Institute for Prospective Technological Studies

joint research centre
EUROPEAN COMMISSION

Strategic Policy Intelligence: Current Trends, the State of Play and Perspectives

- S&T Intelligence for Policy-Making Processes -

edited by:

Alexander Tübke (JRC-IPTS)
Ken Ducatel (JRC-IPTS)
James P. Gavigan (JRC-IPTS)
Pietro Moncada-Paternò-Castello (JRC-IPTS)

with chapter contributions from:

Ruud Smits (Utrecht University)
Axel Zweck (VDI-FTD)
Michael Rader (ITAS)
Rémi Barré (Futuribles)
Ahti Salo (HUT)

December 2001

EUR 20137 EN

EUROPEAN COMMISSION
JOINT RESEARCH CENTRE

European Science and Technology Observatory

IPTS Technical Report Series, EUR 20137 EN

"Strategic Policy Intelligence: Current Trends, the State of Play and Perspectives
- S&T Intelligence for Policy-Making Processes"

Editors: Alexander Tübke, Ken Ducatel, James P. Gavigan, and Pietro Moncada-Paternò-Castello (all JRC-IPTS)

Authors: Ruud Smits (UU), Axel Zweck (VDI-FTD), Michael Rader (ITAS), Remi Barré (Futuribles), and Ahti Salo (HUT)

Seville, Spain, 2001
Published by:
EUROPEAN COMMISSION
Joint Research Centre
Institute for Prospective Technological Studies (IPTS)
Edificio Expo-WTC
C/ Inca Garcilaso, s/n
E-41092 Sevilla, España (Spain)
http:\\www.jrc.es

Printed in Spain

Table of Contents

Foreword

There are many reasons why we need better forward-looking intelligence to support policy decisions. These primarily stem from the interaction between important applications of science and technology and their wider implications for the economy, society and environment. Science and technology have very complex forms of interaction with the economy and society. Effects are often not immediate or direct, but are of second or third order, or occur after a substantial delay. At the same time, science and technology is advancing at a very high pace. Policy-makers do not have the luxury of waiting until situations are clarified and until the effects are evident before they take decisions. Tomorrow's scientific and technological development originates in the conditions established today. Therefore, it is not surprising that there is a demand for "Strategic Intelligence" to support policy-makers in understanding the relevant aspects and scope of the impacts of science and technology and their possible future developments.

The area of forward-looking Strategic Intelligence has a history spanning several decades. However, its various branches have grown-up separately in a heterogeneous way. Although this differentiation is a source of strength, it can also be regarded as obstacle. No integrated view of the different branches exists nor connections between them. Even at the level of methods, the linkage between practitioners could be reinforced, particularly between separate national scenes and across the private-public divide. Not only are the questions posed to Forecast, Assessment and Foresight exercises often overlapping, but there are also similarities in the techniques used and the perceived informative content. The result is sometimes a loss of synergy between policy researchers that are addressing rather similar issues.

That is why the European Science and Technology Observatory network (ESTO) launched a set of studies to monitor the state of the art in three areas:

Technology Forecasting, Technology Assessment and Technology Foresight. The results are presented in a synthetic form. For each area there is a substantial background paper available that provides the complete version of each study.

This report on Strategic Policy Intelligence shows the knowledge and learning value of the three approaches, their contributions to the decision-process, and how they may be combined. It thus intends to illustrate how decision-makers can benefit from the diversity of techniques instead of regarding each technique in an isolated fashion. In this spirit, the present report provides a stimulus for developing an integrated set of instruments for Strategic Policy Intelligence.

Seville, December 2001

Abstract

This report provides an overview of the current trends of Strategic Policy Intelligence and its current and future potentials in contributing to the policy-making process.

Three methods of Strategic Policy Intelligence are examined: Technology Forecasting, Assessment and Foresight. Technology Forecasting analyses conditions and potentials of technological development within a concrete framework. Technology Assessment supports decision-making by generating technology or problem-specific options arising from new developments. Technology Foresight addresses the impacts of technological development on a broader scale.

The individual methods already have a tradition in supporting policy-related decision-making, but the growing knowledge-intensity, the pace of technological and structural change and the increasingly distributed and networked character of the economy produce the need for new modes of governance and policy-processes. These conditions increase the complexities and uncertainties of policy-making, shorten the lead-time for preparation, and lead to a higher necessity for prospective methods like those incorporated in Strategic Policy Intelligence.

Recent developments in Technology Forecasting, Assessment and Foresight have lead to the point where their contributions to policymaking become the more evident and straightforward the more they are regarded in a less isolated fashion, but applied within the comprehensive perspective of Strategic Policy Intelligence. Still, the need to combine these methods and disciplines, improve the user interface, and better link the organisations active in this area, is underlined.

At present, the European Union faces a wide range of challenges, such as the integration of new Member States, the implementation of the European Research Area, the search for new modes of governance and improving the economic impacts of S&T. This report shows that, in its current state of development, the concept of Strategic Intelligence offers not only methodological strength to address these issues, but also enough degrees of flexibility to link to other forms of interaction, to adapt to new governance models and be open to the rapid and unforeseen technological changes and societal developments.

Executive Summary

Author: **Alexander Tübke** (JRC-IPTS)

The objective of this report is to provide an overview of the current trends and developments in Strategic Policy Intelligence, based on the three background-papers of the ESTO-network[1] and two additional chapters[2]. This overview is targeted to policy-makers and examines the contributions of Strategic Policy Intelligence and ways in which this concept can be strengthened for the benefit of policymaking in the knowledge-based economy.

Strategic Intelligence can be defined as 'the set of actions to search, process, diffuse and protect information in order to make it available to the right person at the right time in order to make a right decision[3]'. In this report, we focus our attention on forms of Strategic Intelligence that are prospective or forward-looking and targeted on policy decisions, with special reference to Technology Forecasting, Technology Assessment and Technology Foresight.

With this in mind, these forms of Strategic Intelligence are understood in the following way:

- Technology Forecasting consists of a continuous monitoring of technological developments and their conditions, leading to an early identification of promising future applications and an assessment of their potential. It is considered as a three-step process (identification - validation - information transfer and implementation) that assists decision-makers in a concrete

[1] ESTO is the JRC-IPTS' "European Science and Technology Observatory", a group of national research centres and other S&T organisations in Europe (see http://esto.jrc.es/).

[2] The three background papers were produced in a project of the ESTO-network led by the authors of the respective chapter. Together with the two overview papers, they were presented in a workshop in May 2001 (see http://esto.jrc.es/). The present report and the background papers on Technology Forecasting, Assessment and Foresight are avaible at http://www.jrc.es/pages/f-project.html.

[3] Derived from Rouach (1996), p.7 and Commmisariat Général du Plan (1994)

technological framework. It takes broad technological developments and socio-economic aspects into account, but does not analyse them in detail.

- The results of Technology Assessment support decision-making on technology through the analysis of social, economic and environmental potentials of new scientific and technological developments. This includes their impacts and framework conditions. It is often based on a previous Technology Monitoring exercise. With the help of Technology Assessment, options for better exploiting opportunities arising from new technologies are developed. Technology Assessment either focuses on a specific technology (technology-driven) or on societal problems arising from the application of a technology (problem-driven).
- Technology Foresight is based on a much broader concept than the other two. It implies a wide range of themes and stakeholders in order to examine the social, economic and environmental aspects of new technologies. The process is highly interactive, open and has a bottom-up spirit in order to identify breakthroughs and explore hypotheses that support strategy-formulation. Technology Foresight is frequently used to support policy-related decision-making at the national or supra-national level.

With the ever-growing knowledge-intensity in the economy, science and technology-induced innovation will be decisive for meeting the Lisbon process target of making the European Union "the most competitive and dynamic knowledge-based economy in the world by 2010"[4]. The Lisbon process points to a direct need for robust intelligence on innovation patterns. New forms of knowledge and their application in products and services, together with powerful knowledge technologies, increase the importance of knowledge management. Previously unknown tools and data that can contribute to intelligence are emerging. In addition, the rising demand for

[4] See European Commission (2001) (COM (2001) 79 final)

greater transparency and participation in public decisions about science and technology creates new patterns of decision-making about S&T. First, there is no central locus of innovation anymore. Innovation occurs in networks and alliances rather than in an individual firm or R&D lab. This distributed nature of innovation creates a much more complex and volatile picture than the traditional view of a successful invention. Second, most policy relevant science and technology applications affect wider society. This in turn drives the search for styles of anticipatory analysis that are able to take account of the shared nature of innovation, in which risks and decisions are negotiated between different stakeholders in society. This is exemplified by the increased profile of Science and Governance issues in recent years, and the demand for higher levels of participation and transparency in setting science and technology agendas[5]. It also finds its expression in a reinforced public attitude that policy-makers be able to explain and justify their decisions at almost any time. Taken together, these trends increase the complexity and uncertainties about the impact of science and technology in society even more and raise the stakes for decision-makers. They make the policy-maker's task of establishing systemic policies much harder.

As background to the innovation-based knowledge-economy, the speed of technological development and its role for the society and the economy leave less time for political decision-making. This is the more true in rapidly advancing fields and with respect to technological breakthroughs and "unpredictable" developments. Strategic Policy Intelligence includes tools that support the anticipation of breakthroughs, assigning it a kind of "early-warning" function.

Strategic Policy Intelligence offers a variety of methodologies to meet the demands of policy-making. This variety is a strength of the concept,

[5] For EU-activities on Science and Governance see: http://www.jrc.es/sci-gov

creating flexibility and promoting independence. Technology Forecasting, for example, tends to be specific to a concrete technological framework, and thus tends to be performed by small, independent and specialised units of larger organisations. It is frequently used in the private sector, maybe even more than in the public one. Technology Assessment is usually related to a certain technology or a problem arising from the application of technology. It has a long tradition in supporting policy-makers, especially at the parliamentary level. Also, Technology Assessment exercises are frequently undertaken in formal institutional settings at the national and regional level, in specific technological fields (e.g. healthcare) and at universities. In some cases, there is a public requirement for Technology Assessment ahead of political decisions. Technology Foresight exercises, meanwhile, are initiated by regional or national level bodies or even undertaken at the European level[6]. They are generally organised as specific initiatives, bringing together an ad-hoc arrangement of stakeholders rather than addressing existing decision patterns. This variety of modalities of action is important because it avoids the institutionalisation of Strategic Policy Intelligence input to the policy system due to its independence from single stakeholders and political interests.

Beyond the need for variety of institutional setting, there are nevertheless common trends concerning the implementation of Strategic Policy Intelligence in each of its areas. First, all techniques have shifted away from any pretence that the future can be reliably 'predicted' on the medium to long term. This is more clearly seen in the case of Technology Forecasting. It is no longer the quantitative prediction of key-characteristics of a certain technology through extrapolation of technology trends, but provides the factors that govern how technologies develop within a certain field and

[6] Through a combination of expert panels and the analysis of national Foresight studies, the IPTS Futures project examined the individual and combined effects of the drivers that shape Europe by 2010 (see: http://futures.jrc.es/).

proposes recommendations and implementation measures. Second, each area now explicitly addresses the fact that the development of technologies is defined not just by immutable laws of science and engineering, but by the context of application, i.e. how different groups conceptualise and understand the opportunities and risks of a new technology. Third, perhaps the most significant change is that each Strategic Policy Intelligence area has become more proactive in respect of the development path of new technologies. For example, Technology Forecasting now positions itself more towards supporting the process of technology transfer through facilitating dialogue between suppliers and potential users of technology. Technology Assessment has developed towards identifying social and political choices concerned with technological developments, going beyond its former role of addressing potential negative impacts of specific technologies. It is now a combination of the classic Technology Monitoring with a prospective assessment methodology. Technology Foresight meanwhile has established itself as a process accompanying policy-makers mainly at the national and supra-national level.

These three trends have lead to the present point where the contributions of Technology Forecasting, Assessment and Foresight to decision-making become the more evident and straightforward the more they are no longer regarded in an isolated fashion, but applied within the comprehensive perspective of Strategic Policy Intelligence. The tasks, fields of application, kind of political issue addressed, and the results of the methods of Strategic Intelligence are shown in table 1.

Table 1: Comprehensive perspective of Strategic Intelligence and its possible contribution to political decision-making

Method	Task	Fields of application	Kind of political issues addressed	Results
Technology Forecasting	• Based on monitoring developments and taking into account broader aspects, analysis of the conditions and potentials of new technological applications	• Concrete technological framework, • Frequently used in the private sector	• Conditions and consequences of technology development in general, • Identification of breakthroughs and early-warning function in a specific techno-logical framework	• Support of the political decision-making process adequate to the reality of the knowledge-based economy, including the identification of breakthroughs and early-warning function • Preparation of integrated S&T policies based on more robust knowledge • Access to intelligence on a wide range of themes, which reduces the lead-time of policy preparation • Avoiding errors from not considering the complexity of the underlying development and possible side-effects of a decision
Technology Assessment	• Support decision-making by generating options arising from new technologies	• Technology or problem specific, • Long tradition in advising national parliaments	• Potentials of specific techno-logies or techno-logical issues related to certain problems, sometimes linked to a concrete public requirement	
Technology Foresight	• Address a wide range of themes in order to examine the broad social, economic and environmental aspects of new technologies	• Support national or supra-national policy-making	• Broader impact of technological development, identification of cross-cutting issues, • Identification of breakthroughs and early-warning function in a broader context	

Note: The dotted lines show that the tasks, fields of application and kind of political issues addressed sometimes overlap. The vertical arrows in the results column represent the synergies arising from the comprehensive perspective of the results of Forecasting, Assessment and Foresight.

Source: Author's own compilation

The full potential of Strategic Policy Intelligence will not be captured until a number of methodological and scientific aspects are addressed. Thus, while variety is important, isolated discussions on the definitions of Technology Assessment, Forecasting and Foresight seem rather counter-productive. First, the synergies between these three methodologies should be exploited and the

"methodological fit" explored. There is a real need for the methodologies Technology Assessment, Forecasting and Foresight to be subject to more rigorous testing and evaluation in order to better meet the objectives of the decision-maker and not impose unnecessary methodological restrictions. Improving the methodologies of Strategic Policy Intelligence would mean that its methodologies should themselves be the focus of monitoring and comparison. Also the subject of quality assurance and an improved interface for the user need to be regarded in this respect. Second, increased empirical efforts need to be taken, especially in order to better understand decision-making processes in the knowledge-based economy, analyse the interaction between innovation processes and institutional structures, and link the findings to Strategic Policy Intelligence. This is important because much of the Strategic Policy Intelligence work undertaken targets policy areas, but has an unclear relation to policy decisions.

