. 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 synthesise 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 prioritise urgent themes for social research in the genomics area. (The workshop also noted aspects of the organisation 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.)

[6] Full reports of the workshop are provided on the CRIC (les1.man.ac.uk/cric) and IAF (www.altfutures.com) websites. The discussion here draws on text produced by Clem Bezold and colleagues.

BOX 2 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 reconceptualisation 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 like 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 organisation. *Signposts* include China buying a big biotech company like 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 mobilising 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 wellbeing); innovation studies on global issues; global actors and changing industrial structures; and ecosystem impacts of genomics and public processing of ecological knowledge.

Case Study 2: Success Scenarios

The "success scenario" method has been applied to issues of science and technology policy in the UK[7] - 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 – 5 to 10 years – on account of sponsor requirements, though inevitably longer-term prospects were also discussed.

[7] ICT and biotechnology scenario reports are reported on the CRIC (http://les1.man.ac.uk/cric) and DTI (http://www.ost.gov.uk/policy/futures/ict/intro.htm

www.ost.gov.uk/policy/futures/ biotechnology/scenario.htm) websites as ICT in the UK a scenario for success in 2005. and Biotechnology in the UK a scenario for success in 2005. CRIC also presents the background analyses for these studies. The nanotechnology scenario report has just been placed 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 the autumn of 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 subdomains of the technology field. There was some background information constituting a scenario or roadmap of the most probable technology path in each subdomain.

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 organisation 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, and

❑ 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 organised, 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 our 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 usefully 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 groundrules 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 are 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 are attached to the walls to provide a record of development and material for other groups to inspect at intervals. The key technique is crystallising 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 characterise 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 characterise the success scenario by specifying concrete ideas about how to recognise 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. Box 3 reproduces the introduction to this task as provided in the nanotechnology workshop. Box 4 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 maximise 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 categorisation 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 organised.) 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 synthesised and prioritised, 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 organisations, 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 which they previously lacked. Or they may serve to confirm what the policy expert already believed, but legitimise this by validating the views by reference to a wider set of experts and stakeholders.

Formally, we know that the studies described above have been utilised 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 organisation 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 summarised 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 organisation, 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 maximised is needed to make sure that scenarios effectively contribute to decision making.

Box 3 Task of developing Success Scenario

Text of three PowerPoint pages used in nanotechnology workshop.

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 UK stands?
- ❑ 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 organisation 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 recognised 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/ recognising 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)

Box 4 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, stock markets, government)·
- ❑ Instrumentation, standards·
- ❑ Structure and organisation 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 *(could you 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.

Continued

Box 4 Continued Session 2b

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 & Safety, Environmental & 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 *(again, can you 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.

Continued

Box 4 Continued Session 2c

Summarising the scenario

Here we would like you to characterise the scenario developed by your group. One way in which this can often be assisted is to come up with 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 characterise 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 characterise 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.

Continued

Box 4 Continued

Session 5 Indicators for success

In session 2c we asked you to begin to characterise 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 recognise 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.·
- ❑ Harmonisation 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% 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 which need to be taken to maximise the likelihood of your success scenarios. Please do so by discussing them in your groups, and writing points down 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 which 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.

We can anticipate 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. Hopefully, we will accumulate information as to best practice and quality issues in scenario work. Perhaps we could even generate scenarios for the future of scenario analysis!

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Delphi method*

Abstract

The Delphi method was originally developed in the 50s by the RAND Corporation in Santa Monica, California. This approach 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 'looses 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 (20-30 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 ten years, the Delphi method was used more often especially for national science and technology foresight. Some modifications and methodological improvements have been made, meanwhile. 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, which can be explained very shortly. This means for complex themes, it is better to use other methodologies like 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 education 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 the 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 during the course. For the preparation phase and the implementation, some practical exercises in small groups are conducted so that the participants gain a feeling for a Delphi procedure.

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What are Delphi procedures?

On the History of Delphi

The Delphi method belongs to the subjective-intuitive methods of foresight. Delphi was developed in the 1950's 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 pre-dictions 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 archeologists and historians we have extensive knowledge on 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, who was 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.

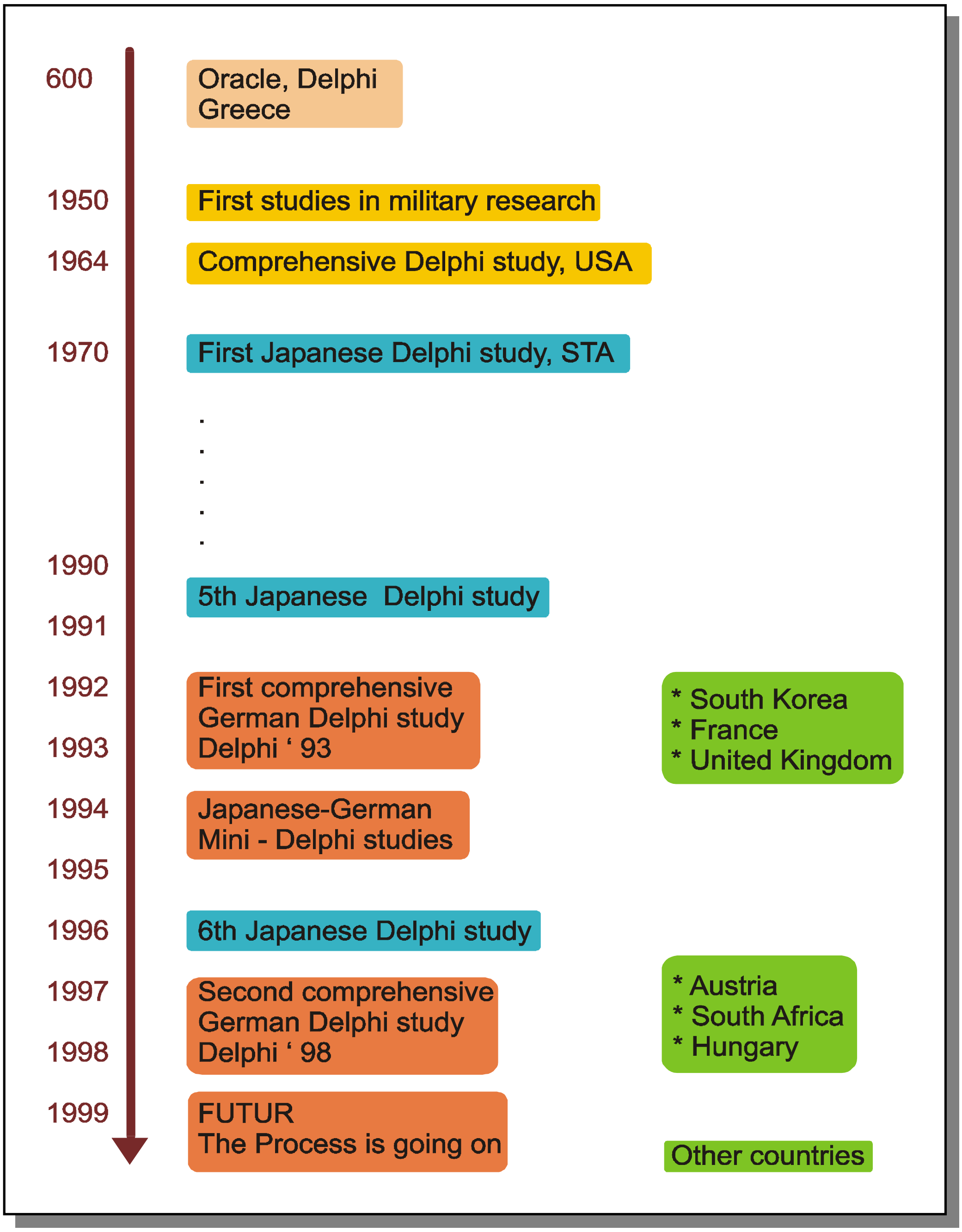
One should consider that the Delphi monastery was one of the very few spots on the earth where knowledge was accumulated, ordered and preserved. The information came in from the ambassadors through their queries and the answers were written down on metal or stone plates, several of them found by archeologists. 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 circum-stances, modern psychology will find no 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 better.

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 civilisation to which it contributed no small part. It is no wonder that a witness of that time, Socrates, around 400 years before our time, 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 1-1, 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 or doctoral thesis. Also not included are business applications on a more focussed 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 type of Delphi application, 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 1-1: Genealogical tree of Delphi



As already stated, the initial work 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 this, 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 and 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 organised a learning phase starting both from the 'mediating' publication of Irvine and Martin (1984) as well as from Japanese experiences and co-operated in their first Delphi with the Japanese fifth endeavour (Cuhls/ Kuwahara 1994). France in turn followed in just copying the Ger-man 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 (see figure 1-1 or Grupp 1999) were pursued in parallel and organised by different, even competing ministries. Again in co-operation between Japanese and German 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 de-livers qualitative as well as quantitative results and has beneath its 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 answer from the second round on 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', so the definition of Häder and Häder (1995, p. 12).

Wechsler characterises 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...*' (Wechsler 1978, pp. 23f.). This sounds a bit complicated but the essentials are:

- ❑ Delphi is an expert survey in two or more 'rounds'.

- ❑ Starting from the second round, a 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 (see e.g. Häder/ Häder 1995):

- ❑ Content of Delphi studies are always issues about which unsure respectively incomplete knowledge exists. Otherwise there are more efficient methods for decision-making.
- ❑ Delphi are judgement processes with unsure aspects. The persons involved in Delphi studies only give estimations.
- ❑ For the participation experts are to be involved who on the basis of their knowledge and experience are able to assess in a competent way. During the rounds, they have the opportunity to gather new information.
- ❑ Especially the psychological process in connection with communication and less in the sense of mathematical models have to be stressed (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 and makes it possible to judge upon. Therefore, the use in combination with other methodologies like scenarios, technology list or others can be interesting. On the other hand, in more complex issues, when the themes cannot be reduced that much or when thinking and discussions in alternatives are the major target, the Delphi is not the method of choice. It is also suitable if there is the (political) attempt to involve many persons in processes (Eto 2003).

For the Japanese policy, it was especially interesting to answer the following question (and this question is also asked by other governments, too, now): How should we proceed with the long-term application-oriented basic research of the hyphenated type? This extension is no mistake, it is really meant *long-term application-oriented basic research*. This is the research where one does not know what will be found out in the laboratory in the next month or year, but it is research which does not only satisfy scientific curiosity and the enhancement of knowledge. It is re-search with a definite long-term economic or social perspective. Let me mention climate research, health research, environmental research and so forth. In days of low budgets many business and policy-makers think it is impossible to support each piece of interesting research only for the sake of good quality. One has to discuss the long-term orientation in which we invested our precious money. The public is convinced that science and technology are partly responsible for modern bottle-necks and problems and hence has a right to learn about priorities in technology and also the opposite, the non-priorities, what is down at the end of the list of priorities.

Consider the situation in which a company or a ministry has to decide which of two research programmes to support, A or B. Programme A is proposed from faculty A and industry A and the peers from discipline A have given their reviews. Programme B in conjunction with industry B originates from faculty B and the peers of discipline B made up their minds. Everybody did her or his best. But how to decide between them?

Do the peers know each other? Our science and technology system of tomorrow needs, alongside with disciplinary peers, new instruments to mediate between A and B, and here is another function of foresight, across the board. A second argument here is that they all have their stakes in the matter. They come from the technology provider side. But do they really know what is needed?

The Delphi technique as a foresight tool seems to possess certain degrees of invariance to survive in the changing challenges of the past 50 years. The method could serve different understandings of forecasting or foresight and was probably under-stood by the users as being relevant for covering technical perspectives, organisational perspectives, but also personal perspectives. The individual could express a distinctly different opinion as compared to the group perspective and this to a differing degree between the technical details under scrutiny. As multiple perspectives are recommended for decision-making, (Linstone/ Mitroff 1994; Linstone 1998) the Delphi technique seems to have appeal in quite diverse situations which touch the long-range scales. 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 to tacit knowledge to the 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?

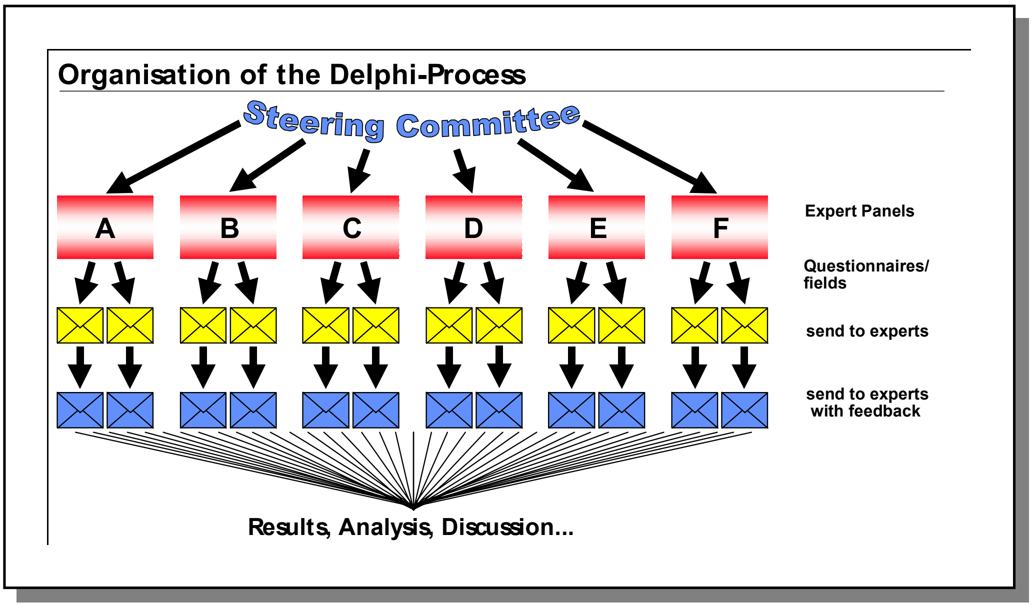
There are certainly different possibilities to organise a Delphi process. Before starting, you should answer the following questions:

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

The formal organisation of a Delphi process

As mentioned before, the usual way is a combination of methods as especially the topics have to be formulated, a process that already needs methods like creativity procedures or can even be combined with scenarios or future workshops. In the following, a more 'standard' procedure is described. It starts with the organisation of the process as such. In Figure 2-1, this is illustrated by the 'real' example of the Del-phi '98 in Germany (Cuhls/ Blind/ Grupp 1998 and 2002).

Figure 2-1: Organisation of a Delphi survey



The first step is to found a steering committee (if you need one) and a management team with sufficient capacities for the process. Then expert panels to prepare and formulate the statements are helpful unless it is decided to let that be done by the management team. The whole procedure has to be fixed 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 the paper versions) have to be organised. Will there be follow-up work-shops, interviews, presentations? If yes, these also have to be organised and pre-pared. Printing of brochures, leaflets, questionnaire, reports have also be considered. The last organisational point is the interface with the financing organisation if this is different from the management team.

How to formulate topics

When the organisation is roughly defined, the fields of the Delphi should be decided on. In some cases, one thematic field is enough, in many cases it is wished to get an overview so that more fields are decided on and handled in a flexible way. There is always the possibility to add or disclose or re-name fields. To give some examples, the Delphi '98 (Cuhls/ Blind/ Grupp 2002) fields were:

- ❑ Information & Communication
- ❑ Service & Consumption
- ❑ Management & Production
- ❑ Chemistry & Materials
- ❑ Health & Life Processes
- ❑ Agriculture & Nutrition
- ❑ Environment & Nature
- ❑ Energy & Resources
- ❑ Construction & Dwelling

- ❑ Mobility & 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 over topics from literature and surveys that are available. But the more creative way is to found working groups who have the task to structure the field and formulate topics. One can start from scratch, but it is very difficult to focus the themes, then. Therefore, the more efficient way is to feed in already existing material from re-search. Then a brainstorming, brainwriting or other creativity activities can add themes. When there is the critical mass of topics, then 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 (from discussion to giving points or school notes, even computer semi-anonymous topic selection is possible). It is recommended not to have more than 50 topics per questionnaire but it also depends on the questions you intend to ask.

It is also helpful to start with structuring the field a bit before the creative phase and then flexibly adapt the structure of a field, figure 2-2 is one example from Services and Consumption in the Delphi '98:

Figure 2-2: 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.

Therefore, it is often necessary to filter twice or even three times because often, the experts in your working groups add topics instead of reducing the number. The last step is the fine formulation. Often there are stereotypes of verbs (e.g. for science and technology foresights), that indicate innovation phases (is elucidated, is developed, is used, is in widespread use) or others so that the topics fit. The topics have to be formulated in a way that misunderstandings are impossible. It is also necessary not to have two different things mixed in one topic. And the topics have to fit to 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 that should be asked but one of the major criteria or questions is always the one about the estimated time of realisation. 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?

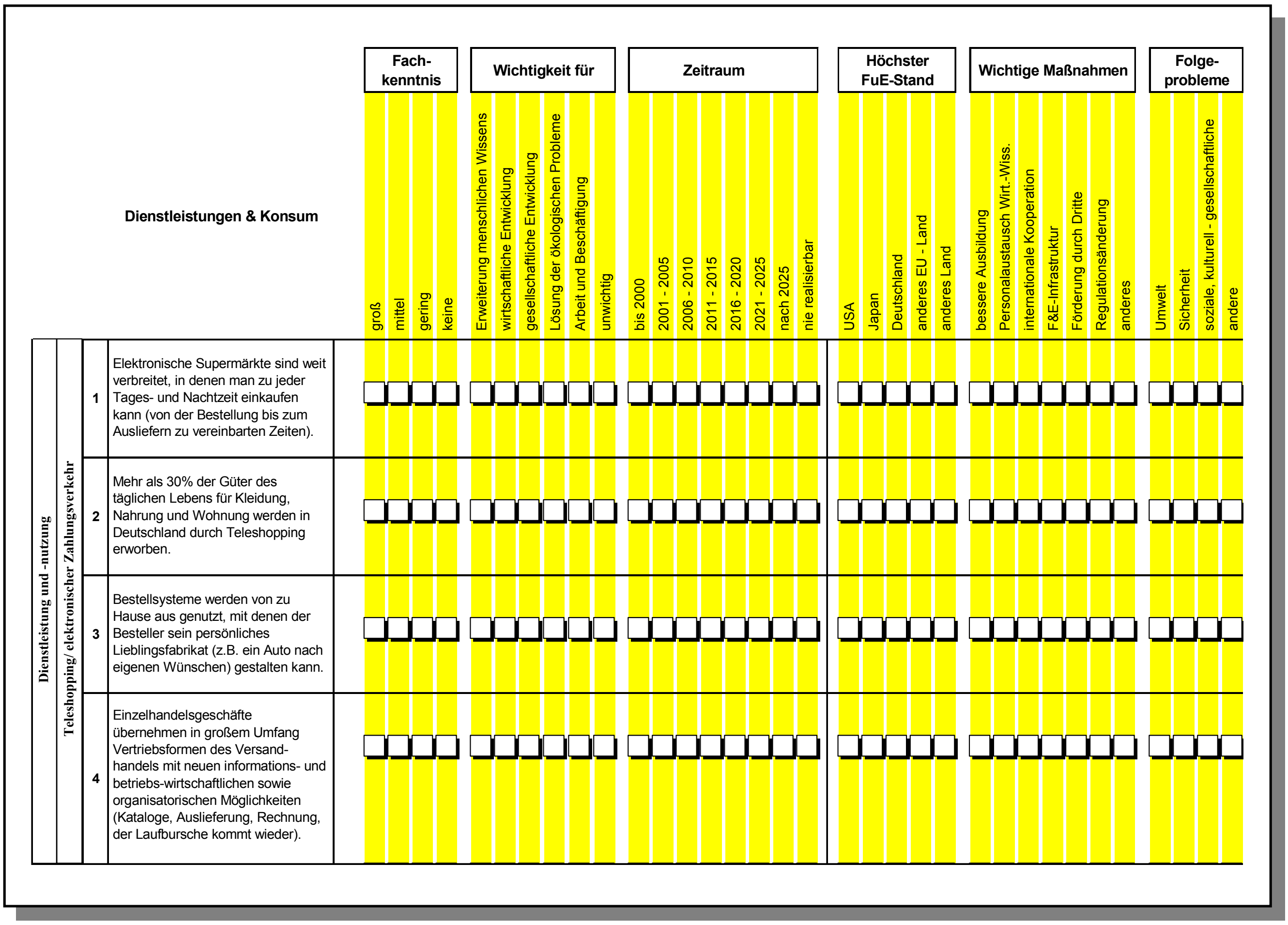
Other criteria can be:

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

The time of realisation 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 (e.g. from now to 2033), but it is also helpful to ask for a later time (after 2033) 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, too. The illustration of the design of the Delphi '98 questionnaire is only a part and the 'comments' are missing. What is of-ten 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 2-3: Example of a questionnaire design



When designing the questionnaire (for an example see figure 2.3), 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 gives often the impression of a very 'full' picture and too many information have to be shown on one page. The new electronic media provide many more possibilities. Here is much room for creativity.

Dimension of a study, resources needed

As in all processes, the resources are the crucial point: Is there enough money, time and personal capacity available? Therefore, one has to calculate from the beginning, which 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 rather 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 700,000 Euro including the end report (re-financed via selling it, only for participants, it was free). Follow-up additional expenses were paid for international comparisons, presentations, newsletters, conference etc. Thus, it is recommended to answer in advance the following questions which determine the costs:

- ❑ Do you intend 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 for participants?
- ❑ Do you need to type the results (e.g. from paper questionnaire)?
- ❑ What are the management costs? What are your salaries? And how many external persons contribute to the process so 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 version, the participants need time to answer the questionnaire. Preparation time, analyses and implementation should also be calculated. Therefore, for a larger Del-phi with different fields, at least one year should be calculated.

Who is involved? Who is an expert?

This question sounds trivial but it is not. Most sociologists of science 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. 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 al-most perfect correlation was found between the number of experts and their rating of German research performance. In sub-areas where we know more, we are good. In sub-areas where we are not advanced, we know little of the opportunities.

A test for Delphi expert bias in the energy area from the German Delphi '93 tends to support this 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 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 %) than in the second round (10.18 %). This can have several reasons. New foresight approaches tend to involve more and different stakeholders of the innovation systems 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, wherever they stem from. But they have to be selected carefully according to the themes asked for. It is recommended to invite a mixture of persons from industry/business, academia, re-search institutions, and others.

As in all surveys, the sample in the end needs to be large enough to draw 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 e.g., 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, data bases, 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 to be considered, too.

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 under-stand. 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, which can be used in very different ways. But also comments are often asked 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 selection. Looking at the different international reports, there is a wider range of possibilities. What a Delphi manager should do is to think about the way to analyse in advance because this has implications on the criteria and the whole design of the questionnaire as described above.

Rankings

Simple rankings of statistical data are the easiest way of presenting results. Of course, the data have to be aggregated first, sometimes an index has to be built. Of-ten, the importance categories are used to figure out the most important topics. But also the measures or other assessments can be ranked. Especially, the older Japanese Delphi studies worked a lot with rankings (e.g. also NISTEP 1997). Figure 4-1 stems from the Delphi '98 but is of different character. Here, the megatrends asked for are ranked according their agreement (persons could agree to a topic personally or not), which was important because the megatrends were used to figure out a per-sonal opinion of the answering participant cohorts by a factor analysis (for details, see Blind/ Cuhls/ Grupp 2001).

Figure 4-1: Ranking of agreements on megatrends

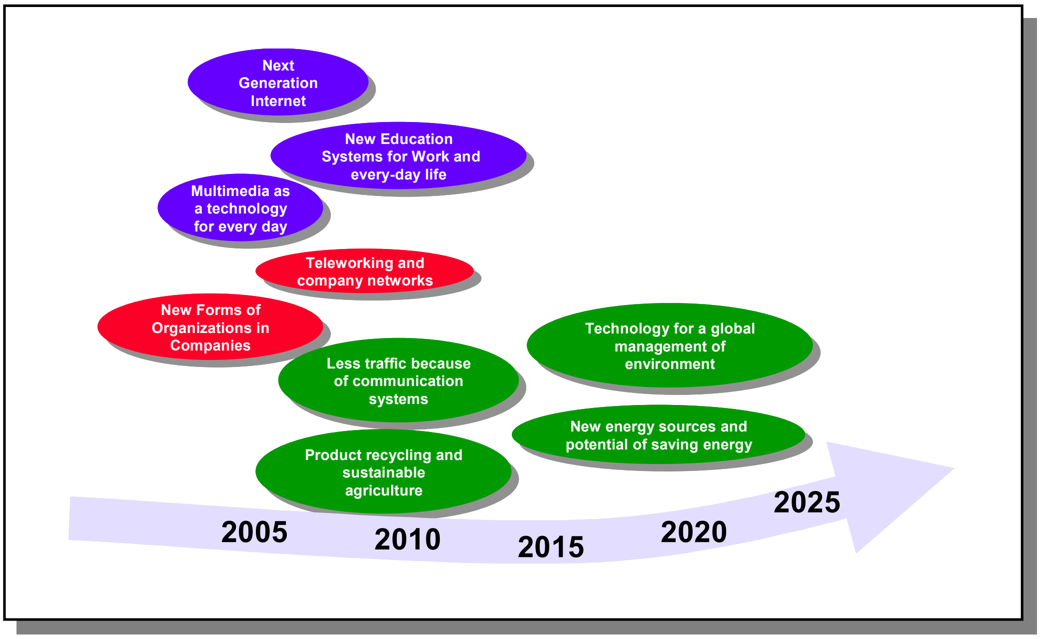
Megatrends

Megatrend	Agreement	Time Frame	Disagree-ment
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 will 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

Qualitative Clustering

Another possibility is a half quantitative and half qualitative way 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 often highly scored were clustered qualitatively and described under a joint headline. This was done to provide a very compact picture on results. Figure 4-2 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 4-2: The most important topic cluster



Different graphics

Like in every report, graphics are welcome to illustrate and make understanding easier. Figure 4-3 shows an example for the different importance categories of the Delphi '98 (all data compared with the innovation field Big Science Experiments).