With these aspects in mind, an important step for the future is that Strategic Policy Intelligence should be better linked, leading to the establishment of a distributed network across Europe. This would enable a timely generation of information from independent and heterogeneous sources and allow covering a wide range of themes and demands. It might also build a more adequate link towards meeting the requirements of decision-making in the knowledge-based economy. In the new role of Strategic Policy Intelligence, an important function of the distributed network would be the control of quality, the evaluation of its members, and the monitoring and improvement of the methodology. Another challenge that a distributed network could address is the implication of the private sector in generating Strategic Policy Intelligence, which applies especially in the case of Technology Forecasting. A distributed network would not only stimulate scientific and methodological progress in this area, but also lead to a sharper, more rigorous, profile of Strategic Policy Intelligence.

However, new concepts like that of Strategic Intelligence also require some learning from their users. A clear mandate, combined with a certain degree

of independence from single stakeholders is necessary to make it work. The results of Strategic Policy Intelligence are not to be taken as predictions, and users must be aware of not creating self-fulfilling prophecies. Strategic Policy Intelligence thus needs to be embedded into a wider decision-making and scenario-building process. It cannot be evaluated by the degree to which its results are true or not, but rather by its contribution to an informed, qualified and legitimate policy-debate.

In total, Strategic Policy Intelligence is an instrument that contributes to addressing the challenges of decision-making in the knowledge-based economy. It can provide special support to policy-making, but only on the prerequisite of an adequate degree of policy-awareness. At present, the European Union faces a wide range of challenges, such as the integration of new Member States, the implementation of the European Research Area, the search for new modes of governance and improving the economic impacts of S&T. This report shows that, in its current state of development, the concept of Strategic Intelligence offers not only methodological strength to address these issues, but also enough degrees of flexibility to link to other forms of interaction, to adapt to new governance models and be open to the rapid and unforeseen technological changes and societal developments.

I. The New Role of Strategic Intelligence

Author: **Ruud Smits** (Utrecht University[7])

1. Introduction

This chapter analyses the drivers behind the growing need for Strategic Intelligence and its implications for prospective policy analysis. In this context, Strategic Intelligence is understood as tailor-made information to support decision-makers in developing and implementing their strategies, policies and interventions. Its value-added stems from its overarching conceptual structure that comprises sub-specialisations like Technology Assessment, Technology Forecasting or Technology Foresight.

In the first part of the chapter, we examine a variety of reasons why the various forms of Strategic Intelligence are becoming more important and demanded by policy actors. To analyse these drivers, stock of three major developments in the context of innovation processes is taken: structural changes in our economy, the broadening of decision-making processes, and the emergence of the network society and changes in the knowledge infrastructure.

These demands raise a number of important questions and challenges for the players and managers involved in innovation processes, from which topics for a research agenda for Strategic Intelligence are derived. These topics are examined in the second part of the chapter, illustrated by the example of the transformation of Technology Assessment in recent years.

This chapter concludes with some suggestions for the improvement of Strategic Intelligence, especially through the recognition that no single group in the

[7] Utrecht University, Department of Innovation Studies and Copernicus Institute of Innovation and Sustainable Development, Bestuursgebouw 001, P.O. Box 80125, 3508 TC Utrecht, The Netherlands, e-mail: r.smits@geog.uu.nl

policy process has the full power to determine outcomes because all actors in the policy system hold fragments of knowledge and authority. Building on this important insight, the final section stresses the importance of an open approach to different sources of analytical inputs to Strategic Intelligence in order to build synergies. It also points to the importance of guaranteeing the quality of Strategic Intelligence contributions. Finally, it emphasises the crucial element of users' participation in Strategic Intelligence exercises.

2. Why is Strategic Intelligence important now?

The starting point of this chapter is to recognise that science and technology is the work of man, and that we ourselves determine to a large extent how it is given shape and form in our society. In doing so, we can note that there is a great deal to learn from the past, and that 'to make science and technology work', or to innovate, is not easy. A number of problematic cases that may illustrate this point are set out in Box 1 below.

Box 1: Why innovation is not easy

- *Complex ethical debates on nanotechnology*
- *Nuclear energy, which fails to meets its promises and leads to major problems*
- *Societal objections to genetically engineered food, cloning and genetic screening*
- *Computers that do not really help to raise the quality of education*
- *DDT, a substance that fails to free the world of famine, but results in a major environmental problem*
- *The many unsuccessful attempts to introduce road pricing*
- *The small and medium-sized enterprises that continue to find it difficult to transform knowledge into successful products and services*
- *The high number of promising new High-tech firms in the fields of life sciences and new media that are still unsuccessful*

Source: Author's own compilation

Taking a closer look at these examples, two more observations can be made. First, innovations sometimes look successful on the short run, but appear far from that in the longer term. Often, this is because of unrealistic expectations about the future development of technologies and the lack of understanding of indirect impacts. A second observation is that scientific or technological problems are the main barriers in only few cases. Innovation generally involves ethical, social, managerial, organisational and institutional problems. This is also evident from the early nineteen-eighties when, in response to the economic recession and for the promotion of innovation, the OECD nations substantially increased their investment in research. While this led to a major growth in scientific and technological knowledge, it failed to produce a higher number of innovations, let alone the expected increase in productivity. This phenomenon has become known as the 'Solow Paradox', the 'Productivity Puzzle', or the 'European Disease'[8]: Europe is proficient in the production of excellent scientific knowledge, but weak in transforming inventions into successful products, services and solutions for societal problems[9]. The solution to this problem has been the main theme of innovation policy for nearly two decades in most OECD countries. Although a certain amount of progress has been achieved, it is obviously a very persistent problem, raising the question of how Strategic Intelligence can make a better contribution towards the support of public and private players involved in innovation processes.

Against this persistently high level of ignorance about how really to succeed in innovation, the general increase in the rates of S&T development (or attempts at innovation) can be set. Various factors drive this disparity, but the growth of the knowledge-intensity in the economy may be the most prominent one. Over the last twenty years, exports of knowledge-intensive products and services from the United States and Japan have

[8] See OECD (1992)

[9] See Eurostat (1999)

[10] See Eurostat (1999)

increased by more than five times[10], reducing the export share of non-knowledge-intensive products and services by half. With an export increase of knowledge-intensive products of 300%, the European Union lags behind these countries. Knowledge is of paramount importance for society in the broader sense, too. The role of information technology in education, of biotechnology for health care and food and the significance of new materials for clothing and consumer products and the high level of penetration of high-tech equipment into our homes are only a few examples[11]. At present, the objective of matching the production and use of knowledge is probably the core driving force behind Strategic Intelligence.

We can track the way that these changes affect the demand for Strategic Intelligence in at least three ways. First, knowledge-intensity is driving through structural changes in the economy that affect the 'traditional' agricultural and industrial sectors as well as knowledge services and the 'new economy'. Providing help in understanding these transformations is a primary obligation of Strategic Intelligence. Second, the growth of a knowledge economy increasingly shows how difficult it is to believe in a single locus of innovation anymore (such as the sole inventor or innovating firm). Rather, innovation is increasingly seen as operating in a network formation with many different interests being involved in the process of translating a 'piece of S&T' into a successful application. Recent trends in Strategic Intelligence recognise the 'social nature of innovation' and the importance of wider participation in converting S&T insights into practical use. Third, as the knowledge society permeates society as a whole, there is a fanning out of new opportunities (and cost) of S&T. Thus, there is increased emphasis on value for money and social return from investments in research. This again drives the demand for Strategic Intelligence.

[11] See van Dijk and de Haan (1998)

2.1. Structural changes in our economic system

The main sectors of our economic system are currently going through a period of structural transition; future innovation processes will differ from those in the past. This results in changes within one sector, shifts between sectors, mergers and the emergence of completely new sectors. Moreover, partly because of a growing knowledge-intensity, the boundaries between the agricultural, industrial and services sectors are becoming blurred. Even supposedly traditional sectors such as agriculture get more and more industrialised, whereas the industrial and the services sector become more and more intertwined. In the Netherlands, the traditionally knowledge-intensive agricultural sector is under pressure to respond to environmental problems caused by its past economic success. This leads to the obligation of putting structural changes into effect that are both better for the environment and improve the economic performance of this sector. The resulting process of "creative destruction[12]" is not painless, as the recent swine fever, BSE, foot-and-mouth disease and manure crises show.

In the 'old' agricultural sector, dominated by mass production, the request for new knowledge and technologies was homogeneous in character. However, the diversification of products in the 'new' agricultural sector will lead to the agricultural knowledge infrastructure not having a homogeneous group as a customer, and produce the obligation to anticipate the wishes and needs of highly different and heterogeneous customers. This development will have an enormous impact on the content, organisation and institutionalisation of the agricultural knowledge infrastructure, particularly on the interface between the users and the producers of knowledge.

Despite the greater integration of industry and services, innovation processes in industry are still fundamentally different from those in the services sector[13]. The understanding of these new innovation processes is improving, but it

[12] See Schumpeter (1980 (1934))

[13] See Hertog et al. (1998)

has not reached yet a level that allows a substantial contribution to be made towards the management of innovation processes[14]. Apart from the question of the major differences between innovation in services and in industry, the question of the role of knowledge intensive (business) services in innovation processes in all other sectors plays an ever more important part.

Meanwhile, private services sector and, to a lesser extent, non-commercial services continue to grow enormously. Science and technology-based innovations play a key role in this respect. These trends confront researchers with new questions and decision-makers with new challenges. For example, there are enormous changes implied by the emergence of the "cultural industry", which lives from excellence in producing innovations rather than inventions[15]. Again, the recent discussion on the existence or non-existence of the new economy raises the question if and how Information and Communication Technologies (ICTs) change the economic rules of the game.

Sustainability is another major issue in today's economy. Major questions here concern the relation between economic performance and sustainability and the role of ICTs (Information and Communication Technologies), life sciences, materials technology, and nanotechnology in the development of a more sustainable economic system.

In all of these cases there is an increased relevance of change in innovation and on the use of knowledge tools. Prospective Strategic Policy Intelligence is a leading element of this new rapidly moving scene.

[14] See Gallouj and Weinstein (1997)

[15] Note from the editors: In a general definition, innovations are inventions that have success in the market. The term "Cultural Industry" describes the idea of a Europe shifting from the production of ideas or inventions to the production of innovation. See also: EU-white paper "Growth, Competitive Strength, and Employment. Towards the 21st Century: Roads and Challenges", European Commission, Brussels, (1998)

2.2. Broadening of decision-making processes and the network society

The broadening of decision-making for innovation processes in terms of players and aspects has become manifest over the past few decades, and it is expected that this trend will continue in a more intense form in the future[16]. An increasing number of players wish to become involved in the progress of innovation processes, and this decision-making is starting to involve an increasing number of different aspects (see Box 2). This change in the 'strategy and management paradigm' is typical for a much wider development, known as the emergence of 'network-management'. Reliance on the old institutions continues to decrease. Not only is a constantly higher number of *Neue Kombinationen*[*] formed, but the boundaries between the institutions and organisations are also becoming less significant. The management of societal changes is increasingly taking place in complex networks, in which it is impossible to pinpoint a dominant player. In these networks, success and failure are strongly associated with the ability of all participating parties to form wise alliances and mobilise the creative potential of users. It has been observed that the number of strategic, technology-based alliances between firms is growing[17]. Numerous problems with 'dot com' firms, failing automation projects, or discussions on life sciences related products (food, drugs) demonstrate the dependence of innovation processes on the acceptance by users and the ability to mobilise and use the creative potential of users to improve the innovation process. Other laws apply in this 'network society' or 'knowledge economy' than in the hierarchical variant. More and more, the main goal becomes the optimisation of *chains* or *systems* of organisations, rather than a maximisation of the performance of components (e.g. companies).

[16] See Smits et al. (1995)

[*] Note from the editors: "Neue Kombinationen" = new combinations

[17] See Hagedoorn (1996)

In terms of performance, organisations, and also companies, are constantly made more dependent on the performance of other organisations (also their competitors) within the networks in which they are active. Encouraging effective alliances, bringing players with often totally different interests into a consensus, and acting as the intermediary are becoming increasingly more important tasks for administrators in both the public and the private domains.

Box 2: Changes in the 'strategy and management paradigm'

- *From 'weakly-linked systems with discrete components' to 'strongly-linked systems with fuzzy components'*
- *The end of 'top-down' management, the growth of (horizontal) 'network management',*
- *The optimisation of chains and systems, instead of the components thereof,*
- *The growing importance of the management of the interfaces between organisations and the networks within which they operate, the formation of strategic alliances, the ability to mobilise the creative potential of players, and the flexibility of institutional systems and arrangements that facilitate horizontal policy,*
- *The aim towards sustainability reinforces the network characteristics,*
- *ICT work as an amplifier and facilitator of the network characteristics.*

Source: Author's own compilation

ICT is a significant, but not the only factor in the transformation of the 'strategy and management paradigm'[18]. Thanks to ICT, information is becoming more rapidly accessible to a widening public. This leads to the breaking down of information monopolies, and the rapid and efficient exchange of information, which is a precondition for operating in networks, becomes easier. The call for a more sustainable society makes this network even stronger. Flexibility and the ability to eliminate (institutional) barriers

[18] See Castells (1996)

and to stimulate initiatives that promote interaction between organisations and the networks within which they operate thus become crucial characteristics of the players involved in innovation processes. This flexibility is sometimes difficult to detect in today's structures. One of the main reasons lies in the fact that subjects where innovation processes play a major role, for example sustainability, the emergence of the cultural industry and the information society, are often to be found in the blurry area of responsibilities shared by different ministries. It seems that the policy area is unable to muster up the flexibility needed to form institutional structures, which would allow pursuing horizontal and more flexible policies. This inflexibility creates a huge problem for innovation management.

All the trends outlined in the foregoing have contributed towards a broadening of decision-making on innovation, which produces the following challenges:

(1) Innovation is becoming *more reflexive:* Insight into the nature of innovation processes is increasing, thanks to innovation studies and through learning by doing and learning by using among policy-makers, innovation managers and other parties concerned. This highlights the considerable importance of the co-evolution of innovation processes and their context.

(2) *New kinds of innovation processes are emerging:* Whereas today's innovation studies focus mainly on agricultural and industrial innovation processes, new kinds of innovation processes stand out because of the greater role of tacit knowledge (innovation in services), other kinds of markets, the greater importance of ethical aspects (biotechnology) or because of their network characteristics (ICTs).

(3) *The context of innovation is changing:* In a nutshell, it can be stated that (parts of) our society are developing from 'a system with weakly linked discrete components' to 'a system with strongly linked fuzzy components'.

The context is also increasingly characterised by a multilevel structure. Internationalisation and regionalisation lead to the emergence of a very difficult position resulting in, particularly on the national level, roles, responsibilities and relationships that need to be redefined.

These trends reveal that the future of Strategic Intelligence will hinge on the process of broadening out decision-making relating to innovation. The following issues come up onto the research agenda:

(a) In the knowledge society, innovating in chains, networks and systems is becoming the rule rather than the exception. This provides firms with many new questions at strategic, conceptual and operational levels, for example: How to handle intellectual property rights? How to strike the balance between competition and co-operation? What are the implications for the 'corporate culture' of the far more porous character of the firm? Therefore, systems thinking becomes increasingly important in innovation studies nowadays. The actor network approach, innovation systems thinking, the cluster approach and other recent developments in transition management may assist these developments[19].