Figure 4-3: Importance categories

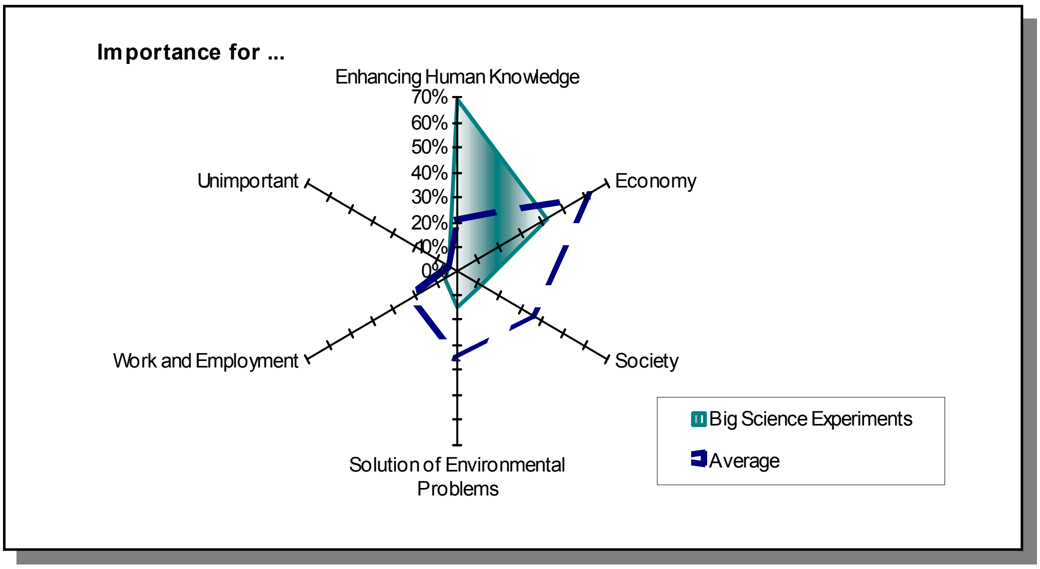
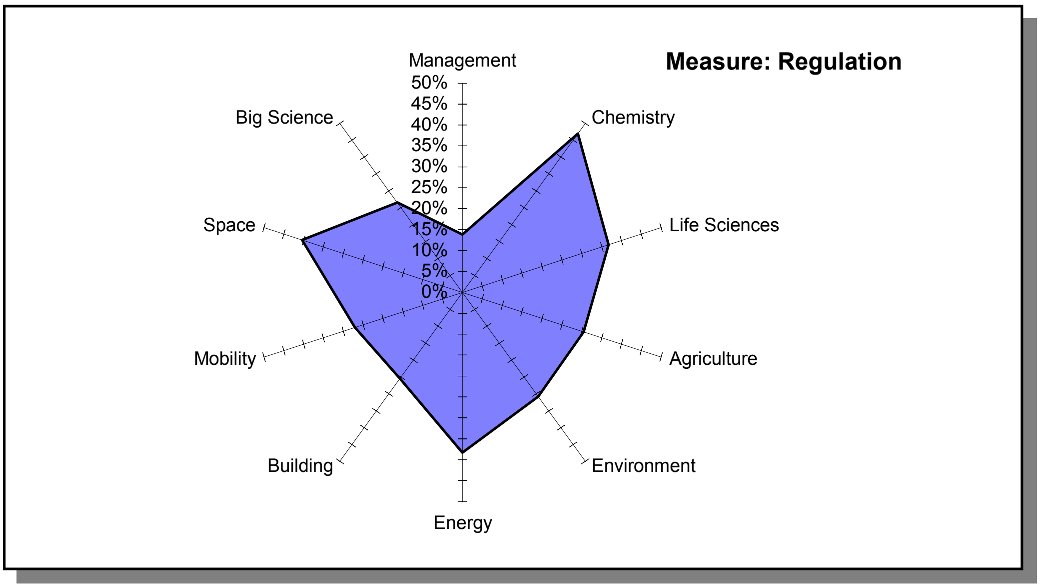


Figure 4-4 shows a different approach. Here it is not asked for the categories but asked, in which innovation fields, there is the highest demand for new regulation, different or less regulation (category: measure regulation). The result is not shown in a simple ranking but in a graphic which is scaled only up to 30 % because (interestingly for Germany), this measure was not really often asked for. The results can be interpreted in more detail by the comments. Later on, we figured out single topics and deepened them in interviews.

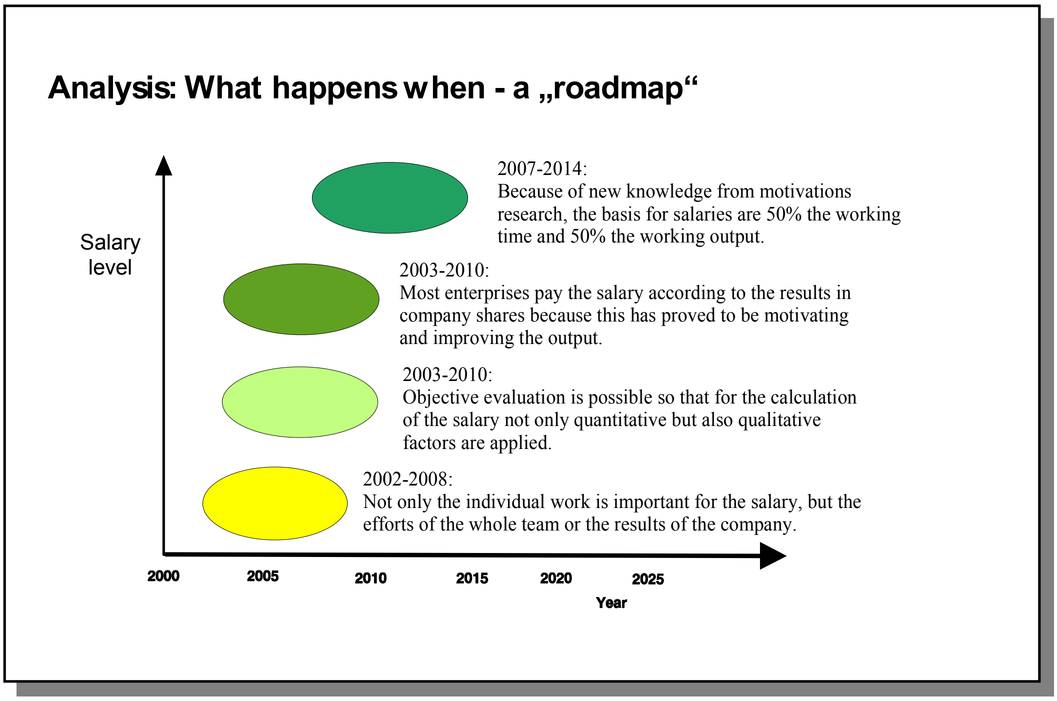
Figure 4-4: Measure Regulation judged in the different innovation fields



Scenarios or roadmaps

As in most Delphi surveys, it is asked for the time of realisation, and small roadmaps can be drawn from the field. If the categories and statements fit to each other, also small scenarios can be derived from it. Figure 4-5 shows a kind of roadmap concerning the development of paying salaries in Germany. This analysis can also help to identify breaks in the assessment of the statements. It can be checked, if it is plausible if one development is realised earlier than another, it could also be the case that a technology is not yet developed that would be necessary for the development of another one – but the experts judge the second one earlier, which would lead to the question of plausibility. In the German Delphi '98 we found breaks, especially in the field of Management and Production, but no implausibility.

Figure 4-5: Example of a 'roadmap' from the field Management & Production



To be able to compare topics, it is important to formulate them in an identical way. Figure 4-6 gives you an example from the Delphi '98: It is a comparison of the German most important topics for the economy in the field of Agriculture & Food with the identical topics of the same field in Japan (ranked according to the difference).

Figure 4-6: Comparison of identical topics in the field of Agriculture & Food

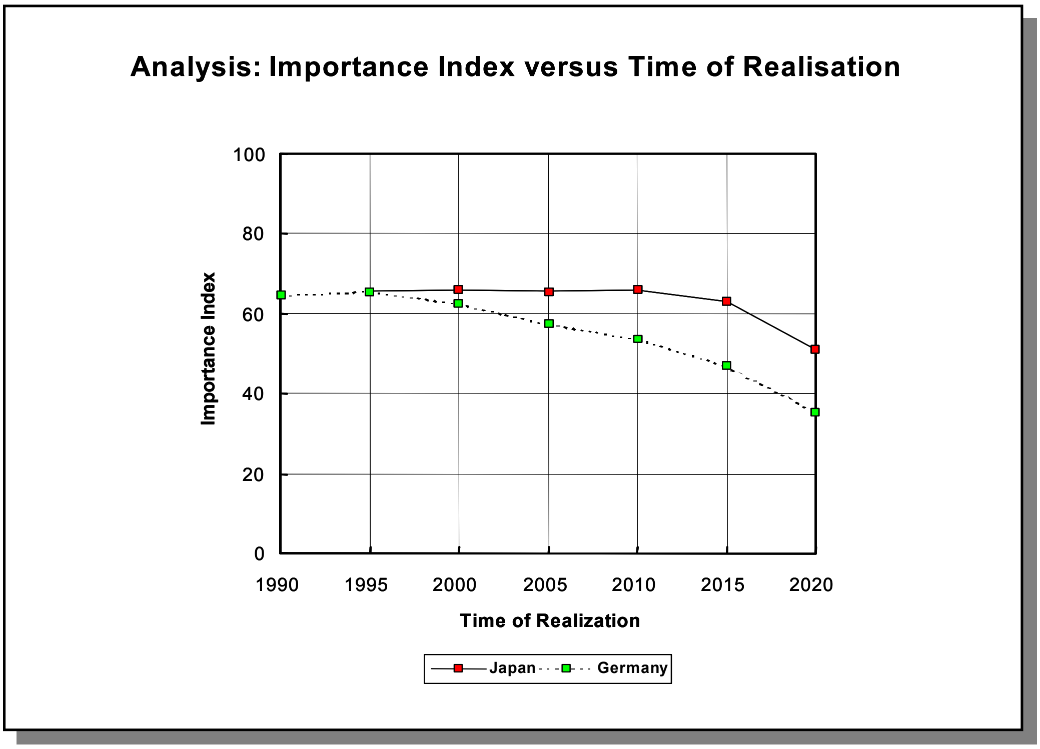
Agriculture & Food	Germany	Japan
	Importance for the economy	Importance for the economy
Plants which are specially cultivated for resistance to drought and salt and provide barriers to desertification are in practical use.	78.3	25
Cell fusion and gene technology will make possible the cultivation of 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 fertilised 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 and 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 forms, will be implemented in tropical regions.	50.7	10.6

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 realisation in a Japanese-German comparison. In Figure 4-7 this graphic is shown. It demonstrates, that the hypotheses 'the higher the importance, the earlier the topic' cannot be proven in general and not in

Japan, although there is the tendency in Germany that earlier topics have slightly higher importance rates.

Figure 4-7: Importance Index versus Time of Realisation



But as already hinted at: With creativity, a lot of different analyses and results can be gained. These were just very few examples...

Implementation

The second problematic point remains the interface to implementation. In some surveys, it is already enough to provide some results in form of graphics or statistical analyses as 'information about the future'. But how can the 'results' further be used? New foresight processes are more than just providing 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 the difficulties

1. of bringing them together
2. of linking the needs of the users and the concepts of the methodologies very early
3. of making potential users aware of the possibilities (marketing) so that they have the choice
4. of establishing mechanisms of transfer
5. of delivering results that are useful
6. of involving persons who have the power to decide and implement.

Until now, the use of foresight results in Germany and other countries was based on ad hoc activities. There are different possibilities (see Cuhls/ Blind/ Grupp 2002): One of the most interesting was the use for an evaluation of the Fraunhofer Society by an international panel (SWOT analyses). The different ways of implementation were very useful and there were a lot of them, especially by companies, but a more strategic approach would certainly bring more results. The Delphi '98 was aimed at information for those who are interested in.

The question if one works closely together with the financiers has to be thought about very carefully. Sometimes, a more neutral look-out is asked for or suits the situation better. On the other hand, the interface between Delphi and the financier is more difficult, then. But this is true for nearly every foresight approach that can be conducted externally.

Some recommendations

The major recommendation is to clarify the objectives of the foresight approach at first. The second point is to check if a Delphi is the right choice and if there are enough resources for a Delphi (rarely possible without the combination of creativity methods and those for the formulation of statements). If you considered all pro's and con's, 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 I ask for?
- ❑ How will the organisation be? Who manages the process?
- ❑ Who will be invited to participate (active or non-active)?
- ❑ What results can be expected?
- ❑ What are the questions asked?
- ❑ How is the questionnaire designed?
- ❑ What kind of analysis need to be possible?
- ❑ 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 organisations who for example in Germany were the major users of data and who also conducted own Delphi processes. Delphi has its advantages and disadvantages that are described above and elsewhere but the major danger is – as in all Foresight pro-cesses – 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 are provided and worked out, the future cannot be predicted and will always be different from what you expect.

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Critical Technologies*

Abstract

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 utilising limited public funds, is subject of numerous foresight studies. Various methods are applied to identify a limited set of national research priorities – this paper deals with the method of critical technologies, which is widely used in several countries, e.g. the United States, France 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 paper summarises the basics of the critical technologies method and it 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 should be launched in January 2004.

Introduction

A typical basic objective of national foresight exercises is to identify the most important technologies (research priorities) likely to be demanded by the national industry and service sector over a certain period of time. Research conducted in the defined priority areas should contribute to the achievement of strategic goals in key sectors which are important for the creation of national wealth and for the improvement of the quality of life.

Technologies representing the driving forces in the national economic prosperity and security are regarded as *critical* to national interests. Due to the limits in 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 initiate a national foresight exercise 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 of European countries and Japan developed more or less sophisticated foresight exercises, in the United States a much more straightforward

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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's organization). The last (fourth) report was prepared by RAND in 1998 [1].

In France, the Ministry of Industry initiated the last national exercise based on the critical-technologies principle in 1999. The exercise called "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 [2].

The Czech Government decided to sponsor the first national technology foresight in 2001. The main objective of the exercise was to propose key research directions (critical technologies) having 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 and it is also available on Internet [3].

The above examples of the four countries do not represent an exhaustive list of using a method of critical technologies in foresight exercises. They should be understood as a demonstration of the method applicability in different countries as for their size and type of economy.

Critical Technologies

In some languages, the word "critical" has a "catastrophic accent", therefore the wording "key technologies" is used instead. Despite the name, the meaning is always the same – technologies having 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?

Bimber and Popper declared in their recent paper [4] that for a technology three criteria should be met to be considered as a critical:

1. Policy-relevant – the produced list of technologies should also indicate where are the potential areas (issues) for political interventions to make results feasible. Particular attention should be paid to the issues of R&D processes, commercialisation, dissemination and utilization of results.
2. Discriminating – it should be clearly possible to distinguish between critical and non-critical technologies. It should not be 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 procedures used to select the critical technologies. The used method should be transparent, robust and publicly accessible.

The term of "critical technology" should not be mixed with other terms, like:

- ❑ 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 include „a popular“ technology in the final list;

- ❑ technologies for national self-sufficiency – with rising globalisation there are many technologies (particularly in 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 return 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?

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 France and in the Czech Republic are examples of that trend [2], [3].

In principle, the method of critical technologies may be also used to identify "non-technology critical issues", for instance social ones but no example of such an activity has been published so far.

What are potential weaknesses?

The main danger may be a relatively narrow group of experts participating 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 that exercises based on the method of critical technologies can be designed and managed in such a way that both mentioned potential weaknesses are reasonably eliminated.

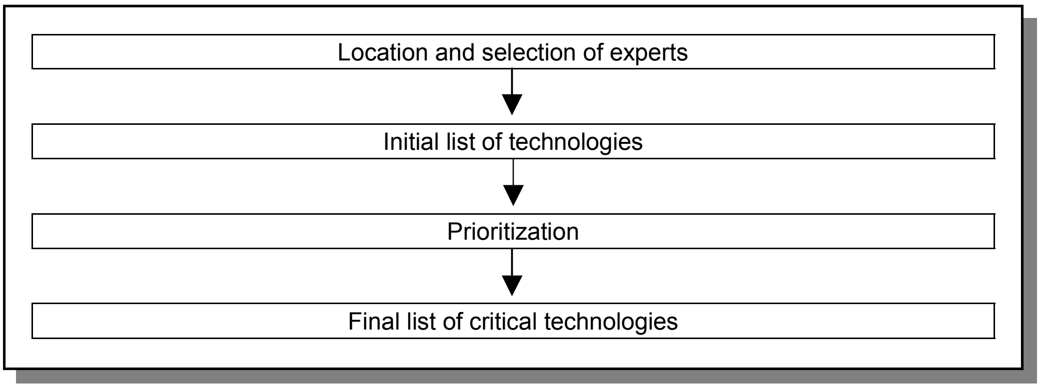
How to conduct the exercise?

There is no single recipe which could be generally considered to be "the only one" for any foresight exercise based on the method of critical technologies. The following paragraphs summarize some general suggestions that could be derived from foresight exercises conducted in the recent past. The case example in the following section provides a more detailed suggestion how to conduct a foresight exercise using the principle of 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 particular tasks and objectives of the exercise.

Structure of the exercise

Although a wide variety of patterns may be used for structuring the critical technology exercise, there are always some typical steps that are involved (Fig. 1)

Fig. 1 – Typical steps of critical technologies exercise



Individual steps of a more detailed structure of a critical technologies exercise are discussed in the case example (Czech foresight exercise) in the subsequent section of this paper.

Location and selection of experts

Location and selection of experts is a key initial step of any technology foresight. The method used for the location of experts is profoundly influenced by the total extent of the consultation scheme [6]. Two possibilities – (i) narrow consultation, and (ii) broad consultation are likely to cover any programme, although mixed approaches are always possible.

The narrow consultation scheme is typical for most "expert committee studies" conducted for instance in the US programmes of critical technologies [1]. A relatively narrow group of experts is appointed by the exercise sponsor, the sponsor also prepares (initial) terms of reference. The expert committee uses dominantly 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 unbiased because special interests in a small group are very likely.

Broad consulting scheme includes a central management group that co-ordinates and manages the whole exercise using amply external expertise gathered in panels, expert groups, knowledge pools. The core group is responsible for finding and selecting of 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 the industry, environmental scanning, may be combined to receive a comprehensive list to examine.

Prioritization procedure

Prioritization is the most difficult and risky step of the exercise. The main objective sounds quite simply – to reduce the initial list of technologies considered 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 the point when 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.

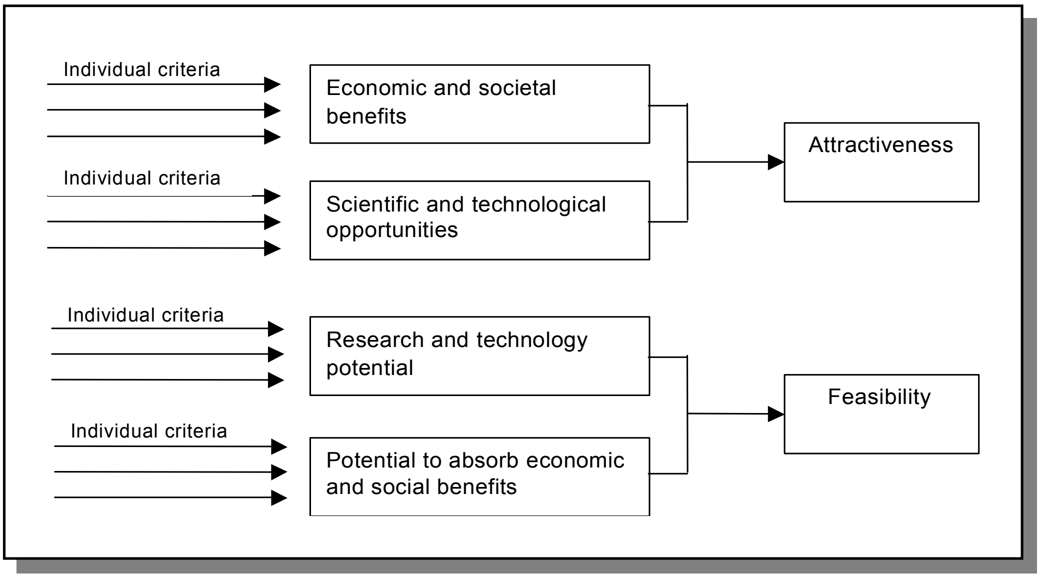
In practice, usually a *voting procedure* is used to make a selection from the initial list of technologies. It should be noted that prioritization is not exclusively tied to the method of critical technologies. Practically all foresight techniques have to make a selection of priorities at a certain point. In some programmes, for instance in the case of the UK foresight exercise [5], in which a Delphi survey is used, an objective function is formally defined. The prioritization procedure is looking for a maximum of the objective function. In the UK exercise the prioritization is made by sorting the topics in descending order of indices representing the objective function. The objective functions chosen for the UK programme were the *wealth creation* and *the quality of life*. The following Tab.1 published by Loveridge [6] illustrates both variables in detail. Delphi respondents indicated the influence each Delphi topic would have on each objective function by selecting the appropriate number. The result then can be depicted in a two-dimensional graph with both objective functions as variables for each of the considered topics.

Tab.1 The objective functions for the UK foresight programme [6]

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 realisation 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 recognisable 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.

Another type of voting (prioritization) procedure follows the approach used by the Australian CSIRO [7] or by the United Nations University in the Millenium Project [8]. In this case, two parameters, *attractiveness* and *feasibility* (CSIRO) or *importance* and *likelihood* (Millenium Project) were used. A similar voting method using the a set of parameters on importance and feasibility was used in the Czech foresight exercise [3]. 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 scoring 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 the following Fig.3.

Fig.3 Scheme of prioritization

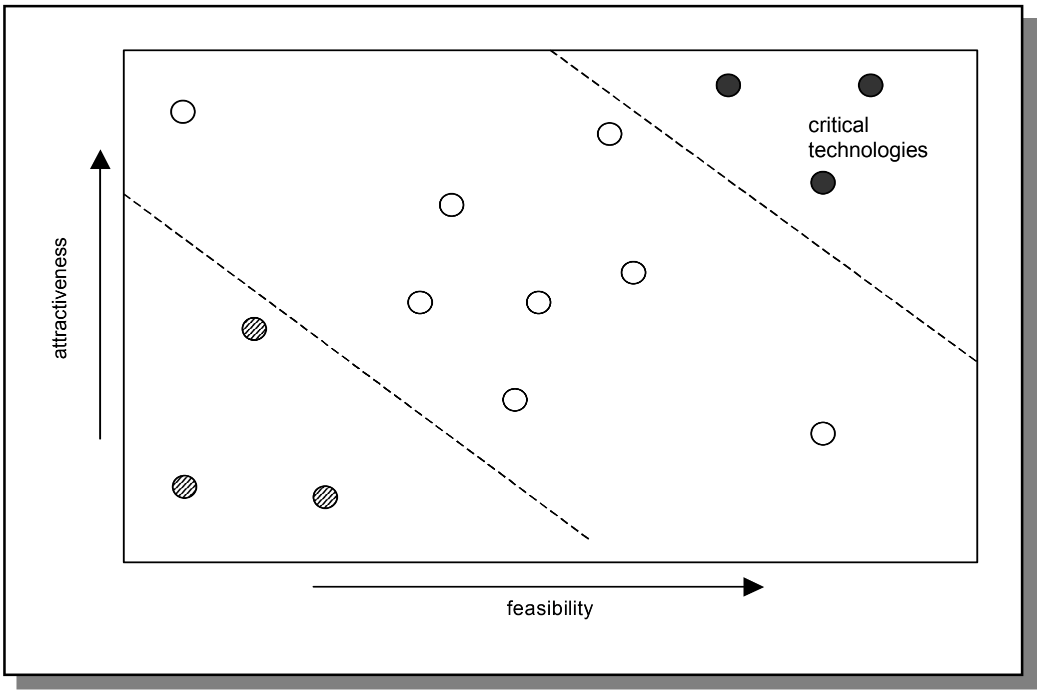


Individual criteria may differ in their form, usually they should express what benefits may be expected of the new technology (or what economic or societal needs may be satisfied). For instance the criteria of economic benefits may be formulated as “market growth”, “contribution to productivity”, the criteria of societal benefits 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 the scale 1 (low), ..., 5 (extremely high) to each of the criteria for each specific technology. Individual marks are then clustered following the scheme in Fig.3. to receive two parameters – *“attractiveness”* and *“feasibility”*. 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 number of received data may reach the amount of several hundreds of thousands. Electronic voting procedures have been developed to make the voting and handling large number of data feasible. Such an attitude will be illustrated using the case example of the Czech exercise in the following section of this paper.

Once the two parameters are received for each considered technology they may be used to represent graphically the ranking of individual technologies in a two-dimensional graph. An example of such a presentation is given in Fig. 4 below.