(b) Growing attention is paid to the role of (knowledge) intermediaries in innovation, for instance knowledge intensive business services. Their influence, role, contributions, and their linking role between the firm level and the (innovation) systems in which these firms function need to be understood.

(c) Users have an increasingly important role in innovation processes. This raises the question of how to organise the interface with users in such a way that innovation processes benefit from the creative potential of possi-

[19] See also: Actor network approach (Law and Hassards (1998)), Innovation Systems (Edquist (1997), Freeman (1987), Barré et al. (1997)), the clusters approach (OECD (1999)), and other recent developments in transition management (Rotmans et al. (2000), Smits et al (2001)).

ble users. Consumers and user-producer relations receive more and more attention in innovation studies. Constructive Technology Assessment and interactive/participatory Technology Assessment also put the interaction between users and producers at the forefront[20]. Until now, however, these approaches have all too often played a marginal role.

Broadening decision-making on innovation not only poses new questions for researchers but also for policy-makers. The network character and the growing importance of users demand a new roles and concepts for governments and other players involved in innovation processes. During the last two decades, innovation policies of most OECD governments have shifted from supply-oriented (production of knowledge), via diffusion-oriented, towards far more user/demand-oriented policies. Without doubt, this trend will continue and produce the need for concepts, methods, techniques and instruments that enable players to fulfil their new roles.

With its ability to capture many of the new issues arising from the distributed nature of innovation and the increased importance of intermediaries and end-users, Strategic Policy Intelligence sits at the interface of these trends.

2.3. Major changes in the knowledge infrastructure

The evolution of science and technology is constantly rising. Although nations are very much aware of the significance of science and technology for their economic status, the amount of money they are willing to spend on them is inevitably limited. More than in the past, this compels nations and businesses to be selective at which knowledge development they wish to invest in. Such choices imply commitment: Choosing ‘x’ implies that cuts will need to be

[20] See also: Innovation studies (Akrich (1992), den Hertog (1996), Fonk (1994)), constructive Technology Assessment (Schot (1992), Smits and Leyten (1991)) and interactive/participatory Technology Assessment (Grin et al. (1997)).

made in 'y'. Together with the increasing social and economic importance of knowledge, research organisations are being asked to prove their specific contribution to solving economic and societal problems.

Scientists are gradually losing the exclusive right to be the producers of scientific and technological knowledge; the sharp division between the *production* and the *application* of knowledge is blurring. The emergence of knowledge-intensive services (engineering firms, software houses, and knowledge-intensive consultants) plays an important role in this respect. This trend is brought under the heading of 'the social distribution of knowledge production', describing a revolutionary change from mode 1 to mode 2 science, of which culture, content and organisation of the knowledge infrastructure are a part[21]. Table 2 below sets out the main differences between mode 1 and mode 2 science.

Table 2: Main differences between mode 1 and 2 science

MODE 1 SCIENCE	**MODE 2 SCIENCE**
Academic context	*Application-oriented*
Disciplinary	*Trans-disciplinary*
Homogeneous	*Heterogeneous*
Hierarchic and stable	*Heterarchic and variable*
Academic quality control	*Quality measured on a wider set of criteria*
Accountability to science	*Accountability to society as well*

Source: Author's own compilation

This creates a dilemma for universities and public research organisations[22]. Universities have to face the demand for a problem-orientated multidisciplinary approach, while at the same time they are under a great deal of (scientific)

[21] See Gibbons et al. (1994)

[22] See Smits (1997)

pressure to score in the mono disciplines. Public research organisations are on the one hand driven onto the market in order to demonstrate that they produce 'practicable knowledge', and on the other hand they are clipped around the ears and accused of 'unfair' competition.

Making 'mode 2 work' calls for deeper insights that contribute towards a knowledge infrastructure that will maintain a healthy balance between the curiosity-driven and problem-driven approaches to S&T (Science and Technology). Major questions and challenges in this context are:

(a) The 'mode 1-mode 2' debate attracted a lot of attention, but few consequences in terms of missions, new institutional designs and relations have been drawn. For instance, the strategic position of the 'traditional' knowledge infrastructure vis-à-vis the knowledge intensive intermediaries has up to now been neglected[23].

(b) 'Mode 2' raises many questions, which until now have hardly been addressed. Examples are the role of multi- and inter-disciplinary research in highly mono-disciplinary oriented research systems, quality control with non-scientific criteria, and the status of scientists in a society in which their exclusive right to the production of scientific knowledge is challenged.

In this new context of knowledge infrastructure, choices are much more important and receive increased attention. Strategic Policy Intelligence provides in important support to the process of selecting the right decision, and its structured inputs mediate the between the supply and demand of S&T-related information (e.g. agendas of S&T scientists vs. scenarios of societal needs vs. indicators for budgeting allocations).

[23] See den Hertog et al (1998)

3. Elements of a research agenda

Elements of the agenda for Strategic Intelligence research that may be useful for decision-makers in innovation processes are identified here. Attention is drawn to increased empirical efforts, the critical review of theory relating to understanding innovation and prospective analysis, and improvements in the application of Strategic Intelligence to decision-making.

3.1. Empirical studies of innovation processes and innovation systems

As a first step, it is important to get a better understanding of what is going on in the field of S&T innovation. Empirical description of successes and failures in innovation is fundamental in order to understand better the way that S&T is translated into innovations. It is particularly useful to undertake rich case studies of specific innovation trajectories, close analyses of the context in which innovation processes occur, and the provision of insight into the dynamics of innovation processes and the way they interact.

Particular examples can be related to some of the key topical issues and trends. For example, it is important to conduct case studies that deal with innovation processes in the area of the emerging technologies, such as life sciences. At sectoral level, better understanding of innovation in the fast growth economic areas, especially the services sector, is needed. Areas of complex cross-interaction are also important such as the contribution of ICT in building a more sustainable society. Historic and international comparative research into the development of innovation systems, as well as studies of the role of (knowledge intensive) intermediaries in the course of innovation processes, are examples of case studies at system level. Furthermore, studies that focus on changes in research systems in general and at sectoral level (agriculture, ICT, services sector) must also be mentioned here.

Together, these case studies could serve as the basis for the development of various types of indicators to better understand and monitor the input, throughput and output of innovation processes and systems. This in turn will produce a sounder analytical (empirical) base for prospective inputs to policy.

3.2. Critical reflection on innovation theories

As a second step, we need a better understanding why S&T innovation happens the way it does, and this is a complex issue. Innovation processes take place at various levels, like specific products, firms, sectors and regional, national and international communities. For example, a technological artefact such as the petrol engine is embedded in more complex technological systems like the motor car. In turn, the motor car is a component of the techno-social system of roads, petrol stations, mobility-behaviour and transportation policy.

Innovations are also not always a causal result of inventions. Innovation processes can be better perceived as interactive processes in which there is a large extent of co-evolution of scientific, technological and societal systems. Innovation processes are thus increasingly perceived as a seamless web[24] and or related to 'technology culture'[25].

These points are core insights in the emerging discipline of innovation studies. Some innovation researchers focus on the contribution of the individual players to the success of the innovation process[26], while the *innovation systems* approach sees the structure of the system as the main

[24] See Hughes (1987)

[25] See Schwarz and Thompson (1990)

[26] See Bijker et al. (1987); Dosi et al. (1988) and Nelson and Winter (1977)

factor determining the success of an innovation[27]. These two approaches are potentially complementary but not yet adequately interrelated. The co-evolution of institutional structures and innovation (and learning) processes has not been explained yet. This is a major deficiency given that the interaction between processes and systems drives change in innovation systems[28]. Developments are still often described as a competition between mutually relatively independent organisations and/or technologies[29], despite the increased emphasis on network structures in innovation.

As long as the technological development is not well embedded into innovation theory, substantial progress for the better understanding of innovation processes in relation to their surrounding systems cannot find sufficient explanation.

3.3. Strategic Intelligence in support of decision-making processes

Thirdly, insight alone is not enough, it is also important that we look at the consequences of empirical results and theories for the practical application of Strategic Intelligence in policy-making. This relates to aspects of both *content* and *process*[30].

The aspect of *content* addresses the nature of the strategic information required by the players involved in innovation processes (see table 3).

[27] Freeman analyses the strength of the UK during the first industrial revolution as an example of the importance of these relationships. His proposition is that the success of the UK in this period should not primarily be attributed to the strength of the system components (politics, economy, science and technology, culture), but rather to the efficient way in which these subsystems were coordinated (Barré et al. (1997)).

[28] Some emerging approaches, such as actor network theory, transition management, constructive and participatory Technology Assessment and cluster studies, focus on the development and transition of innovation systems as well as on the relation between innovation processes and the systems in which they develop. See also: Actor network theory (Callon (1987)), transition management (Rotmans et al. (2000)), constructive and participatory technology assessment (Schot (1992) and Grin et al. (1997)) and cluster studies (Jacobs (1998)).

[29] See Arthur (1988)

[30] See Smits (1994)

Strategic Intelligence provides insight into the potential of new technologies for the economy and society, its appreciation by several different parties, the consequences that result from realising these potentials. In addition, it provides more room for interaction for those involved.

Strategic Intelligence not only focuses on the technical side of innovation processes. It also meets the need for a better understanding of the decision-making processes in innovation systems. Research that looks at both aspects is relatively scarce and needs to be encouraged. In this respect, the lessons learnt from Technology Foresight[31] and Technology Assessment[32] can be used.

Table 3: Characteristics of Strategic Intelligence

Content	Process
• Tailor-made • Hard- and softside • Distributed character: ▸ Scale effects ▸ Facilitating learning ▸ Mix between specific and generic ▸ enlarging accessibility	• Articulation of demand • Mobilising creativity • Elucidating "tacit knowledge" • Assessment of the technological potential • Facilitating processes • Optimal link with decision-making

Source: Author´s own compilation

Technology Assessment and Foresight have undergone a radical evolution over the past few years. They have evolved from a predictive character into research that now takes the co-evolution of innovation systems and innovation processes as the point of departure. They then provide information from a perspective that supports those involved in drawing up scenarios for potential future developments.

[31] See Martin (1995)

[32] See also: Impact of the conditions for innovations (Smits et al. (1995), Smits and Leyten (1991) and from evaluation studies of research programmes and innovation processes (OECD (1997)).

In this way, this kind of research helps players to anticipate and shape the course of innovation processes and the evolution of innovation systems.

This process is illustrated by the way that Technology Assessment has developed since the 1970s[33]. At the beginning, Technology Assessment was concerned with the potential negative or undesired social and economic outcome of technological development. From this perspective, Technology Assessment took place outside the process of formulating technology policy and technological strategies. Its major functions were 'early warning', evaluation, and some sort of 'counter-intelligence'[34]. In the new concept, which emerged in the late 1970s, scientific analysis of technological developments and their impacts had to take a step backwards in a number of ways:

- Expectations of the potentials of scientific Technology Assessment research are considerably less ambitious. The all-embracing Technology Assessment of the early years has been replaced by consecutive partial studies in which knowledge gained in one study is passed on to the next.
- Technology Assessment was extended to the participation of actors from outside the scientific community. Their participation extends from outset, when deciding on the subject for study, until completion, when the results are ready.
- Greater attention is given to dialogue between Technology Assessment researchers and the users of the results. Policy-makers and other

[33] See also Chapter III on Technology Assessment

[34] See also: Boroush, M.; Chen, K. and Christakis, A.: "Technology Assessment: Creative Futures: Perspectives from and beyond the Second International Congress", Elsevier North Holland, New York, 1980; Paschen, H.; Petermann, T.; Schevitz, J. and Smits, R.: "Review of TA-institutionalisation on selected OECD-countries", paper presented at the OECD-conference on technology assessment, Vienna, June 1989; Smits, R. and Leyten, A.: "Key issues in the institutionalisation of technology assessment", in: Futures, February 1988

potential users are often intensively involved in the formulation of the problems, frequently participate as suppliers of information, and are involved in determining the organisation of the research process.

- Technology Assessment as it is now has a much more interactive nature than its previous forms. Technology Assessment has to be seen as a process of studies and discussions, which runs parallel to and has close links with decision-making processes. Its main goal is to support the different actors involved in development, production, supply and usage of new technologies in formulating their strategy with regard to the new technologies. In this sense it is much more and advisory type of activity than a scientific research activity

Box 3 below presents an example of how Technology Assessment is integrated into the technology policy-making processes.

Box 3: The new form of Technology Assessment

The new Technology Assessment concept helps to better link technology policy and Technology Assessment, forming the notion of comprehensive technology policy[35]. The basic assumption of this user-oriented technology policy is that it is necessary to close the gap between socio-institutional and techno-economic developments and strategies. The general framework for developing such a comprehensive technology policy can be seen as a revolving process:

- A number of existing socio-institutional and economic conditions and goals form the basis for formulating strategies with regard to the development and implementation of new technologies.
- The technological strategies lead to certain (expected) impacts on the socio-institutional and economic environment, largely based on how users and other parties concerned interact with the new technologies.
- The potential or expected impacts of technological strategies may lead to changes in the socio-institutional and economic conditions for implementing the technological strategies or to changes in the technological strategies themselves.

Within this framework, Technology Assessment can provide the following contributions:

- Generate knowledge and stimulate awareness about the social, economic and material choices in relation to technological developments, in which special attention is directed to the position and interests of users to improve demand articulation;
- Stimulate the debate on the direction of technological developments in relation to social-institutional questions;
- Support the development of technological as well as socio-institutional innovative strategies, which guide the process of finding useful and desirable applications.

Source: Author's compilation from: Smits, R., Leyten, A. and den Hertog, P.: "Technology assessment and technology policy in Europe: new concepts, new goals, new infrastructures", Policy Sciences, 28, 1995

[35] The concept of 'comprehensive technology policy' is up to a certain degree interchangeable with concepts used today like integral-, user oriented- or demand oriented innovation policy.

Through this shift from relying on the analytical power of (scientific) Strategic Intelligence methods towards interactivity and participation of key stakeholders, the way has been opened for Strategic Intelligence to contribute to the 'tuning' of the techno-economic and socio-institutional subsystems. Strategic Intelligence processes can be seen as institutional agents of change that continuously try to bridge the gap between technology producers and users.

Strategic Intelligence is still useful in making choices more visible or more explicit in an early stage of technological developments, but it perhaps has its greatest impact by stimulating the interaction between those supplying and those using technologies. In essence, the traditional reactive early warning Technology Assessment concept had much in common with a 'watch dog', whereas in the new Technology Assessment concept is closer to a 'tracker dog'.

It is not easy to divide Strategic Intelligence into a 'content-part' and a 'process-part'. Given its networking character the tacit form of intelligence needed, content and process usually are closely intertwined. In terms of process, support relates to the consequences of the emergence of the network society for the set of instruments used by policy-makers and other parties involved in the innovation process.

The knowledge society places high demands on the managers of the interfaces between organisations and the surrounding networks, the formation of strategic alliances, the ability to mobilise and use the creative potential of the players concerned, the flexibility of institutions and systems, and the institutional arrangements that facilitate horizontal policies and collaboration.

There is a great need for policy concepts and the instruments that promote flexibility and make a direct contribution towards the reinforcement of networks. Rules (and legislation) regarding competition and collaboration in networks need to be developed, which would effectively integrate the

public knowledge infrastructure integrated into innovation systems[36]. The fact that the concept of cluster policy currently receives special attention from policy-makers is a good initial step in this direction, but many more steps will have to follow[37].

An important component of this set of instruments consists of instruments that help to eliminate many barriers between the players in innovation networks[38]. A number of new developments have been underway in this field over the past few decades. Strategic workshops, scenario workshops, electronic boardroom systems, and gaming and consensus development conferences are selected examples. While such instruments offer potentially major opportunities, a deeper study into their functionality and conditions for use is called for.

4. What Next? Steps to Improve Strategic Intelligence

The systemic character of innovation processes and the tendency towards 'fuzzy' systems underline the need for improving the management of interfaces in innovation systems at various levels and between various arenas. As argued before, Strategic Intelligence plays a crucial role in this. In the last section of this chapter some suggestions for improving the *quality* of Strategic Intelligence and the surrounding *infrastructure* are presented.

Suggestion 1: Stop the debate on definitions and exploit synergy between the various strands of Strategic Intelligence

For many years, fruitless discussions on definitions within sub-domains, e.g. Technology Assessment, and between sub-domains, e.g. Technology Assessment, Foresight and Forecasting, have been the focus of scientific

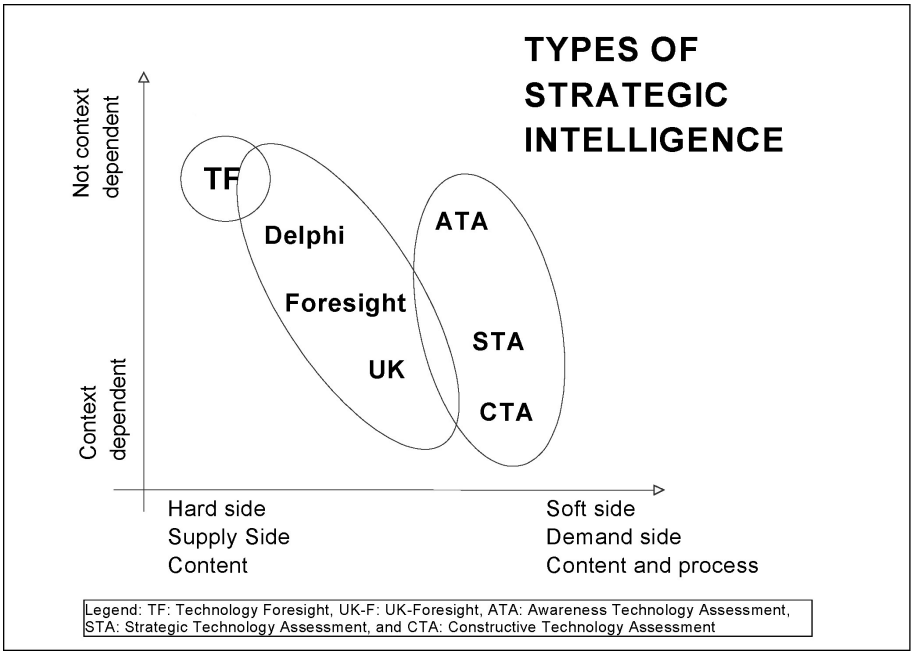
[36] See van Dijk (1995)

[37] See Netherlands Ministry of Economic Affairs (1999)

[38] In this context, Geurts (1993) speaks about gaps between administrators and citizens, experts and laymen, producers and users of knowledge, different scientific disciplines, policy and science.

activity in Strategic Intelligence. As remarked above, these debates did not add much value. It is already quite clear what the various strands of SI represent and how they relate to each other (see Figure 1).

Figure 1: Types of Strategic Intelligence



Source: Author's own compilation

A second major flaw of the scientific field is the lack of co-operation between the various strands of Strategic Intelligence[39]. This observation is highly remarkable, because the sub-domains overlap, frequently use the same research techniques and methodologies, and the scholars meet regularly on

[39] See also: Kuhlmann, S.; Boekholt, P.; Georghiou, L.; Guy, K.; Héraud, J.-A.; Laredo. P.; Lemola, T.; Loveridge, D.; Luukkonen, T.; Polt, W.; Rip, A.; Sanz-Menendez, L. and Smits, R.: "Improving Distributed Intelligence in Complex Innovation Systems", Office for Official Publications of the European Communities, Brussels/Luxembourg, 1999.

conferences and workshops dealing with innovation policy. In other words, a lot of possibilities for exploiting synergy are available but hardly exploited[40].

Suggestion 2: Improve the quality and reinforce existing sources of Strategic Intelligence

The sources of Strategic Intelligence are often rather sub-critical and their quality could be improved[41]:

- A large number of organisations and institutions are performing Strategic Intelligence, but the number of official Technology Assessment or Technology Foresight organisations is limited, the landscape in most countries is changing slowly.
- Most of the organisations involved have an insufficient size and find it hard to broaden their scope of users.
- The impact on governmental and industrial policy-making is limited. Links with national and European technology policy are scarce.
- There is a lack of a strong political basis and a well-defined political mandate.
- There is no clear image of Strategic Intelligence and a considerable part of the work in the area is not recognised as such.
- There is a lack of transparency and an absence of international learning processes.
- The various initiatives at the EU-level operate without mutual awareness of co-ordination.

[40] In the ASTPP project (Advanced Science and Technology Policy Planning network), the results of which are reported in Kuhlmann et al (1999), this problem is analysed further and recommendations for improvement are made. The development of a so-called infrastructure for distributed Strategic Intelligence is the focus of these recommendations and addressed later on.

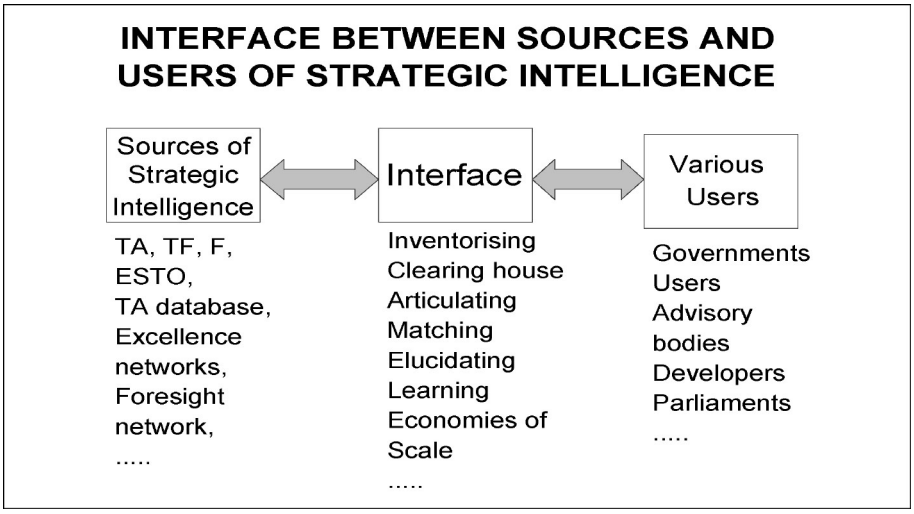
[41] See Smits et al. (1995)

One way to overcome these problems would be organising the various institutions and organisations in a network of distributed Strategic Intelligence[42], which is proposed in the next section.

Suggestion 3: Develop an interface between the sources of Strategic Intelligence and users

Over the last three decades, the sources of Strategic Intelligence as well as the types of users have increased steadily. These developments emphasise the growing need for and variety of Strategic Intelligence to support actors in the development, implementation and evaluation of their interventions in innovation processes. The quality of Strategic Intelligence and the tuning of the activities of the various sources to each other are far from optimal. In addition to this there often is a mismatch between users and producers and more than once users have difficulty to find the required intelligence in time (see also Figure 2).

Figure 2: Interface between sources and users of Strategic Intelligence



Source: Author's own compilation

[42] See Kuhlmann et al. (1999)

The development of tools that enhance the input of Strategic Intelligence into policy-making and providing access to and exploitation of Strategic Intelligence in different locations would improve its impact[43]. Initiating and exploiting these intelligence tools in a systematic way across innovation systems demands new architectures, institutions, configurations and inter-linkages.

If we manage to develop and implement a new Strategic Intelligence infrastructure, research and innovation policies could become more realistic, efficient, relevant, and democratic. Four *basic principles for effective Strategic Intelligence* can be extracted[44]:

(1) *Principle of participation:* Foresight, evaluation or Technology Assessment exercises take care of the diversity of perspectives of actors in order not to maintain one unequivocal 'truth' about a given innovation policy theme.

(2) *Principle of objectivisation:* Strategic Intelligence supports more 'objective' formulation of diverging perceptions by offering appropriate indicators, analyses and information processing mechanisms.

(3) *Principle of mediation and alignment:* Strategic Intelligence facilitates mutual learning about the perspectives of different actors and their backgrounds, which supports the finding of consensus.

(4) *Principle of decision support:* Strategic Intelligence processes facilitate political decisions and support their successful subsequent implementation.

There is no single 'correct' or 'best' configuration of tools, procedures, institutions and structures for all contexts and situations. So far, the focus has been on national level policy configurations, but we can see that regions, supranational

[43] See also: Kuhlmann, S.: "Management of innovation systems; the role of distributed intelligence", in: "Nijmegen lectures on innovation management", Ben Dankbaar 9th edition, Nijmegen School of Management, Nijmegen University, Nijmegen,.2001

[44] op.cit.

organisations and 'thematic' organisations are becoming more important as policy arenas. Moreover, there is a growing need for new configurations that link private and public actors and promote their interaction. By private actors we do not limit to companies, but also representatives of many stakeholders (professional associations, consumer organisations, environmental organisations, etc.).

The application of Strategic Intelligence can be further improved if information is gathered simultaneously from independent and heterogeneous sources. Therefore, a *second route* to improved Strategic Intelligence leads us to the concept of *distributed intelligence*. This concept starts from the observation that policy-makers and other actors involved in innovation processes can only use a small share of the Strategic Intelligence of potential relevance and cannot access to all the necessary tools and resources. Nevertheless, the whole range of tools and information exists within a wide variety of institutions and at many organisational levels, scattered across the globe. In *distributed intelligence*, a decentralised architecture of information sources is established, spanning across innovation systems and related policy arenas and working as brokering nodes which guide and enable the supply of Strategic Intelligence. Five *general requirements* of such infrastructures can be outlined:

(1) *Network requirement*: Distributed intelligence will not be designed as a top-down system, but rather the opposite. The ideal design allows for multiple vertical and horizontal links across the existing sources of Strategic Intelligence.

(2) *Active node requirement*: Three types of active nodes can be distinguished:

   (a) The first type provides enabling facilities, e.g. a 'Foresight database'.

   (b) The second type delivers a 'directory' allowing direct connections between the relevant actors.

   (c) A third type offers a 'register' allowing free access to all Strategic

Intelligence exercises undertaken under public auspices, hence facilitating collective learning processes.

(3) *Transparent access requirement*: Clear rules concerning the access to the infrastructure of distributed intelligence are needed.

(4) *Public support requirement*: Distributed intelligence infrastructure is in need of a regular and reliable support by public funding sources.

(5) *Quality assurance requirement*: Three major lines of quality assurance can be followed:

(a) Professional associations; expert journals; university teaching;

(b) Accreditation mechanisms for providers of Strategic Intelligence, based on a self-organising 'scene' of experts;

(c) A reliable support with repeated and 'fresh' Strategic Intelligence exercises and new combinations of actors, levels and methods initiated by innovation policy-makers across arenas and innovation systems.

5. Conclusions

In this chapter, the challenges that decision-makers face with the upcoming knowledge society have been analysed. The starting point for this analysis are the structural changes in the economy, changes in the 'strategy and management paradigm', and changes in the knowledge infrastructure.

Departing from these questions and challenges, taking stock of the state of the art and recent developments in innovation studies, research questions relevant for actors involved in innovation were formulated. Box 4 presents the shifts in the context of innovation processes that will lead to a radical transformation of innovation systems, in which (knowledge intensive) intermediaries and the quality of the interface between users and producers play a highly important role. It becomes clear that Strategic Intelligence is an important resource to improve the quality of this interface.

Box 4: Elements of a research agenda from the perspective of the decision-maker

(a) Empirical research into innovation processes and systems:

- Improving insight into the nature of innovation in services,
- Improving insight into the nature of innovation in the life sciences,
- Research into the relationship between ICT and sustainability, and
- Development of (intangible) throughput and output indicators of innovation processes.

(b) Reflection on innovation theories:

- Better understanding of the dynamics of innovation in chains and clusters,
- Improving insight into the role of (knowledge intensive) intermediaries in innovation processes,
- Improving insight into the interaction between innovation processes and systems,
- Contributing towards the endogenisation of innovation in other disciplines, and
- Improving insight into the transition of innovation systems.

(c) Analysis and support of decision-making processes:

- Improving insight into the potential, assessment and implementation of new technologies (Technology Assessment, Foresight, Forecasting, evaluation, cluster studies), and
- Developing methods and techniques to support players in innovation processes and networks (scenarios, group support systems, gaming).
- Development of an infrastructure for distributed Strategic Intelligence

Source: Author's own compilation

This agenda is an attempt to link policy needs to Strategic Intelligence in a more effective way and thus to provide support for more effective innovation processes. Innovation is the work of man, but making science and technology work is by no means easy. With the support of this agenda, innovation researchers can help policy-makers, managers and other actors involved in improving their performance in trying to make science and technology function in such a way that it serves their and society's goals better.

II. Synthesis of Technology Forecasting

Author: **Axel Zweck** (VDI-FTD[45])

1. Introduction and Definition

This chapter describes the findings of the longer-term monitoring project on Technology Forecasting. As understood in this project, Technology Forecasting is the continuous monitoring of technological developments leading to an early identification of promising future applications and an assessment/validation of their potentials. Technology Forecasting focuses on particular technology fields and aims to identify areas of large potential. Chances for new products following scientific discoveries are of central importance as well as the conditions of emergence, development and diffusion of technological innovations.