Fig.4 Ranking of technologies in the plane of parameters „attractiveness“ and feasibility“



The points in the graph correspond to individual technologies. Black points in the upper right-hand corner are strong candidates for "critical technologies", the points in the lower left-hand corner correspond to less attractive technologies with low feasibility in considered environment (national economy, industry). A special attention deserves the point in the upper left-hand 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 consider it as a good candidate for a key technology and recommend support measures that would 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 to change the standing of some technologies moving them to a better (or a worse) position in the graph. However, in such a case the project management should require a detailed justification, otherwise 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 in the responsibility of policy makers but it brings an important experts' 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 in detail in this paper. 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.

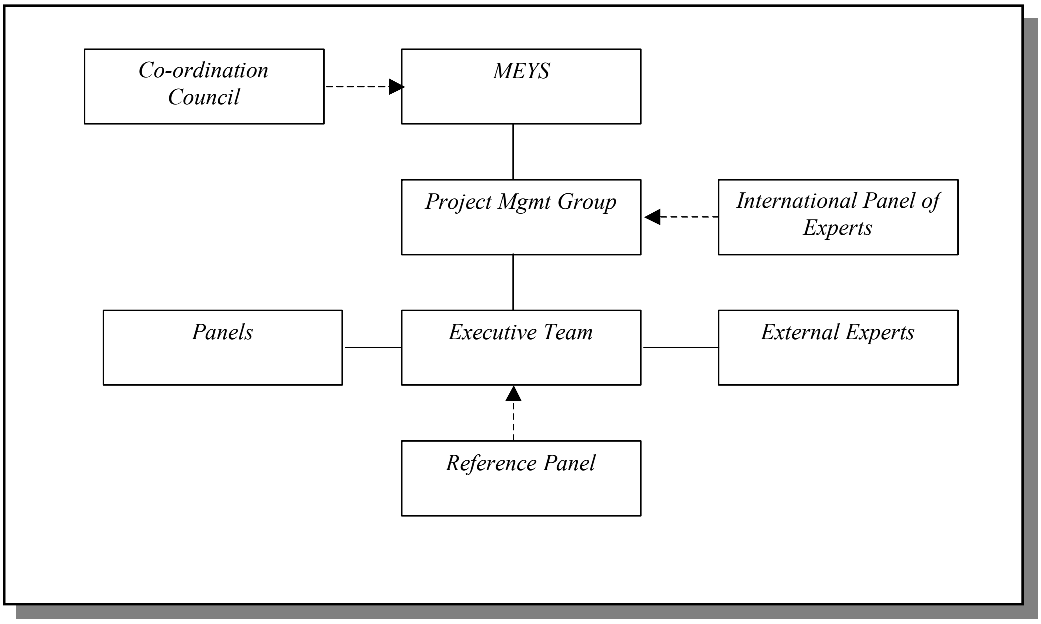
The objective of the exercise

The National R&D Policy approved by the Czech Government in 2000 declared the need of early identification of priorities for research funded from public resources using a proven methodology (or a combination of methodologies) of technology foresight. The accomplishment of this task was the principal objective of the national technology foresight 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 may be achieved only through a co-operation within a relatively complex structure in which all the important stakeholders are represented. The basic structural elements of the Czech foresight project are illustrated in Fig. 5. The dashed arrows indicate an advisory role.

Fig. 5 – The structure of the Czech technology foresight project



The Ministry of Education, Youth and Sports (MEYS) was the project principal promoter and sponsor.

The Co-ordination 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 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 – 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 Expert Panels, co-ordinated in-depth interviews of industrial managers and worked out a quantitative analysis of significance of individual business sectors to the Czech economy.

External experts were leading national professionals in particular fields. They were invited to prepare a SWOT analysis of their sectors and suggest priority areas of oriented research to match the needs identified in the analysis.

International Panel of Experts was a group of prominent international experts in the area of technology foresight. They provided their opinion on the project methodology and their view on the analysis and interpretation of the results.

Reference Panel consisted of representatives of research institutions, industrial companies, associations of entrepreneurs and other organizations. The panel included several tens of people who were electronically contacted about 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 hundreds of national experts were needed to participate in the panels and to perform independent analyses of application 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 application 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 – the so called co-nomination procedure used for instance in the UK Foresight Programme [5]. Finally, names and characteristics of more than 800 candidates were collected.

Preparatory phase

Expert panels constituted the “creative backbone” of the project. The panels were provided with input information as a background for their efficient work from the beginning. The information consisted of three major components:

- *Results of interviews of the application sphere.* In-depth interviews (the demand side) of a representative sample of key companies from each application sector (286 companies in total) were conducted to identify the demand 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 the R&D strategy. To ensure fully professional communication external experts were appointed to collect the data.
- *Results of desk research.* A thorough desk research was performed by the Executive Team to collect basic economic data and data on public research expenses in individual application 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 application sectors. The analyses included expected trends (scenarios) for the next 10 years.

Panels

Panels consisted typically of 15 – 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 an efficient work of panels was to bring together people with different backgrounds and experience to combine professionals from the “supply -” and the “demand” side.

After complex discussions with representatives of the MEYS (the project sponsor), Co-ordination Council and other key stakeholders, 17 panels were established:

- 13 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

- ❑ 3 cross-cutting panels:
  14. Human Resources for Research and Development
  15. Integrated Research and Development
  16. Regional and International Co-operation in Research and Development
- ❑ 1 systemic panel:
  17. Management and Implementation of the NRP

Because of the scope of this paper – 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 application sectors. The results of the SWOT analyses were compared with the analyses previously elaborated by external experts. Panels were asked to identify *important research directions* (IRDs) using brainstorming followed by a repetitive 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 thirteen 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 having a very limited support by panels there were still almost six hundred of IRDs. Further reduction was carried out using a prioritisation procedure developed especially for the purpose of this foresight project. The procedure followed the approach used by the Australian CSIRO (Commonwealth Scientific & Industrial Research Organisation) [7].

During the prioritisation 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 (see Tab 2). The original set of criteria suggested by the Management Group was much shorter with an intention to reduce it even further. However, there was much debate, with little room for compromise, particularly in the Co-ordination Council. Criteria were grouped into six clusters, which were, aggregated into two parameters (co-ordinates) *"importance"* and *"feasibility"*. Due to the high number of criteria and IRDs and the number of voting panel members, a set of almost 300 thousand data 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 Internet on the 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%) voted, the resulting data was electronically processed and used for the first identification of reduced lists of IRDs. The obtained lists were further refined after a thorough discussion on the voting results in each panel.

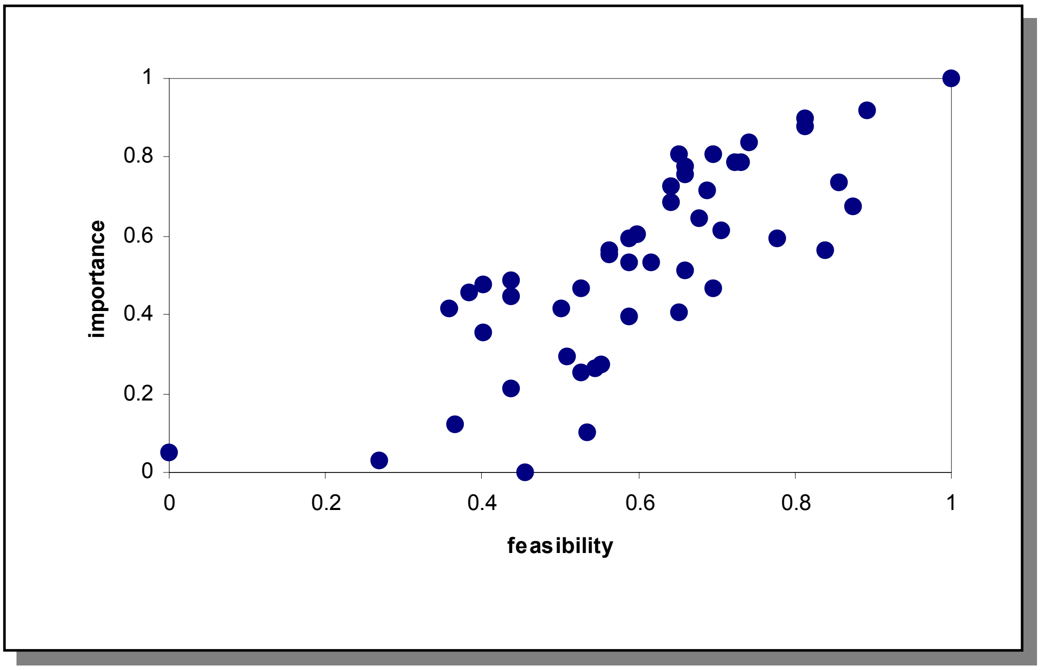
Tab. 2 Criteria for selection of Key Research Directions (critical technologies) in the Czech foresight exercise (2001)

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 unrenewable 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 the scale of 1-5 : 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

A typical result of voting is illustrated in Fig. 6 (panel Information Society). Individual points correspond to the particular IRDs. The upper right-hand corner includes “key research directions”. Panels were allowed to change the standing of some IRDs in a few particular cases, however, in such cases , the project management required a detailed justification.

Fig. 6 – Results of voting – panel Information Society



The voting procedure and the following discussion in thematic panels led to 163 *key* 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 (see the following section). The Working Group also carried out the second prioritisation, i.e. further reduction of the KRDs selected by panels.

The results of panels’ work were summarised 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 prioritisation 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 Co-ordination 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 the exercise moved closer to the implementation stage and, consequently, more "political" actors engaged in the project were necessary.

The main task of the WG consisted in further selective reduction of the163 KRDs produced by 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 panels. After identifying the cross-cutting issues and an extensive debate between representatives of panels the WG further reduced the total number of KRDs to the *final 90 KRDs*. The final list of KRDs is not presented in this concise paper, however, it 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 dominantly 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.

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Technology Roadmapping*

Abstract

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 chapter 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 customising the method. Also important is the process that is required to develop a good roadmap, and the 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.

Introduction

Technology-driven innovation is of increasing importance to industry and nations, 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

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technique has been adapted and applied in a wide variety of industrial contexts, at the company and sector levels. Technology roadmaps can take many forms, but generally comprise multi-layered time-based graphical charts that enable technology developments to be aligned with market trends and drivers.

This paper 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 customising the method. Also important is the process that is required to develop a good roadmap, and the paper describes a method for rapid initiation of roadmapping in organisations, together with some of the characteristics of good roadmaps and the systems needed for supporting their application. A case example is included to illustrate how the approach can be applied at the sector level, based on a series of collaborative workshops.

Much of this paper 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 recognised 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 characterise 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 organisation. 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 organisational 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 paper the following definition is adopted, proposed by the European Institute of Technology Management (EITM)[1] :

"*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*".

[1] EITM is a collaboration between a number of European universities: see http://www-mmd.eng.cam.ac.uk/ctm/eitm/index.html

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, organisational culture, etc. These concepts are illustrated in Fig. 1.

Figure 1:

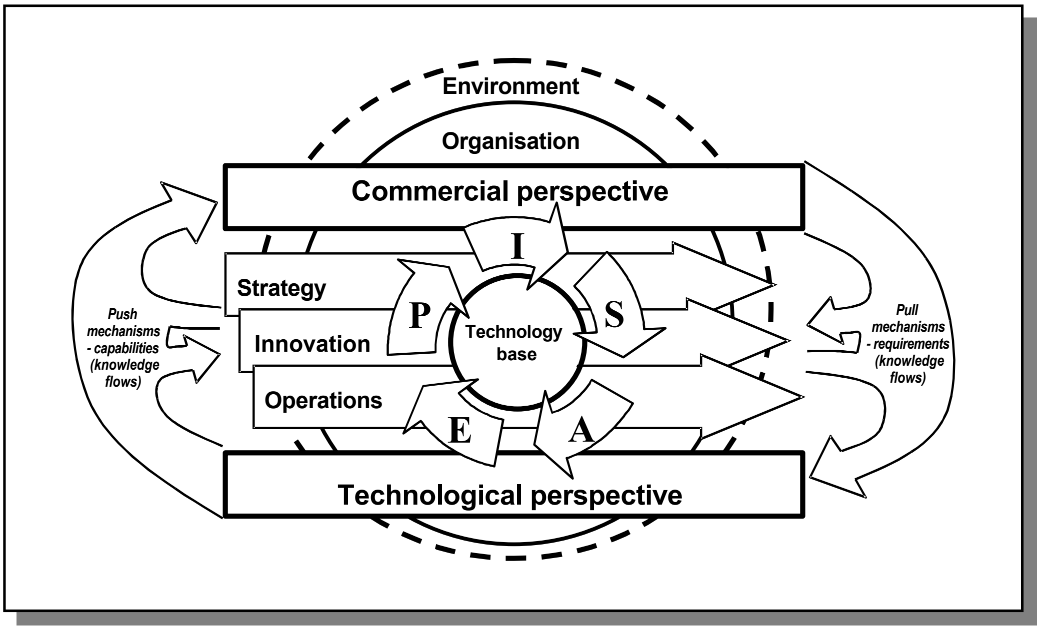


Fig. 1 - Technology management framework (Probert et al., 2000), showing technology management processes (Identification, Selection, Acquisition, Exploitation and Protection), business processes (strategy, innovation and operations), highlighting the dialogue that is needed between the commercial and technological functions in the business to support effective technology management

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)[2] (Kostoff and Schaller, 2001), Aluminum Industry[3] , UK Foresight Vehicle[4] (Phaal, 2002) technology roadmaps. An Internet search using the term 'technology roadmap' will produce thousands of links, mostly relating to sector level initiatives, many of which are available to download (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) - see Fig. 2. 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.