In practice, it can be regarded as a process that consists in some form or another of one or all of the following three steps:

Step 1 - Identification: New, often interdisciplinary, as well as established scientific or technological fields that offer the promise of new applications and exciting technological developments are identified through continuous screening.
Step 2 - Validation: It then includes a validation of the time scales upon which these promises may be realised and lead to marketable products; whether these products in turn contribute to the solution of pressing social or economic needs and therefore would satisfy an appreciable demand. The validation is based on a clear and understandable set of criteria. The sources of information used include, but are not limited to, the study of publications and patents, interviews and discussions with

[45] VDI The Association of Engineers, Future Technologies Division of VDI Technology Center, Graf-Recke-Straße 84, 40239 Düsseldorf, Germany, e-mail: zweck@vdi.de

experts, formal inquiries and questionnaires, analysis of the programmes of scientific workshops and meetings, participation in selected events, analysis of relevant databases, and the organisation of hearings and workshops.

Step 3 - Information Transfer and Implementation: These two steps emerge into a detailed analysis, which includes a set of specific recommendations on implementation measures. The results of the analysis are then communicated to policy-makers, selected business representatives and scientists in the fields involved as well as the general public. Based on the recommendations a first round of implementation projects is initiated.

Although these three steps may sometimes occur closely intertwined, they cannot always be clearly separated or are sometimes carried out only partially. Thus, the presence of any one of these is indicative of a technology forecasting activity.

The term 'Technology Forecasting' is not perfectly self-evident and might be misleading. Here it is exclusively used in the sense described above. As pointed out by Coates (1999), Technology Forecasting is now distinguished from the term 'technological forecasting' that is also widely used in the literature on the subject. Technological forecasting emphasises in general the quantitative prediction of a parameter that measures the performance of a given technology. An approach that is exemplified by Martino (1983), where a technological forecast is defined as "a prediction of future characteristics of useful machines, procedures, or techniques" and where the characteristics of the technology are understood in terms of "functional capability" considered to be a "quantitative measure"[*].

[*] Note from the editors: In literature, two different types of Forecasting are distinguished. In contrast to the three-step process used here there is a type of forecasting that deals with the quantitative prediction of key-characteristics. In this chapter, Technology Forecasting is regarded in the sense of the first term and not in the second one.

According to Bright (1978) it is not feasible to forecast a technology in this sense before it has reached the stage of an "operating prototype", whereas the main focus of public support of technology development in general lies on the earlier stages. Step 1 may be adequately described by the term 'Technology Monitoring' as used by Porter (1991), where it is introduced as one method of Technology Forecasting amongst others. The scope of this form of Technology Monitoring on the other side clearly falls short of a full three-step Technology Forecasting process as it is understood here. It is thus recognised that the term 'Technology Forecasting' is probably not the best choice for what has been defined above. Since it has been the working term throughout the project and up to now no better term has been agreed upon it is nevertheless used throughout this chapter, but with the specific meaning given here.

While socio-economic aspects are important in the validation of an identified technology field (step 2), the investigation of socio-economic questions as such is not the primary focus of technology forecasting. Future-oriented activities that centre on socio-economic trends and rather broad technological developments are considered as Foresight[**] activities, which have not been included in this chapter.

Technology Forecasting is a tool to assist decision-makers confronted with concrete problems in a technological framework. It is used not only in the public, but maybe even more in the private sector[46]. Technology Forecasting needs a mandate from the client fixing the validation criteria in order to start the work. One advantage of Technology Forecasting is that it has the potential to break-up a fixed mind set, especially if interactive and interdisciplinary methods are employed. Another advantage is that Technology Forecasting serves as a communication platform.

[**] For Foresight activities see also chapter IV.

[46] See EIRMA (2000)

Technology Forecasting has also the potential to be a strategic instrument at the European level. Through bilateral and multilateral co-operation among Technology Forecasting institutions it is possible to generate synergies, reduce the amount of duplicated work effort, and to merge existing partial competencies of different countries. This creates trans-national full-scale competence in a given field of technology and thus to improves the position of Europe in global competition.

Technology Forecasting is widely considered as a social process where various types of knowledge are integrated into meaningful messages on the future developments of some specific technologies. But this does not include participation of the general public. In this process, various modes of knowledge-conversion play an important role. In particular, it is the forecaster's task to externalise the experts' tacit knowledge and to combine the various pieces of existing open and tacit information.

One central question in Technology Forecasting is how to deal with breakthroughs. The most successful forecasts can be made in fields with only incremental changes, where it is possible to get rather accurate statements about future developments by a straightforward extrapolation of the past. Scientific and technological breakthroughs are widely considered as completely unpredictable. Experts involved in this project pointed out though that the use of creativity methods is most appropriate for detecting breakthroughs. All steps of Technology Forecasting contain aspects of pure information processing of stored information as well as social and communication aspects that refer to the interaction with the involved parties. These social aspects become the more relevant the more the creation of outcomes on a qualitatively higher level is concerned. This particularly applies when implementing creativity methods for dealing with breakthroughs.

It is a great challenge not to deal with isolated topics only, but also to discuss several of them in parallel and build a basis for comparison and finally generate a ranking among them in order to choose the best area to support.

Basically all technology fields are covered by some organisation identified in this project. The most frequently named fields are Information and Communication Technologies (ICT), materials, electronics, energy, environment, biotechnology, chemistry, transport, engineering, health, nanotechnology, life sciences, manufacturing, and automation. In addition, a large number of very specific technologies are covered. A more detailed discussion of the themes covered follows in section 3 of this chapter[47].

A new development that impacts on Technology Assessment is the availability of advanced software for information retrieval and storage. Challenges lie in the creation of a base for comparison between distinct technologies and in the development of technology roadmaps as an output of Technology Forecasting.

Apart from this, Technology Forecasting is often felt to improve technology transfer. Technology transfer was traditionally interpreted as a one-way transportation of new knowledge from the science sector to industry. Technology Forecasting processes implement multi-directional communication and moderate between science, policy and industry. This fosters the transfer of ideas and concepts, and thereby solves the failure of the conventional technology transfer approach. In an early stage of technology development, information transfer of industry needs is carried out. This ensures a bi-directional information exchange, as it is required in practice to avoid traditional uni-directional technology transfer in the classical manner.

One of the main aspects of Technology Forecasting is its communication aspect. Technology Forecasting initiates and fosters the communication between various communities, such as:

[47] Full further details on this issue and others discussed in the following sections can be found in the complete background paper on the project (see http://www.jrc.es/pages/f-project.html). This background paper also explains in more detail how the results presented here were obtained. In short, the data on which the following two sections are based were collected using a questionnaire. The statements on the characteristics, trends and utilisation of Technology Forecasting are the results of two workshops that were held in the course of the project.

- Science and science (in new interdisciplinary fields),
- Science and technology,
- Industry and policy,
- Technology and public administration, and
- Technology and the general public.

In new interdisciplinary fields it is often the case that scientists from different disciplines use incompatible languages. In the Technology Forecasting process it is then necessary to initiate an interaction between "science and science" and moderate in the generation of a joint language for the new interdisciplinary field. A comparable situation occurs in the exchange between scientists in basic research and the industrial researcher who is interested in the technical application of the results of the basic research. In this respect, one target audience of a Technology Forecasting process are policy-makers, which are usually the clients of the Technology Forecasting work to begin with. Another target audience is the experts in the field and the goal is to initiate a dialogue amongst them. In the communication between science and technology on the one hand and the decision-makers in policy and public administration on the other, Technology Forecasting must advise and educate decision-makers. They are often confronted with problems they are not well prepared to decide on and where the numerous consequences of a decision are hard to anticipate. In such a case, Technology Forecasting can help decision-makers to move on and tackle concrete issues.

The communication aspect is of importance in the information gathering part of the work, as much as in the part of the dissemination of the results. Despite the importance of communication in all steps of the Technology Forecasting process, it cannot be participatory in a practical way as it deals with topics of high scientific and technological complexity. But it does serve the need to inform the general public in the course of the implementation process.

Technology Forecasting must have a mandate from the customer in order to start work. This mandate is necessary to define the criteria on how to filter the large amount of available information. Technology Forecasting allows taking into account inherent non-scientific criteria during the whole process, which benefits from the involvement of experts from many backgrounds, like academia, industry and government bodies.

2. Current State of Play and Perspectives

This section aims to give an overview on the number of organisations in Europe that are active in Technology Forecasting, on the type of organisations that carry out Technology Forecasting, and on the positioning of Technology Forecasting within the organisational structure. It provides a map of the locations of the organisations and discusses recent trends in the way Technology Forecasting is carried out.

A total of 43 organisations are active in Technology Forecasting were identified. These include universities and large national research organisations, funding agencies, consulting companies and industrial companies.

From the data collected in the project it is clear to see that, regardless the size of the organisation or company, the absolute number of Technology Forecasting employees is between 1 and 10 persons with an average of 4.5 persons. It thus seems that the number of Technology Forecasting employees is not proportional to the size of the organisation.

The ratio of Technology Forecasting employees and the total number of employees ranges from near zero (for large companies such as Ericsson[48] , the ratio is about 0.005 %) to a maximum of 20 % (for instance of ICTAF[49]).

[48] See also: www.ericsson.com

[49] ICTAF (Interdisciplinary Center for Technological Analysis and Forecasting), see also: www.eng.tau.ac.il/~ictafweb/welcome.html

The organisations with the highest ratio are rather small (up to 20 employees in total) and have an average number of Technology Forecasting staff. At the same time, the organisations with the lowest ratio (under 1 %) are large private companies.

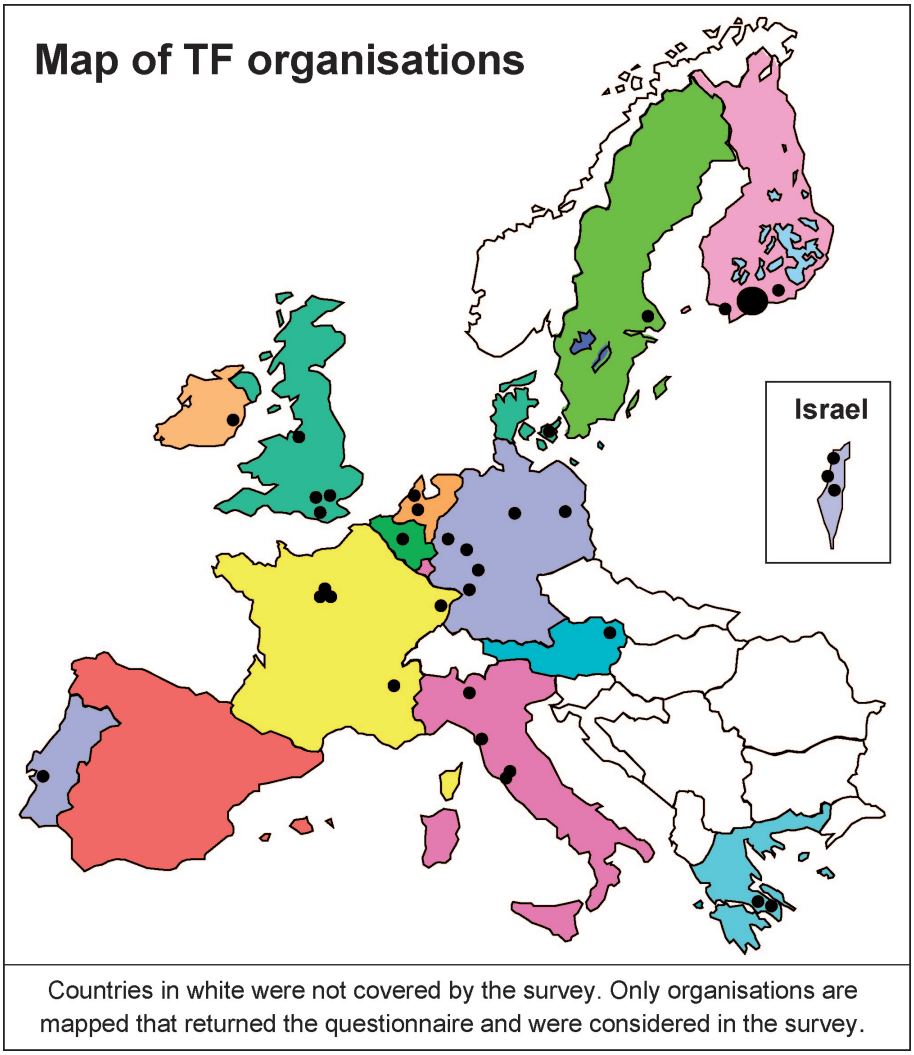
Even if divisions or departments within organisations are considered separately, the ratio of staff members doing Technology Forecasting (full-time) and total number of staff is not higher than 50 %.

Taking a deeper look at the institutions, or divisions/departments with a quite high ratio of Technology Forecasting staff and total staff (over 10 %), it can be recognised that most of them are consultants for clients (mostly public authorities) outside the organisations. Organisations with a very low ratio are large (e.g. number of total staff members over 1,000 persons). These organisations have own RTD divisions. One can assume that in these cases, all of the RTD-staff devote a certain percentage of their time to the identification and monitoring of new or emerging technologies in their particular field. These results can be summarised as follows:

1. The absolute number of persons exclusively involved in Technology Forecasting is up to a magnitude of 10 persons, regardless of the total size of the organisation or company.
2. The ratio between staff involved in Technology Forecasting (full time) and total number of staff is up to 50 % for organisations and even for Technology Forecasting divisions. This means that there is no organisation or a single division exclusively devoted to Technology Forecasting.
3. Technology Forecasting is organised in different ways:
   (1) Centralised: a division or at least a certain number of employees devote their work exclusively to Technology Forecasting
   (2) Decentralised: employees devote a certain percentage of their time to the monitoring and identification of new technologies (this activity is mostly not called Technology Forecasting within the organisation)

The geographic map of the organisations that are active in Technology Forecasting is shown in figure 3 below.

Figure 3: Distribution of Technology Forecasting organisations in selected countries



Source: Author's own compilation

From the experience of the project partners, it is known that about 100 private companies in Europe are active in Technology Forecasting. There is also a substantial overlap and several points of contact between industrial Technology Forecasting and Technology Forecasting for public bodies. However, private companies that carry out Technology Forecasting for their own purposes were not covered systematically. Their results are in most cases confidential and therefore not available as an input to governmental technology policy. Private companies carrying out Technology Forecasting as a contractor for public bodies (i.e. private consultancies) were included where relevant for public policy-making.

3. Themes Covered

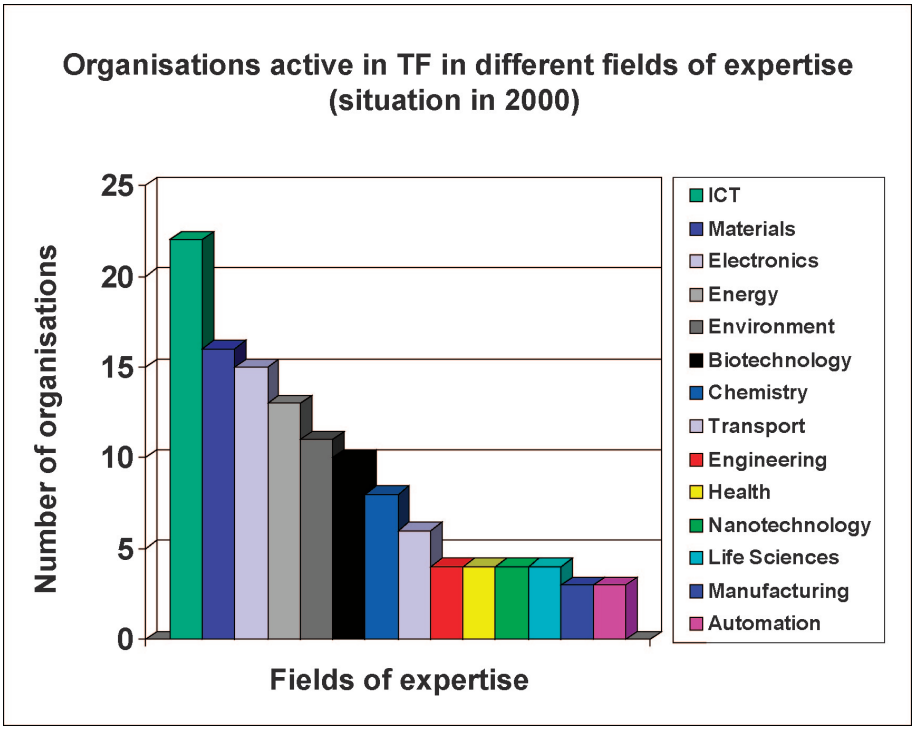
While a number of themes are covered by many organisations, for example ICT, materials, environment, energy, or biotechnology, some organisations are only involved in one specific field and are in some cases the only organisation specialised in this topic. Examples of these topics are combinatorial chemistry, fullerenes, or biomolecular functional systems. These topics are obviously much more precise and specialised than broad fields such as material or environment.

The figure below presents an overview of the fields of expertise given by the various organisations. Twenty-two organisations named one or more aspects of ICT as a field of expertise, which is also the most frequent one. The next field in the ranking is materials with 16 entries. Them following are electronics (15 entries), energy (13 entries), environment (11 entries) and biotechnology (10 entries). Each of the following fields was named by four organisations: engineering, health, life sciences and nanotechnology, while manufacturing and automation were named by three organisations.

The following different aspects of ICT were given: information technology (IT) with 10 entries and telecommunications with 9 entries each; communications

and explicitly ICT with 4 entries and finally e-commerce and computer sciences with 2 entries each.

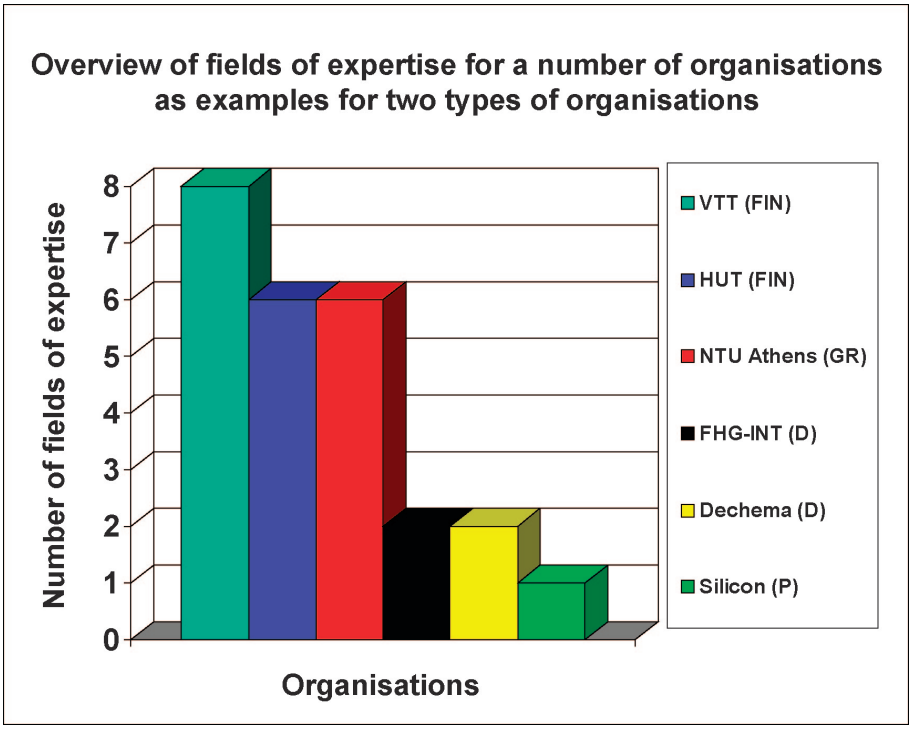
Figure 4: Fields of expertise of the organisations active in Technology Forecasting



Source: Author's own compilation

Not all the fields named by the organisations are directly comparable due to their different breadth. Nevertheless, it is possible to find two different types of organisations, if the number of named fields of expertise are compared. Type I are large organisations that cover a number of broad fields and type II are smaller organisations that cover only one or two of the broad fields. This context is presented in figure 5, showing an overview of fields of expertise (of those fields that were also shown in the previous picture on organisations active in different fields of expertise) for different organisations of type I and II.

Figure 5: Types of Technology Forecasting organisations by their scope of expertise



Source: Author's own compilation

It is no surprise that larger organisations and in particular research organisations cover most of the broad fields, such as VTT or NTU Athens. In comparison the two German organisations are much more specialised and focus on a much smaller number of broad fields. For instance, Dechema focuses on two broad fields: chemistry and nanotechnology. However, a closer look shows that Dechema covers a high number of specialised topics: Catalysis, Combinatorial Chemistry, Sustainable Chemistry, Micro-reaction Technology, Functional Supramolecular Systems, Chemical Nanotechnology, Adhesion, Molecular Surfaces, Separation Technologies, Biomolecular Functional Systems, Soil Decontamination, Chemical Transformations, Non-linear Dynamics in Chemistry, and Scientific Computing for Chemistry.

It is a characteristic of Technology Forecasting that it aims at the technical detail. Therefore, it mostly covers a detailed analysis of one single technology. With this in mind, it cannot be expected to find a Technology Forecasting exercise carried out with the objective of completely covering one broad field, like transport or health. A list of topics can be collected from the titles of the sample studies that are named in the background paper. Due to the diversity of the topics and the intended depth of each analysis it is not possible to come to a general main finding. In the course of the project, an attempt was made to give an overview of one single topic by means of a case study of nanotechnology[50].

4. Utilisation

Other strategic planning tools, such as Forecasting, strive to identify trends in rather broad fields and are often structured along broad fields of application, like transport or health, with a large political and socio-economic relevance. In contrast, Technology Forecasting is highly operational and specific and would not be executed for a broad field of application. Technology Forecasting aims at the technical detail. If a priority list of demands within a broad field such as ICT is given, then a top-down approach of Technology Forecasting is the tool of choice to identify what are pertinent technological developments. Technology Forecasting prepares decision-makers to decide about investments and funding immediately. Technology Forecasting for public clients integrates the view of academic science with the view of industrial applications. However, Technology Forecasting is also fully developed as a tool within industry itself, as indicated by the results of the EIRMA working group on the same topic. Because of this, Technology Forecasting is particularly suited to facilitate the discussion between the academic sector and industrial technology. This allows for a networking approach that could possibly span

[50] This case study is provided in the background paper (see http://www.jrc.es).

both the industrial and the public sector Technology Forecasting scenes and could generate additional synergies.

Regarding the time horizon which Technology Forecasting exercises span, the emerging picture is rather diverse. It can generally be said that the time horizon for public clients is about ten years into the future, going up to twenty years or more. But as exemplified by the French Ministry of Economy, Finance and Industry, the time frame can be as short as five years in the public sector, too.

Concerning industrial Technology Forecasting the most important factors are the typical rate of change in the industry sector and whether Technology Forecasting is carried out at the corporate or the division/business unit level. A recent study found that in relation to time horizons, there is a clear distinction between Technology Forecasting at the corporate level and at the level of divisions/business units[51]. A time horizon of between 1 and 3 years was mentioned in the interviews for business units and a horizon between 3 and 30 years for technology forecasting by corporate research. Companies operating in fields with a long product or technology cycle, such as pharmaceuticals, energy generation or supply, gave a time horizon of up to 20 years. It is clear that in each case the specific market and technology dynamics involved have an influence on the time horizon of technology forecasting and corresponds roughly to the company's time horizon of strategic planning.

It is quite plausible that the situation of SMEs is most similar to business units, so that it can be assumed that the time horizon for SMEs is also around 1 to 3 years. For instance, in very fast moving sectors like ICT and software, the time horizon might be no longer than six months, while in the basic industry much longer time scales might apply. As Twiss (1980) points out, the size of the company is more directly linked to the level of investment in Technology

[51] See Reger et al. (1999)

Forecasting, and limitations in the availability of resources are reflected in the choice of techniques that can be employed. Only large established enterprises can afford Technology Forecasting in its full scale and are also able to study developments on time scales of 25 years and more. While such long-term activities are not immediately applicable to the short-term industrial R&D planning of business units, they are necessary to balance the effects of the short term focus, which may result in short-sightedness. These long-term views should therefore supplement the technological point of view with an analysis of more general trends, e.g. globalisation. On the other hand, one should keep in mind that industrial Technology Forecasting activities are focussed on the competitive position of the respective company, and all measures to assure a proper frame for innovations like sufficiently educated personnel will remain with the public administration.

The case of nanotechnology shows the different national approaches of Technology Forecasting, which can be summarised as follows:

- Finland did not use Technology Forecasting as an entire approach, but as a benchmarking approach. Based on the results, a funding programme was set-up with a small number of projects.
- France did neither have a structured Technology Forecasting approach nor funding programmes.
- Israel did Technology Forecasting studies on nanotechnology, but did not invest in programmes. Instead, research in this field was supported and nanotechnology institutes were established.
- Germany did Technology Forecasting studies on nanotechnology and used the results to set-up several programmes in the field. This approach is similar to the US approach.
- UK was one of the first countries that set-up programmes in the field of nanotechnology. When establishing the Forecasting approach (Forecasting

programme 1), nanotechnology was lost as a subject since it was not included into the panels. Only in the last two years, the subject was re-discovered.

Even though there are substantial national differences, a common structure is that programmes start usually with an initial visionary paper or study or survey that always includes an information summary of the field studied, which initiates a wide communication process. This communication process involves scientists, industrial researchers, politicians, political administration and the general public. The process gets much more complicated for interdisciplinary fields like nanotechnology, which implies that one has to bring together people from different disciplines, different industries and various branches in the political administration. To be successful one needs to have a message and to be able to communicate it to the decision-makers. In the case of nanotechnology, the message is that one needs to bring together all scientific disciplines. Here Technology Forecasting has the role of a moderator or interpreter.

Further, experience has shown that a new unusual message needs time to spread and time to sink in. This phase could be called incubation phase, which differs depending on the typical speed of development in the given field and cannot be arbitrarily accelerated. It was also mentioned that creativity approaches within networks might shorten the incubation period. Nevertheless, the question remains how to ensure that an incubation phase gets started at all. In smaller countries it is sometimes easier to get such an incubation process started, since the step from the first consideration of an initial idea to arriving at a discussion on the national scale is smaller. On the contrary, in larger countries some ideas will fail to gain national support as long as they cannot gain nation-wide attention.

Here is one of the areas where a Technology Forecasting network could ensure that none of the important developments are disregarded, since

one of the reasons for giving attention to a newly emerging topic is the awareness that this topic is taken seriously in other countries. A Technology Forecasting network could assure a mutual awareness of the topics currently under discussion. An evaluation could then examine the relevance for one specific country and assess the complementary competencies supplementing the strengths of that country, giving the starting point for an international co-operation. Such an approach would be particularly suitable for the field of nanotechnology, since its width requires many competencies and it is quite likely that not all of the necessary know-how will be present in one specific country. From that point of view, a European Forecasting process carried out by a European Technology Forecasting network appears essential to create international synergies and to ensure European competitiveness on the global scale, i.e. compared with the USA and south-east Asia. However, The following limitations have to be mentioned:

(1) The free exchange of information is more likely in the early development stages of an emerging field when the potential applications are mostly visionary. The closer the field gets to the product development, the more restricted the information exchange will be as the industrial competition is more directly affected.

(2) In a Technology Forecasting network it would be important to ensure that the benefits for the participants are clearly defined. It would need to be defined what could be expected in return for a contribution.

(3) While for policy-makers in the public field it is necessary to justify the decisions from a specific national point of view, such national consideration is virtually absent in industry. The industry approach is generally global and the reconciliation between national interests is not a concern. Policymakers would be especially interested in the added value for their home country.

It seems to be typical for a small country to look first at the state of the art in larger countries before starting a Technology Forecasting study.

5. Conclusions

The development of Technological Forecasting demonstrates the potentials for multilateral and Europe-wide information exchange on specific topics. A first important item could be the exchange of information on the respective national research landscapes in a given field as a necessary first prerequisite for the initiation of increased multinational networking in Technology Forecasting. While the methodology may remain the same, the experts change with each emerging technology. Second, one could also exchange chapters of technology analyses that describe the technological background or even all chapters that do not include customer-related information or validation. Such an exchange would be suited to reduce the amount of duplicated work effort and could generate synergies at the European level. The possibilities for exchange are currently hampered by the fact that most of the publicly available Technology Forecasting output is in the native language of the particular countries.

Also the danger of not taking account of new interdisciplinary fields could be alleviated by the implementation of a European Technology Forecasting network that could ensure a mutual awareness of published studies and the topics currently under discussion. If that topic is relevant for a specific country or if there are complementary competencies that supplement the strengths of that country, an evaluation could follow, providing a starting point for international co-operation.

Finally, it could be useful to establish thematic Technology Forecasting working groups on interdisciplinary fields, like e.g. biology and materials, biology and physics, electronics and chemistry, or nanotechnology.

These considerations show that enhanced co-operation is necessary. Such co-operation would be useful on a bilateral as well as a multilateral basis. One should therefore aim to establish a European Technology Forecasting-network that eases the exchange of information in an optimal way.

Multinational Technology Forecasting initiatives carried out by a European Technology Forecasting network in specific and carefully selected topics would appear essential to create international synergies and to ensure European competitiveness on the global scale, i.e. compared with the USA and south-east Asia.

In the course of the project it has become apparent that people connect the word 'forecasting' with a vague prediction of the future in a certain direction, often linked to a meaning as in the term 'weather forecast'. In French speaking countries for instance, the terms Foresight and Forecasting are always translated by the same French term 'prospective'. On the other hand, the German word 'Technologiefrüherkennung' expresses the underlying idea of this process much better than the English term. For these reasons a new term has to be identified and established. Therefore, it is proposed to start a discussion in the Technology Forecasting community on this issue. One possible term could be 'Technology Early Recognition' instead of 'Technology Forecasting'.