Figure 2:

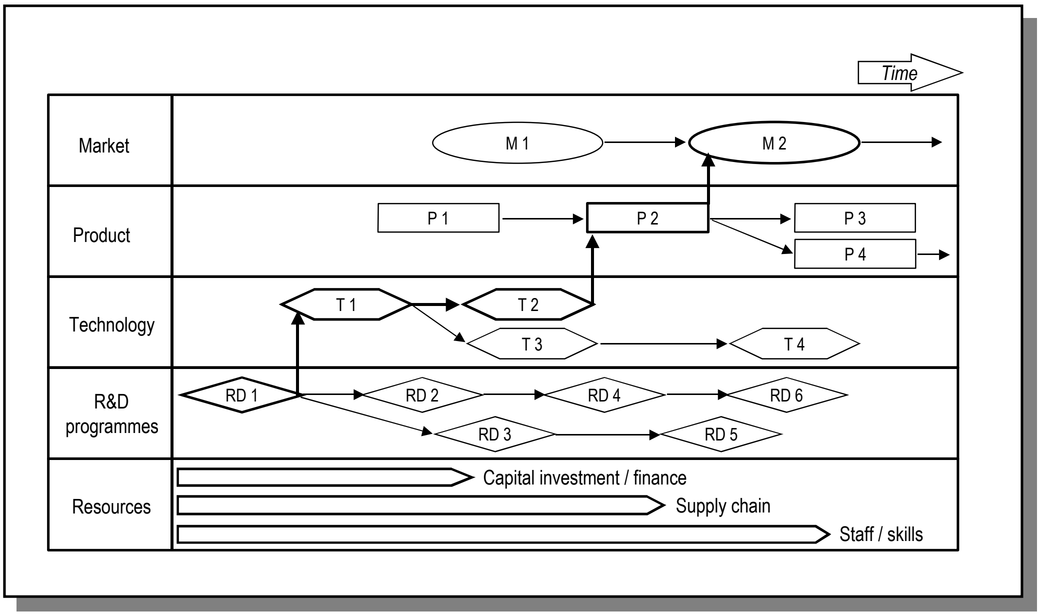


Fig. 2 - Schematic technology roadmap, showing how technology can *be aligned to product and service developments, business strategy, and market opportunities.*

A survey of 2,000 UK manufacturing firms (Phaal et al., 2000) indicates that about 10% of companies (mostly large) have applied the technology roadmapping approach, with approximately 80% 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

[2] http://public.itrs.net/files/1999_SIA_Roadmap/Home.htm

[3] http://www.oit.doe.gov/aluminum/

[4] http://www.foresightvehicle.org.uk/

'alive' on an ongoing basis (50%), starting up the TRM process (30%), and developing a robust TRM process (20%) - see Fig. 3.

Figure 3:

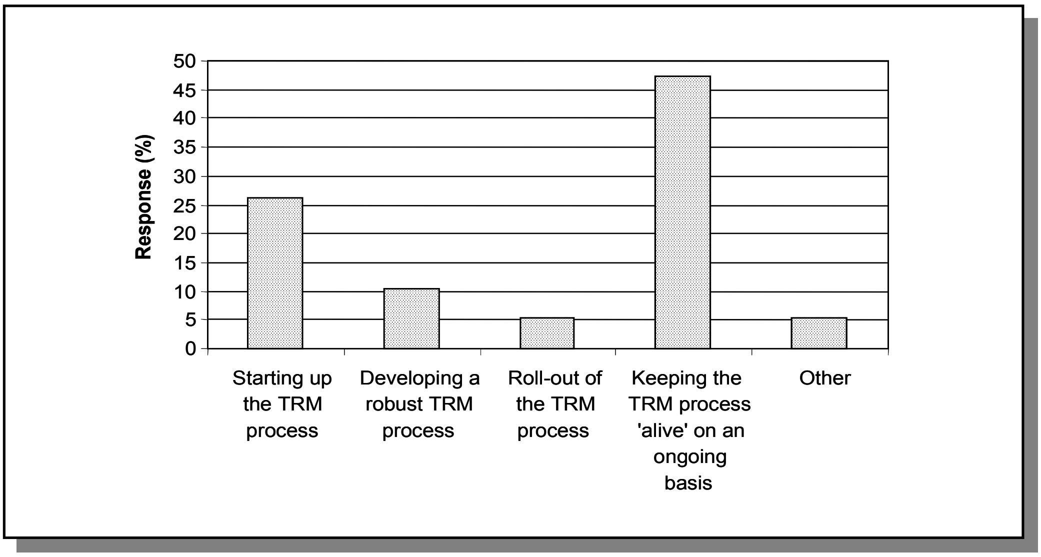


Fig. 3 - Key technology roadmapping *challenges*

One of the reasons why organisations 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 & Garcia (1997), Groenveld (1997), Strauss et al., (1998) and DoE (2000) summarise key technology roadmapping process steps. These authors indicate that the development of an effective roadmapping process within an organisation 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[5] and Canada[6] . 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 also 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 customise the roadmapping approach to suit the particular circumstances for which it is intended, as discussed later in this paper.

Other factors that contribute to (and hinder) successful technology roadmapping are shown in Fig. 4, based on results from the survey described above. Factors that are particularly important for successful roadmapping (greater than 50% 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.

[5] 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

[6] 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

Figure 4:

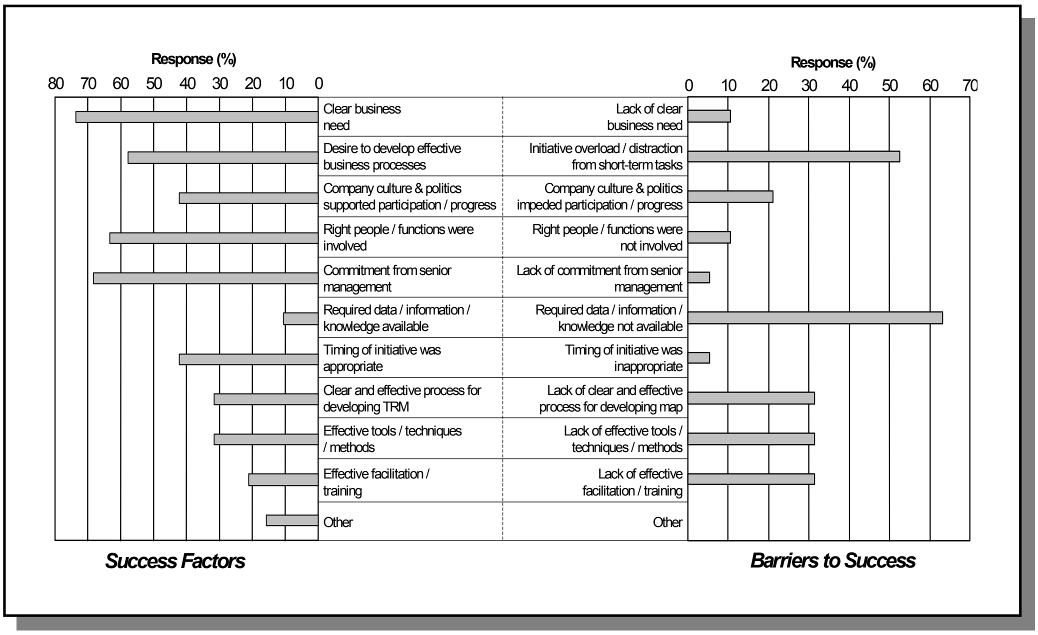


Fig. 4 - Roadmapping success factors and barriers to *success*

This paper 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.

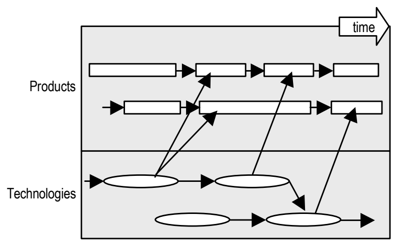
Technology roadmapping approaches

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); see Fig. 5:

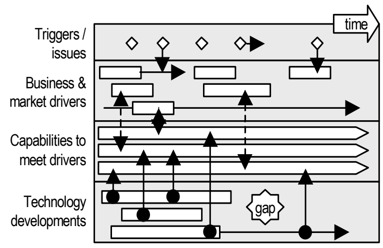
1. *Product planning*

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.



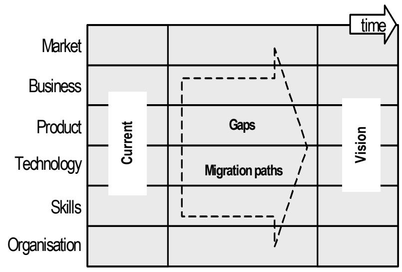
2. *Service / capability planning*

Description: Similar to Type 1 (product planning), but more suited to service-based enterprises, focusing on how technology supports organisational capabilities.
Example: A Post Office roadmap / T-Plan[7] application (Brown, 2001), used to investigate the impact of technology developments on the business. This roadmap focuses on organisational capabilities as the bridge between technology and the business, rather than products.



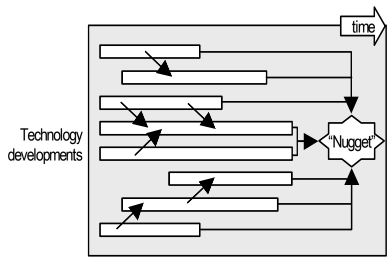
3. *Strategic planning*

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.



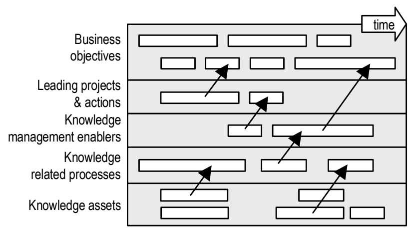
4. *Long-range planning*

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[8] (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').



5. *Knowledge asset planning*

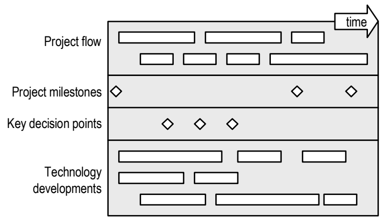
Description: Aligning knowledge assets and *knowledge* management initiatives with business objectives.
Example: This form of roadmap has been developed by the Artificial Intelligence Applications Unit at the University of Edinburgh (Macintosh et al., 1998), enabling organisations to visualise their critical knowledge assets, and the linkages to the skills, technologies and competences required to meet future market demands.



[7] Several of the example roadmaps have been developed during applications of the T-Plan 'fast-start' roadmapping process

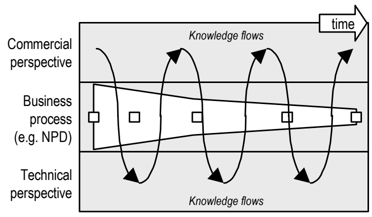
[8] IMTR (1999), Integrated manufacturing technology roadmapping (IMTR) project - information systems for the manufacturing enterprise, http://imti21.org/

6. *Programme planning*



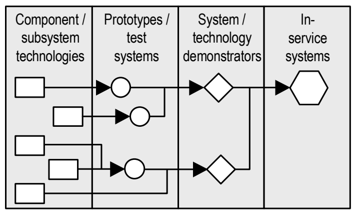
Description: Implementation of strategy, and more directly relates to project planning (for example, R&D programmes).
Example: A NASA roadmap (one of many) for the Origins programme[9] , used to explore how the universe and life within it has developed. This particular roadmap focuses on the management 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

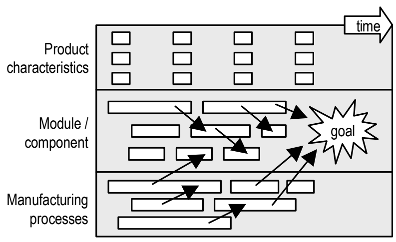


Description: Integration and/or evolution of technology, in terms of how different technologies combine within products and systems, or to form new technologies (often without showing the time dimension explicitly).
Example: A NASA roadmap7 (Origins programme - see #6), relating to the management of the development programme for the NGST, focusing on 'technology flow', showing how technology feeds into test and demonstration systems, to support scientific missions.