III. Synthesis of Technology Assessment

Author: **Michael Rader** (ITAS[52])

1. Introduction and Definition

The term "Technology Assessment" has been existing for three decades or more, although its familiarity, popularity and definition have been subject to variation through time and space. A peak period at the European level were the second half of the 1980s and the early 1990s, when the idea of "Technology Assessment" was popularised throughout Europe by activities such as the MONITOR/FAST program and its three ECTA (European Conference on Technology Assessment) conferences. The most recent event trying to link with this tradition was a congress of the German Federal Ministry of Education and Research[53]. It is difficult to identify a common definition of Technology Assessment. The following definition is probably sufficiently broad, but not too specific to be controversial and is regarded as a working definition for the purposes of this project[54]:

> "*Technology Assessment is a form of interdisciplinary research, the results of which are intended for use in decision-making on technology. It consists of:*
> - *Analyses of the social, economic and ecological potentials of new scientific and technological developments;*
> - *Analyses of the economic, legislative and social framework conditions of the introduction of scientific and technological innovation;*
> - *Analyses of the potential positive and negative impacts of the application of new technologies.*
>
> *The results of these analyses are used for the development of options for the improved exploitation of the opportunities offered by new technologies, and for avoiding and minimising the risks of new technologies.*"

[52] Forschungszentrum Karlsruhe, Institut für Technikfolgen-Abschätzung und Systemanalyse (ITAS), Postfach 3640, 76021 Karlsruhe, Germany, e-mail: rader@itas.fzk.de

[53] The congress "Innovations for an e-Society – Challenges for Technology Assessment" was held in Berlin, 16 to 19 October 2001 and attended by over 200 delegates from 24 countries.

[54] As a precaution to readers, it should be pointed out that the goal of the ESTO "Technology Assessment" monitoring project was to create the conditions for a mid- to long-term monitoring activity which can be continued after the one-year period approved for the project. Its aim was thus not to do a comprehensive stock-taking exercise or an analytical comparison for the whole or part of Technology Assessment.

The starting point for Technology Assessments can be either a specific technology or a group of technologies, which are a potential subject for technology policy decision making ("technology-driven assessment"), or a specific and usually urgent societal problem, which can be addressed by applying technology ("problem driven-assessment").

2. Current State of Play and Perspectives

Technology Assessment as a separate activity is no longer or not yet established as an instrument to provide advice to decision-makers on science and technology policy related issues in many regions of Europe. The only area of policy-making where Technology Assessment has succeeded in establishing itself is the parliamentary field, where Technology Assessment has traditionally found use as an instrument to provide parliamentarians access to concise information on technology and its likely impacts.

The number of institutions working specifically for parliaments has grown steadily in Europe, even since the demise of the US Congress' 'Office of Technology Assessment (OTA)', which was the first institution of this kind and served as the model for almost all subsequent parliamentary Technology Assessment activities. Most recently, parliamentary Technology Assessment units have been set up in Norway and at the regional level in Flanders, Belgium. There is a well-established network called EPTA (European Parliamentary Technology Assessment network), which has its own web site and annual conference.

Much of the recent discussion within Technology Assessment has been devoted to the issue of public participation in development of science and technology policy.

The conclusions of the recent European Commission conference "Science and Governance in a Knowledge Society: The Challenge for Europe" bear the heading "Towards a New Alliance between Science, Citizens and Society". In view of the increasingly pervasive impact of science and technology

in all policy areas, ways of involving all stakeholders (decision-makers, scientists, citizens, industry and media) in a structured dialogue underpinned much of the discussion[55] . In the conclusions of the conference, the changes currently taking place in the European science and technology decision-making landscape are described:

- The belief that science is objective and free of human influence or responsibility is being increasingly replaced by a better understanding of the scientific process and of uncertainty. There is growing consciousness that scientific innovation is also shaped by human values and visions, "which can and should be rendered more accountable in a wider democratic process. The belief that all relevant risks have been identified is no longer regarded as tenable".
- Public questioning and "mistrust" are being increasingly viewed as fruitful for society and science by providing both opportunities and creating new forms of responsibility. In contrast to previous thinking, mistrust is no longer regarded as a matter of "educating the public", since it is now realised that well educated sections of society frequently display most mistrust. It is more a matter of creating a two-way relationship between science and society, where scientific institutions must listen and learn to comprehend public concerns or values. Public inputs are thus not simply "opinions", but relevant knowledge, values and questions, which scientists may have neglected in the past.
- The consequence of these realisations is a call for "new institutional relationships and forms" including experiments.
- The conclusions on "Foresight and Precautionary Research" underline a need for the involvement of normative considerations, calling for "forms of participation processes within which stakeholder involvement is important".

[55] See also: http://www.jrc.es/sci-gov/sumcon.html

- Finally, regarding innovation, it is argued that "the designs should reflect both exploiting the potential benefits as well as the effort to avoid potential risks". In particular the last requirement formulates one of the classical goals of Technology Assessment.

While it would be presumptuous to interpret the conference conclusions as underlining the leading role that Technology Assessment should play in the future, it certainly propagates institutional forms commonly applied by Technology Assessment. Thus Technology Assessment could theoretically play two major roles in restructuring the European science and technology decision-making process:

(1) That of an organiser, helping decision-makers to design the appropriate institutional setting to enable the participation of stakeholders, to organise the processes taking place in these settings, and helping to draw conclusions on the results of these processes.

(2) That of a source of information on the approaches, methods and experience required for restructuring, should the decision-makers decide to organise the processes on their own.

With reference to participatory aspects, both roles appear to be realistic, as witnessed by the popularity of consensus conferences or discourses, where Technology Assessment researchers play roles as organisers and evaluators, and by attempts to devise training schemes for research managers or to compile handbooks for "integrative Technology Assessment"[56]. Explicitly labelled "participatory approaches" to Technology Assessment seem to have emerged in Europe during the 1980s[57], although it has also been argued that participation has always been among the essential elements of any Technology Assessment[58].

[56] See Berlozinik et al. (1998)

[57] See Meyer (1999)

[58] See Gloede (2000), p. 11

The aim of participatory Technology Assessment is to achieve or to negotiate a consensus or compromise on conflicts involving technology by the participation of citizens and societal groups. There is a hope that solutions will be in a spirit of "common welfare", which comprises at least three aspects[59] :

- The knowledge base: Participation of citizens and affected parties takes place to improve the knowledge base for on-going decision-making. This aspect has already been mentioned as a conclusion of the "Science and Governance" conference.
- The value base: Human-influenced visions and values also shape scientific innovation. The aim of participatory approaches is to ensure that the values and norms of all relevant stakeholders are taken into consideration, thus avoiding the risk of manipulation or favouring only certain values and interests.
- The base of (social) legitimation: In the past there have been attempts to create "socially compatible" technologies, which have almost invariably failed. Hopes have now shifted to achieving at least acknowledgement of the legitimacy and acceptance of decisions, which have taken place in participatory settings.

Thus, five main issues can be outlined:

(1) Legitimacy concerning the implications of the results from participation beyond their narrow organisational context. Also the roles of experts and lay people in the process need to be defined.

(2) The relationship between arguing and bargaining regarding the process of finding a solution. This can take place either by relying on certain arguments that dominate a solution or by organising bargaining processes with the stakeholders.

[59] See Grunwald (2000)

(3) The conceptual and methodological context for participation. A major question is to what extent participation is regarded as essential and what role the context plays in shaping requirements for participation. While the local context appears most suitable for the application of participatory methods, it is still very much an open question of how suitable such methods are at the national and international levels, and how these should be organised.

(4) The evaluation and analysis of the impacts of existing participatory approaches. This concerns the parameters for the success measurement of participation. A question is whether a participatory process is only successful when its results flow into decision-making or if it is enough that it provides the decision-maker with aspects, which would otherwise have been disregarded. Additional indicators for success might be suitable, too.

(5) The integration of participation in formally legitimised structures for decision-making. There is a particular danger that certain participatory processes might co-exist independently alongside formally legitimised procedures, with the result that one eliminates the value of the other. In this area a huge need for research exists[60].

In order to analyse participatory methods in Technology Assessment, the EUROPTA[61] project, which involved six partners who examined 16 cases in Europe, was reviewed from the viewpoints of ESTO researchers located in different European countries with different political structures, cultures and democratic traditions. The reviewers were from Denmark, a country that has pioneered the involvement of lay panels in its "consensus conferences", and from Germany, where participatory elements are being introduced within such

[60] See Grunwald (2000)

[61] EUROPTA (European Participatory Technology Assessment - Participatory Methods in Technology Assessment and Technology Decision-Making)

concepts as "discourses". A first shortcoming of the EUROPTA project is that there was no contribution from a country without known attempts at such participatory approaches.

One of the main incentives for the introduction of public involvement is lack of credibility of the political system and experts in the eyes of the general public. One of the concepts most frequently associated with participation in Technology Assessment, the "consensus conference", was in fact imported to Denmark, the country most associated with the concept, from the US, a country not normally associated with participatory approaches. However, the context and aims changed. In Denmark, it is being used at the national level, which was not the case in the US. It is the question whether the size of the country or the application at the local, regional, or national level have an impact on the applicability of the concept or if it needs modification. It seemed that a major barrier to participatory approaches was the existence of an established Technology Assessment community, which can be influenced by the introduction of changes or institutional settings. This also shows in the success of the consensus conferences in Canada and Australia, countries without traditionally developed Technology Assessment landscapes.

The reviews point out that the EUROPTA project primarily pursued scientific targets and only drew a limited number of recommendations. However, the project has contributed to the formation of a European participatory Technology Assessment community, and it can be hoped that the further activities originating from this core will help to create a forum for the discussion of issues of public participation in the "Science and Governance" context.

3. Themes Covered

Not all the European countries are familiar with the term "Technology Assessment". While the term had been used in the UK in the 1970s, it had fallen into disuse, and has only recently been rehabilitated to a certain

extent. It is difficult to identify experts on Technology Assessment in France, mainly because the term and the concept are not commonly used, especially in their participative dimension. Work on the project confirmed that it remains difficult to get an accurate impression of the French Technology Assessment landscape. One possible explanation is that leaders in the public administration, politics and industry are usually recruited from the "écoles superieures", while training scientists is the job of the universities and research academic institutions. There has traditionally been little interaction between these two "pillars" of the French education system. The French OPECST[62] is a parliamentary unit and member of the previously mentioned EPTA network. Its main job is to assist parliamentarians in decision-making by collecting scientific information, launching study programmes and carrying out assessments on subjects identified as relevant by the parliamentarians. Moreover, despite a great number of scientific committees in public administration and ministries, there was a poor functioning of the process for input of scientific expertise and a lack of proper linkage with decision-makers. In the case that scientists were consulted, politicians tended to regard them as stakeholders holding biased opinions. This overall attitude, which is the result of impressions from the ETAI feasibility study of the mid-nineties[63], might be changing gradually as a result of the Science and Governance debate. Several of the speakers from science at the "Science and Governance" conference of early 2000 were in fact from France, notably in the sessions on the involvement of citizens in decision-making and on developing responses to crises. A recent report for ESTO suggests that new mechanisms are indeed being set up to involve scientists in an advisory role for politics and to reform expertise[64]. On the other hand, the participation of citizens or their representatives in Technology Assessment or other expertise processes is far from being achieved in France.

[62] OPCEST (Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques - "Parliamentary Office for the Evaluation of Scientific Choices and Technologies")

[63] See Rader et al. (1995)

[64] See Barré et al. (2000)

The new relationship between policy, science and the citizens that might emerge in France cannot draw on the tradition of discourse, so that those responsible for the organisation of the processes would benefit from the existence of a "clearing house" and information resources. France is obviously not the only country where this applies. It has always been difficult to identify any kind of Technology Assessment community in most Southern European countries.

In **Greece**, as an example of a Southern European country, Technology Assessment has not yet been developed as an autonomous and systematic process. Technology Assessment elements are found in various policy studies dealing with relevant issues, but they were not labelled as Technology Assessment studies, since they follow the wider science-technology–society reference model. Such studies are carried out by different groups and institutions, but the possibility for synthesis and creation of a critical mass of knowledge and human resources is limited. Another basic reason for not having distinct Technology Assessment activities reported in Greece, is also the blurred definition of Technology Assessment itself combined with its significant interrelation and connection with Technology Foresight and Technology Forecasting. Although not supported by a systematic process yet, Technology Assessment activities in Greece can be found in the form of information and consultation, Technology Assessment carried out by the Public Administration with external expertise and support, Scientific Society, and Technology Assessment-related educational / training activities as well as seminars and research.

In contrast, the Nordic countries have always had a reputation for being open to the socio-economic aspects of technology. Technology assessment exists in **Finland** at the parliamentary level, where it is treated in close combination with Foresight. A typical feature of the Finnish system is that it is quite scattered. The responsibility for Technology Assessment is delegated to various research institutes, including universities, and also to private companies. The benefit of this practice is that Technology Assessment is brought closer to

actual decisions affecting the technological developments. At the same time relevant aspects might be neglected.

A very provisional survey on technology-assessment institutions in **Sweden** suggests that the main forces of Technology Assessment in Sweden are Linköping University and The Swedish Council on Technology Assessment in Health Care (SBU). The well-developed Technology Assessment in the health sector has been criticised in Sweden. It has been claimed that it is too difficult to get through the process, so that many useful medicines (and other innovations in health care sector) are introduced to the market long after the technical solutions are available. On the other hand, unnecessary risks should certainly be avoided in this area. The issue of examining the arguments for and against well developed/formalised Technology Assessment-activities in different countries and in various sectors of industry has been brought up in Sweden.

An experience from the **Danish** Technology Assessment scene is that explicit Technology Assessment has almost vanished, except for the activities of the Danish Technology Board and medical Technology Assessment. Today, Technology Assessment is carried out under many different labels. Some of the participatory approaches from action-oriented working life research, socio-technical system design, or environmental management actually resemble what was labelled and carried out as participatory Technology Assessment in the past. Widespread activities carried out by universities, sector institutions, public administrations, private consultants and among grass root organisations make use of methods quite similar to those of participatory Technology Assessment. At the same time, especially in the universities, new approaches to technology studies under the broad framework of social shaping of technology are trying to understand the role of Technology Assessment activities in the development of technology. It can be hoped that they reflect on and guide Technology Assessment activities into a constructive social shaping process. These developments resemble the ideas of constructive Technology Assessment and are being supported through EU-funded projects of the

Targeted Socio-Economic Research program. There is a recognised need to shift attention from individual participatory approaches in a single Technology Assessment project to a broader perspective on the socio-technological context in which Technology Assessment takes place. Even if the individual participatory Technology Assessment project might be effective in creating debate and attention on specific issues, there is no guarantee of any broader impact. The socio-technological agenda might have moved to a different technological frontier, or the dominant political and economic forces can be too strong. On the other hand, defeat in a single battle does not imply a lost war. Old lessons can come to new relevance as public awareness and concern turn into market forces and crosses strategic developmental plans of multinational companies.