Technology roadmapping approaches – 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

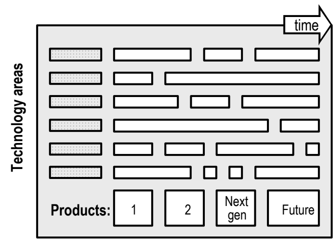


Description: The most common format of technology roadmap comprises a number of layers, such as technology, product and market. The roadmap allows the evolution within each layer to be explored, together with the inter-layer dependencies, facilitating the integration of technology into products, services 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.

[9] NASA (1997), Origins technology roadmap, http://origins.jpl.nasa.gov/library/techroadmap/roadmapidx.htm

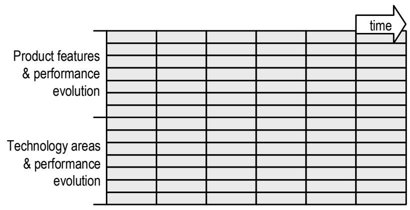
b. Bars

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).



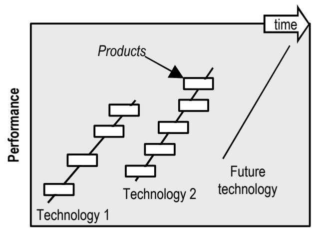
c. Tables

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.



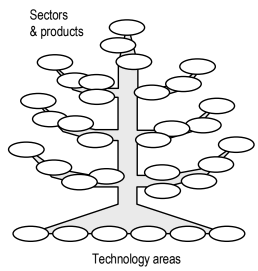
d. *Graphs*

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[10] , relating to the development of products and product families, based on a set of liquid crystal display technologies.

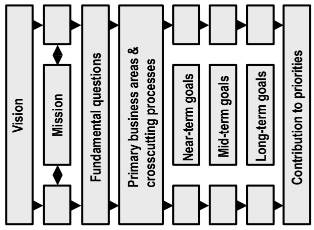


[10] ITRI (1995), Electronic Manufacturing and Packaging in Japan, JTEC Panel Report, http://itri.loyola.edu/ep/

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[11], showing how the organisation'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.



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 it's 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[12] .

Figure 5:

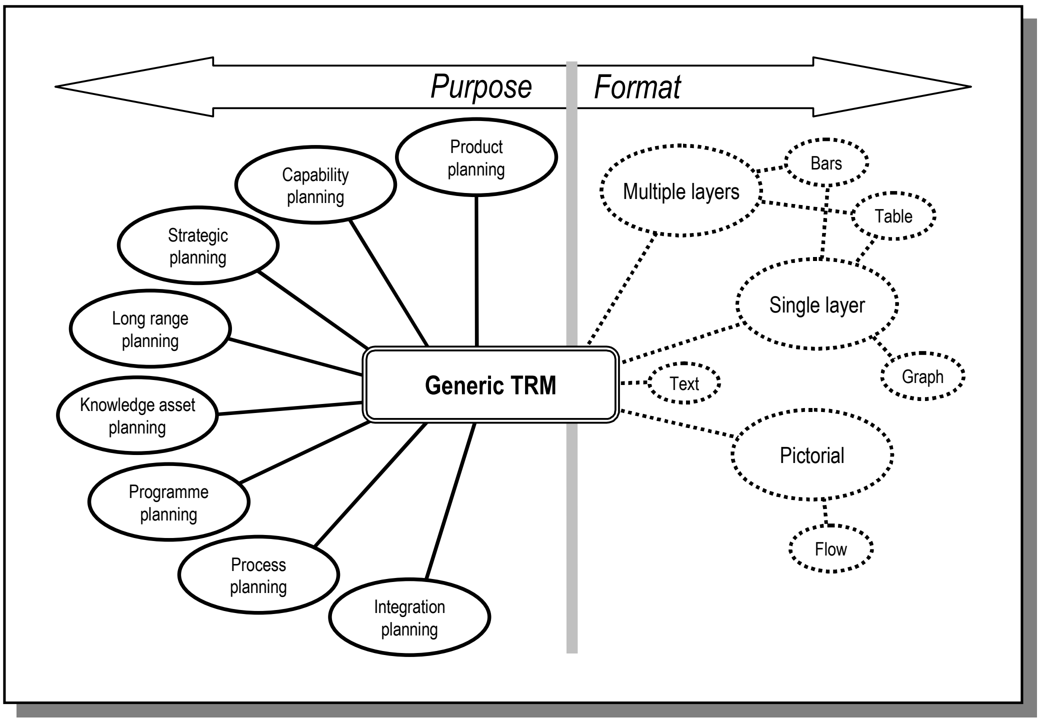


Fig. 5 - Characterisation of roadmaps: purpose and format

[11] NASA (1998), Technology plan - roadmap, http://technologyplan.nasa.gov/

[12] 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 (see Table 1). 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.

The T-Plan process that has been developed to support the rapid initiation of roadmapping in the business comprises two main parts:

a. Standard approach, for supporting product planning (Phaal et al., 2000).
b. Customised approach, which includes guidance on the broader application of the method, incorporating many of the techniques included in the standard approach.

Table 1 - 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 & planning

Sector / product	Focus / aims
Power transmission	Business opportunities for new technology
Railway infrastructure (3 applications)	Capital investment planning and technology insertion
National security infrastructure	Research program 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
Emerging technologies	Research priorities
Automotive	Innovation opportunities
Retail (2 applications)	Business strategy and product planning
Off road vehicles	Global production strategy

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 – see Fig. 6.

Figure 6:

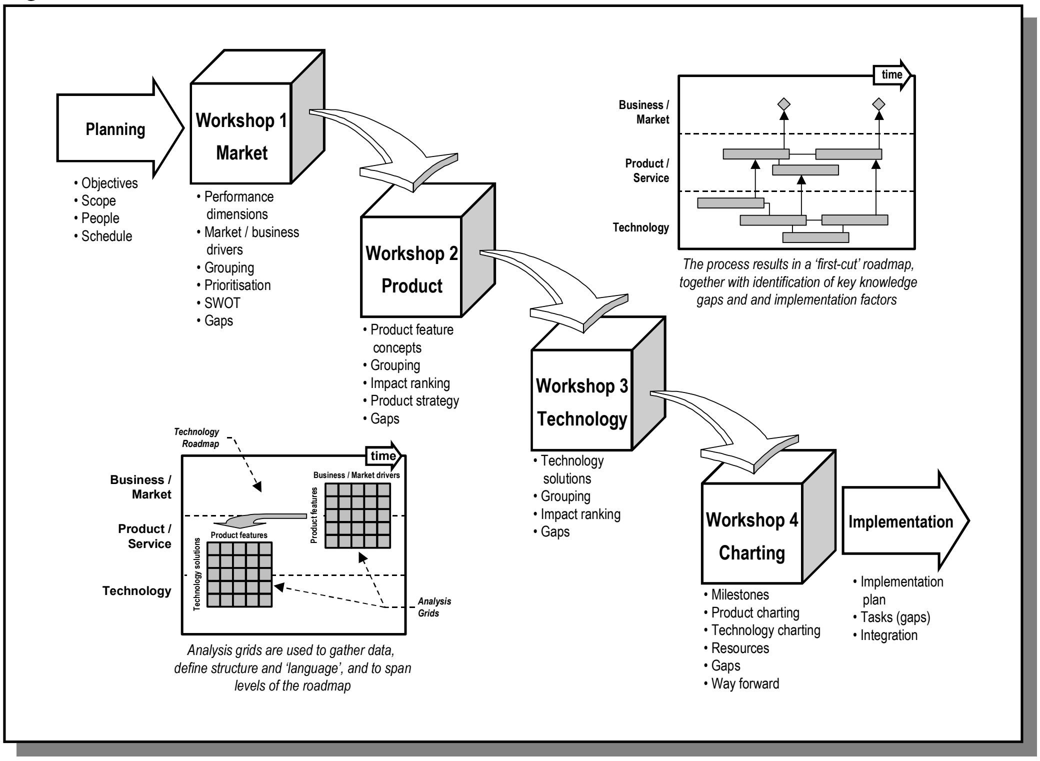


Fig. 6 - T-Plan: standard process steps, showing linked analysis grids

Also important are the parallel management activities, including planning and facilitation of workshops, process co-ordination, 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.

Customising the process

Technology roadmapping is an inherently flexible technique, in terms of:

- ❑ The wide range of aims that roadmapping can contribute towards.
- ❑ The timeframe 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 generalised roadmap shown if Fig. 7, 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.

Figure 7:

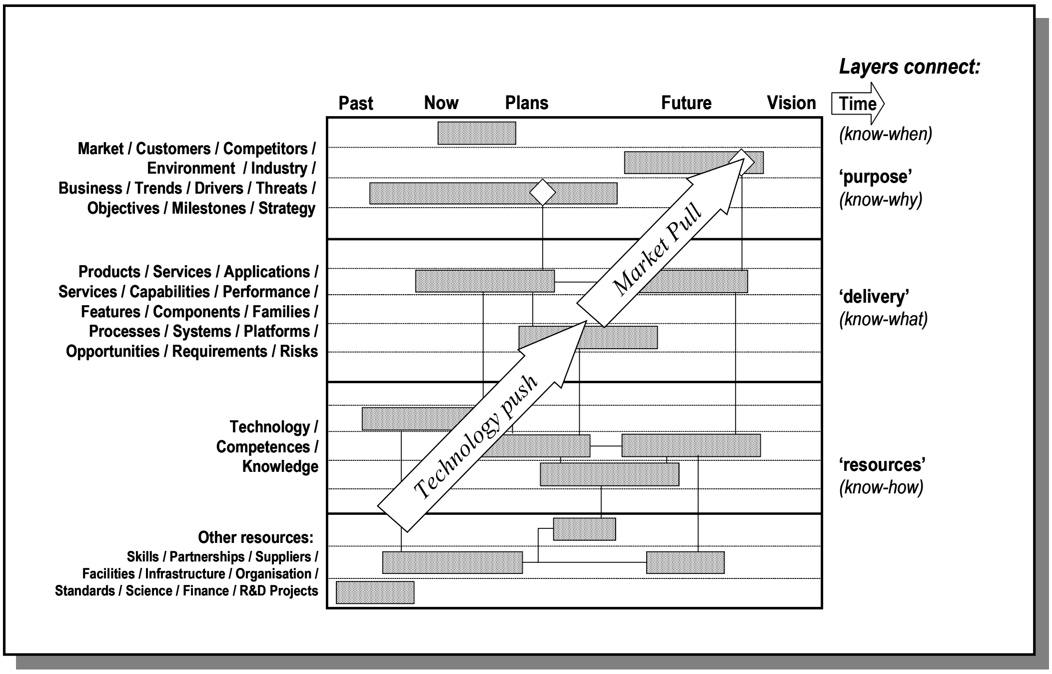


Fig. 7 - Generalised technology roadmap architecture

Customisation 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:
  - S*cope*: 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.
  - *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:
  - *Timeframe*: 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 that 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 to best take the process forward within the organisation.

While some organisations 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 organisation (Fig. 8). Key issues include deciding where the boundaries of the roadmapping process should lie, to 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 organisation, it may be desired to facilitate the adoption of the method in other parts of the organisation. 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 8:

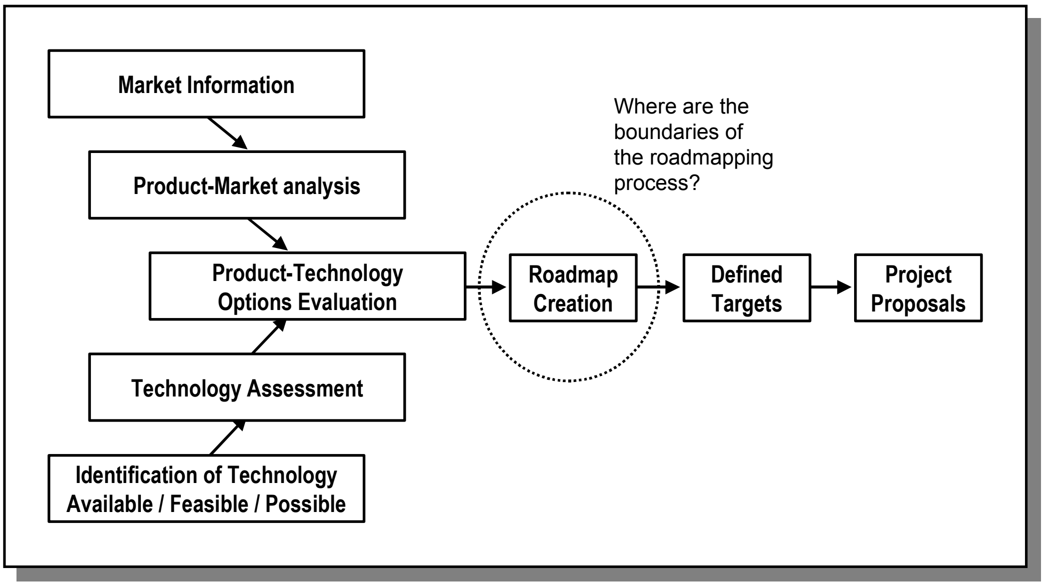


Fig. 8 – Roadmaps integrate commercial *and technological knowledge (EIRMA, 1997)*

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[13] . 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 customisable 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

[13] The authors are aware of two dedicated technology roadmapping software systems: Geneva Vision Strategist developed by The Learning Trust (an enterprise solution used by Motorola and other large organisations): 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

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[14] 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 organisations and sponsoring collaborative research worth more than £80million.

A technology roadmapping initiative was undertaken in 2001-2 (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 organisations. The technology roadmap architecture is shown in Fig. 9, and the roadmapping process is illustrated in Fig. 10.

A systems approach was adopted (see Fig. 11), recognising that the road vehicle forms part of a much larger system, which needs to account for the social, economic and 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 (see Fig. 8).

Figure 9:

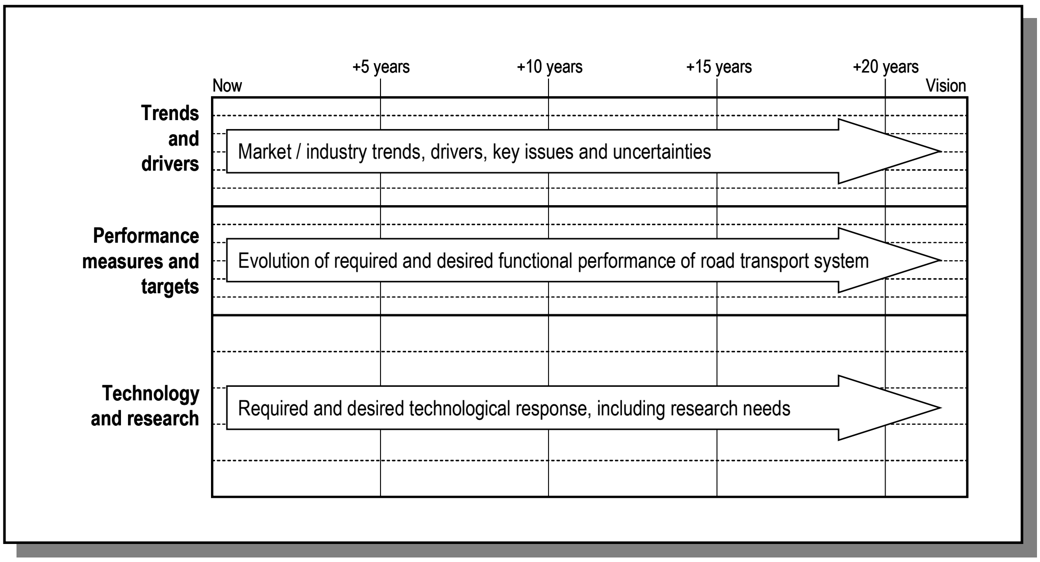


Fig. 9 – Foresight Vehicle technology roadmap architecture

[14] http://www.foresightvehicle.org.uk/

Figure 10:

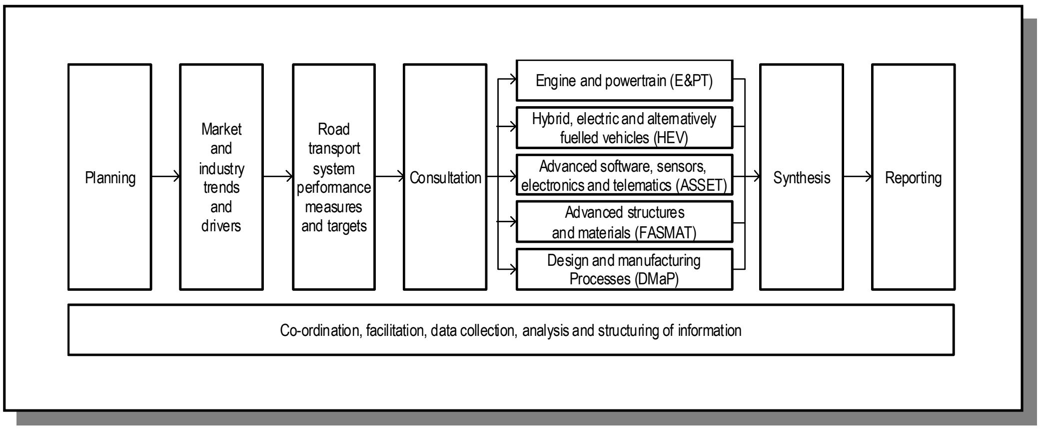


Fig. 10 – Foresight Vehicle technology roadmap process

Figure 11:

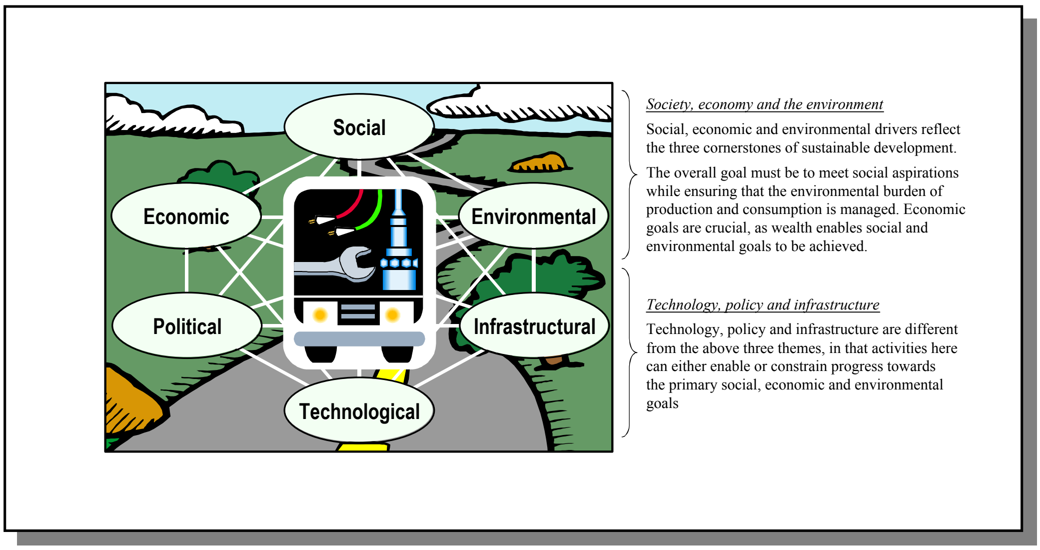


Fig. 11 – Foresight Vehicle systems view

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 as to minimise 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 term this a technology ‘landscape’ rather than a ‘roadmap’. The approach adopted is illustrated in Fig. 12 and 13, 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 12:

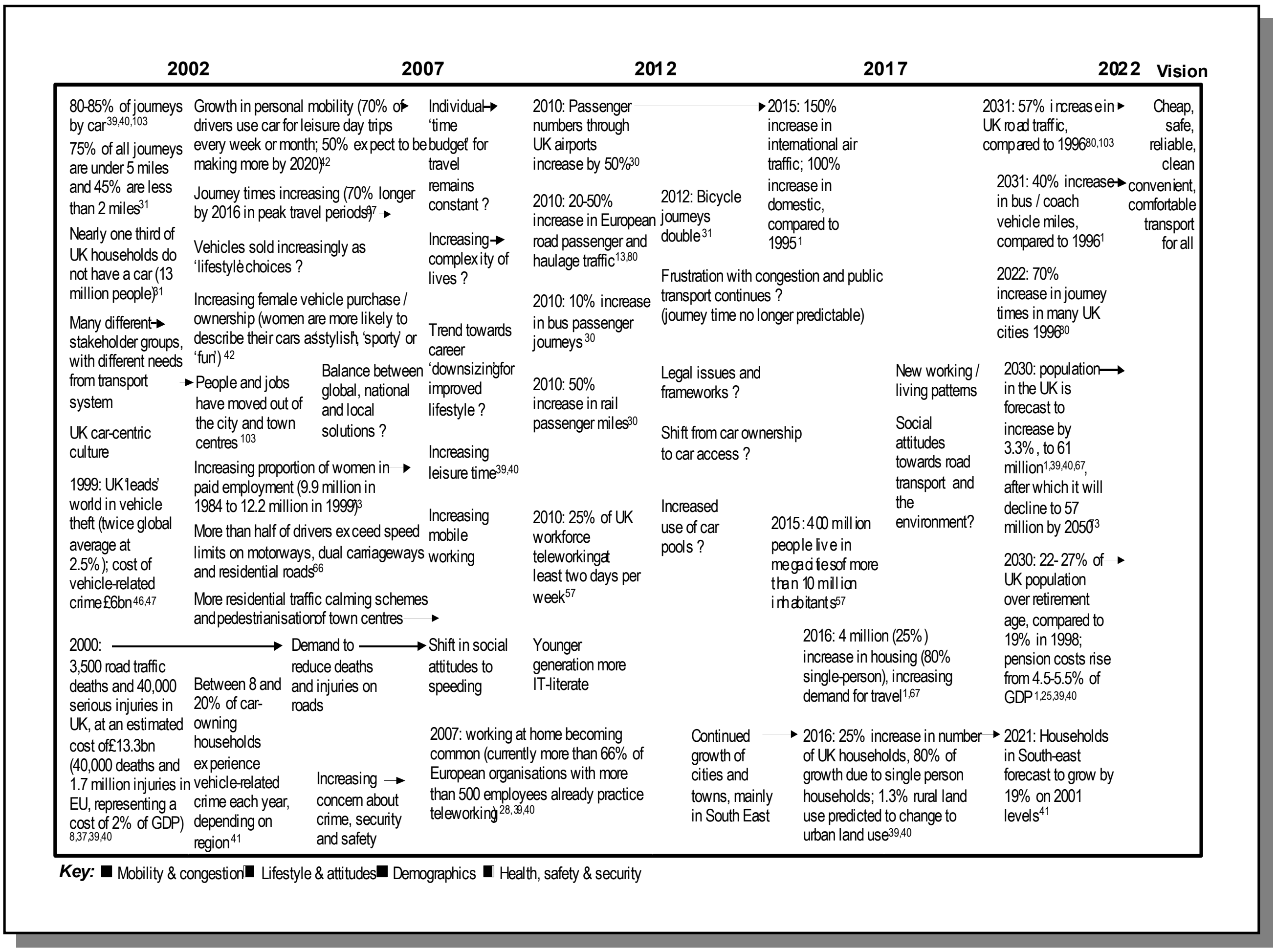


Fig. 12 – Social trends and drivers 'rich picture' roadmap

Figure 13:

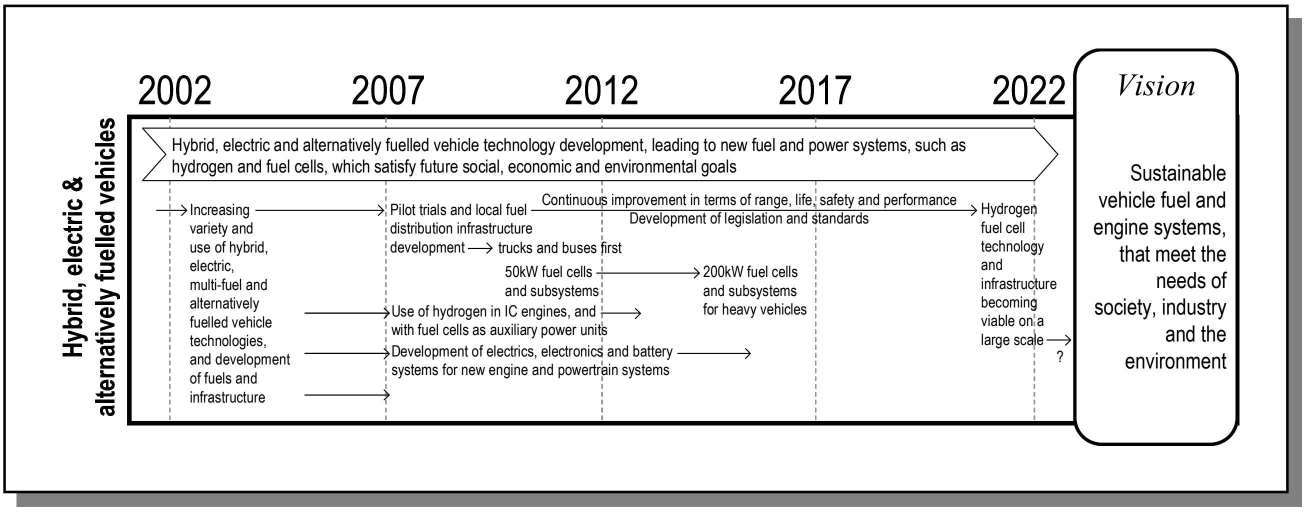


Fig. 13 – Summary graphical roadmap for hybrid, electric and alternatively fuelled vehicle technology

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 recognised 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 synthesised 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 organisation. 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 synchronised 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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