Germany is the country with the most developed landscape for Technology Assessment in Europe and possibly in the entire world. Although its standing with politicians has been subject to extreme variations, the term "Technology Assessment" (or "Technikfolgenabschätzung", which has been accused of having even more negative connotations than its English equivalent) survived various waves of attack since it was imported from the US in the mid 1970s[65]. The issue of "Technology Assessment and Industry" is the subject of an ongoing discussion. The landscape has always been mapped quite thoroughly due to the existence of several databases at the national and regional levels. A comparison of the state of Technology Assessment in Germany over a ten-year period reveals that the number of institutions active in Technology Assessment and related fields has almost doubled from 136 institutions in 1991 to 245 in 2001. Increases in numbers have been particularly significant in the new Länder formerly belonging to the German Democratic Republic, which in 1991 had only recently been united with the old Federal Republic of Germany. It is worth noting that the number of institutions in Baden-Württemberg

[65] See also: Paschen (1999) and Meyer (1999)

has almost trebled during the decade, most probably due to the activities of the Baden-Württemberg Centre for Technology Assessment (AFTA). This centre has fostered Technology Assessment activities by institutions previously not active in the field and established its own database[66]. It has collected information on activities which can be termed "Technology Assessment", but had previously escaped the attention of database surveys since they were not explicitly termed as such and since those responsible for the activities concerned were not aware of the term "Technology Assessment". The results show that coverage of institutions is best in Länder where indigenous Technology Assessment institutions undertake their own periodic surveys, i.e. Baden-Württemberg, Northrhine Westfalia and Saxony.
Approximately half of the institutions active in Technology Assessment are found at universities and the other half within a broad variety of institutional settings. However, the largest institutions in terms of number of staff are generally those outside universities.

The decade has seen the emergence of research on such things as micro systems or nanotechnology, which were not relevant at the beginning of the 1990s. Manufacturing technologies have lost a great deal of their interest to researchers, or more likely to decision-makers, in favour of information and communication technologies. Environmental technologies played a virtually negligible role at the beginning of the nineties, while they are now in fifth place. The controversial status of biotechnology in public debate is reflected in the growing number of German institutions involved in assessment in this area.

Perhaps even more significant are the shifts that have taken place with respect to the areas of impact covered by Technology Assessment exercises. Environmental impacts are now the main focus of Technology Assessment research, while focus on working conditions, which were the subject

[66] See: http://www.ta-akademie.de

of large programmes in former times, has stagnated. The importance of competitiveness, impacts on the labour markets and the emergence of "economics" as a separate area of impact indicate the shifts that have taken place in the public science and technology policy debate since the early 1990s. One result has been the development of the new concept "Innovation and Technology Analysis" as the header of the German Federal Ministry for Education and Research's programme for the field previously termed as "Technology Assessment".

A unique feature of health Technology Assessment is that it has developed in more or less 'splendid' isolation from the mainstream of Technology Assessment for a period of 25 years or more. It was therefore selected as the topic of the 2000 annual EPTA (European Technology Parliamentary Assessment network) conference, which had as its full title "Technology Assessment in Biomedicine and Health Care". Among the other reasons for devoting the EPTA conference to this topic was the increasing interest from parliamentarians for assessments dealing with health-related issues, especially in the following areas:

- The different functions of health Technology Assessment and Technology Assessment in general,
- Concepts and examples from the practice of both approaches, and
- Attempts to bridge the gap between co-operation and integration.

These examples from the different countries and areas underline that the role of Technology Assessment and its contribution to the policymaking process largely depend from the national political priorities, awareness and culture. The practical implementation of Technology Assessment can take many forms and depends to a certain extent on feedback from policymaking.

4. Utilisation

In the past, the main addressees of Technology Assessment were decision-makers on public policies (politicians, advisers, civil servants and officials in administrations) and, to a smaller extent, the representatives of stakeholders in the development and application of technology. Recent discussions have focused mainly on Technology Assessment to assist the actors involved in developing and applying technologies. This issue has repeatedly come up on the agenda of Technology Assessment in the past, but it has probably never been resolved to the satisfaction of politicians, who view this as a means of identifying areas of social conflict created by technology application or as a means of avoiding problems of lacking acceptance. The realisation of concepts that seek to fulfil such goals require their voluntary implementation by the actors involved in developing technology and this condition is seldom met, with the possible exception of projects for the user-oriented development of software.

The main clients of Technology Assessment are thus still politicians and officials, and Technology Assessment is perhaps most established within the parliamentary framework. It has always been difficult to assess the impact of report-based Technology Assessment activities. Even if decision-makers act in accordance with the recommendations contained in reports, it is usually unclear whether this is because the report confirms or supports an opinion the decision-maker had in the first place or because it is due to the strength of arguments contained in the report. An important measure of the success of a Technology Assessment study has often been whether it has been quoted in debates on its subject.

Most other Technology Assessment research targets decision-makers in other branches of government, notably the administration. With the exception of health Technology Assessment, there are no really universally acknowledged hubs of networking activities. A possible explanation is the lack of clear-cut

structures due to the broad diversity of programmes, clients and topics covered by Technology Assessment in general.

Contrary to popular misconceptions, the role of the Technology Assessment specialists is usually not the assessment of the technology itself. Instead, it has to organise different processes designed to compile information, evaluations and opinions from a broad range of experts and stakeholders and to present this in a form digestible by decision-makers. In this process, Technology Assessments frequently produces synthesis reports, which condense the wealth of information compiled in the Technology Assessment process. There can obviously be differences of opinion on the accents set by such reports, e.g. on decisions to include or to exclude certain assessments and opinions or to point out certain conflicts.

The main measure of success in this process is not the achieved consensus on the decisions concerned, but the satisfaction of all main stakeholders that the decision-making process has been just and fair, allowed all parties to present their positions and opinions, and that these have been considered even if they did not have decisive effect.

The current debate on Science and Governance, which discusses the roles of experts and citizens in decision-making on public science and technology related policies, is in fact dealing with similar issues to those debated in Technology Assessment and related research. A challenge facing professionals in this field is thus to feed their experience and knowledge into this on-going debate.

There are changes taking place within the different member countries of the EU, in particular regarding the clients of Technology Assessment and the expectations associated to it. Examples are the discussions on “Technology Assessment for industry” in Germany or social shaping perspectives in the Nordic countries.

In the most recent Technology Assessment debate, there have increasingly been voices calling for a fundamental re-orientation of Technology Assessment, shifting it from providing policy advice to shaping the development of technology within enterprises and research establishments. Technology Assessment is sometimes accused of being "too late" for shaping technology policy. However, the focus of Technology Assessment is not the detection of breakthroughs or the anticipation of inventions[67], and actions in technology policy take place after the 'fait accompli' of the technological fact (i.e. after a new technology has come into existence). The potentials of this technology then define the space for Technology Assessment.

Examinations of impact in the parliamentary domain have shown that the intervention of Technology Assessment has usually not come too late[68]. Hesitance in making political interventions should also not be confused with political inaction. It rather indicates the fundamental problems of inherent subjects that require regulation, conflicting societal expectations, uncertainty in the assessment of possible impacts and impact scenarios, and the mediating function of politics between economic interests involved in the application on the one hand and ethical and social concerns on the other. Making the opportunities and risks of technological developments and societal demands for control an issue within public policy is preferable to leaving this to industry alone, whose doors are not always open to the "interests of society at large".

[67] Note from the editors: Breakthroughs and new inventions can better be anticipated with Technology Forecasting within a certain technological field and with Foresight above that level (see chapters II and IV).

[68] See Hennen (1999)

5. Outlook: A New Future Role for Technology Assessment

In the past, Technology Assessment has operated in a context with somewhat paradoxical demands:

- There have continually been accusations that, by focusing on the negative potential impacts, Technology Assessment is acting as a barrier to innovation ("technology arrestment"),
- At the same time, there is demand to separate exaggerated expectations that accompany innovations from their true potential and to have an early warning of possible undesired impacts, which are frequently not recognised or disregarded by stakeholders in the development and diffusion of technology and its application.

Technology Assessment has always been least controversial in its advisory role for parliaments as a means to counter-balance the advantages that the executive branch has over the legislative one with respect to good-quality information on science and technology. It is to be expected that it will continue to play this role, although not always unchallenged.

Thus, although the German Federal Government's concept of "innovation and technology analysis" is driven by a positive attitude towards technological development and industry, it also stresses the need to focus on negative impacts[69].

An "ideal" situation would be one in which both positive and negative impacts of technology had been considered in advance by the persons responsible for its design and development. The role of Technology Assessment specialists would then be teaching at university and schools of engineering. In some countries, such as Denmark, much has already achieved with this respect,

[69] See Brüntink (2001)

while in others, such as Germany, such thinking is an exception and still regarded as exotic.

Just as the potential dangers of nuclear power stimulated Technology Assessment in its first wave during the 1970s, recent events such as the BSE crisis in Europe or the terrorist attacks on the USA look likely to give birth to increased activity in Technology Assessment and related fields. Since it has been realised that there is a need of adopting precautionary measures against threats to citizens living in modern societies, there is increasing need to identify such threats and also to consider the concerns of citizens regarding use of technology and innovation. There is also a trend toward more problem-driven assessments, i.e. examining the role of technology in its societal context. Added to this is the increasing interest of science and policy decision-makers in future-oriented technological analysis, as witnessed by the current wave of Foresight exercises. This is only partly driven by economic considerations, principally decision-making on the areas of technology with the greatest economic potential for the society or nation concerned, but also with the future needs of citizens, for instance in an "ageing" society.

Thus, on the one hand, Technology Assessment can play a future role in organising processes that involve broad ranges of stakeholders and persons otherwise affected by the development and application of technology in decision-making on specific technologies or other political situations concerning the application of technology. On the other, Technology Assessment can complement related activities, such as Foresight exercises, by focusing in greater detail on the potential and impact of technology identified as having the promise to play a major future role in the economy of a society or nation.

6. Conclusions

The term “Technology Assessment” itself is not in common use throughout Europe, but activities, which fall under existing definitions exist in many countries. Apart from the lack of familiarity with the term “Technology Assessment”, there are also differences in decision-making practices and cultures in the different countries in Europe.

One of the objectives for the future could be to identify reasons why this should be so and to examine whether changes are taking place due to the changing context in the countries concerned, and possibly also due to influence from the European level.

Further, a network model for future monitoring of Technology Assessment and related activities could be established, with correspondents located in the individual member countries of the EU and other European countries. This would provide benefits of information and a context for discussion to those involved.

The discussion on “Science and Governance” has brought up many issues, which have been the subject of debate in “Technology Assessment”, such as decision-making under conditions of uncertainty, controversial or lacking knowledge, the participation of citizens in such decision-making processes and the role of scientific knowledge and expertise in policy making. There is a need for a platform for the Europe-wide discussion of these issues.

IV. Synthesis of Technology Foresight

Author: **Rémi Barré** (Futuribles[70])

1. Introduction and Definition

In recent years, there have been a number of profound evolutionary changes in science, technology and innovation policies and policy-making at national as well as EU level. Such changes are the response to a three-fold challenge.

(a) *The complex and systemic nature of the policy context:* Research and innovation policies are being developed at several levels (regional, national, European). They interact strongly with other public policies (e.g. education, competition, fiscal, procurement, health and safety) due to the systemic nature of innovation dynamics.

(b) *The transformation of the industrial 'innovation fabric':* The innovation process has become a multi-actor, multi-institutional endeavour, linking a variety of competencies to form knowledge and invention production networks and other forms of collective undertaking.

(c) *The emergence of a science, technology and innovation 'social space':* Science, technology and innovation can generate concerns of a social, economic and ethical nature, when they raise issues related to safety, health, ethics, quality of life, and also international relations, independence and security.

Therefore, the government must simultaneously foster speed and efficiency of research and innovation, as well as addressing the potential risks associated with technological development. In both arenas the stakes are very high indeed.

[70] Futuribles, 55, rue de Varenne, 75007 Paris, France, e-mail: remi.barre@cnam.fr

These challenges raise fundamental questions relating to:

- The co-ordination, coherence and steering of public policies.
- The conditions for public and private actors to formulate informed strategies, for investing in promising areas of S&T and for getting involved in the relevant innovation networks.
- Ways in which stakeholders can take part in the exploration and assessment of the technological trajectories which shape innovation, so that associated decision processes are transparent, credible and acceptable – i.e. the democratic dimension of science, technology and innovation.

It is important to note that these concern not only governments in their public policy role, but also firms in their research and innovation strategic choices, universities and public research organisations and the citizens.

The needs underlying such questions have given rise to some developments in the public decision-making institutional and management forms. Examples include the creation of new advisory functions and mediating institutions, the broadening of research evaluation criteria, the emergence of socio-economic assessment procedures, the emergence of 'citizen conferences' or 'consensus conferences', the development of Parliamentary Technology Assessment activities, and the move towards more explicit and transparent scientific advice mechanisms, sometimes linked with the precautionary principle.

Beyond these important developments, so-called Technology Foresight activities have developed in parallel, at a quick pace during the last five years, and constitute an original attempt to address the above-mentioned challenges. Such Foresights have emerged at national, sectoral and regional levels both in EU member states and in several Candidate Countries[*].

[*] The 13 Candidate Countries are those countries the European Union is currently negotiating the path towards membership with, namely Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovenia, Slovakia and Turkey.

The variety of Foresight is so great that it can refer to a whole range of decision support processes with the following common characteristics:

- A long term perspective and a focus on changes,
- An interest in the S&T as well as in the social, economic and environmental realms,
- A diversity of actors and inputs, with acknowledged diversity of visions,
- Transparency, openness and bottom-up spirit,
- Interactivity among participants and appropriation of the process to the actors and stakeholders,
- A concern for alternatives, identification and exploration of hypothesis and events of significance for the actors, and
- Strategy formation.

In brief, Foresight activities are policy-making processes, in which collective learning is developed in the S&T–related arena via interaction between industrial, academic, governmental and social actors. It operationalises interactive processes aimed at exploring openly and collectively possible futures. In this way, it both increases and distributes Strategic Intelligence among social actors on emerging generic technologies and innovations. Such processes help to formulate and co-ordinate the forward-thinking of institutions concerned with (technological, social and organisational) innovation, thus enhancing their strategic capabilities. As both a 'means' and an 'end', Foresight processes also help establish hybrid networking, to build shared agendas and to overcome established boundaries, be they geographical, institutional or disciplinary ones.

Foresight is thus a major feature of the emergence of a new S&T governance regime, relevant at regional and national levels, as well as, and this is new frontier in policy making, for the EU level, as open co-ordination mechanisms fit for the shaping of the European Research Area.

2. Current State of Play and Perspectives

2.1. The substance and method of S&T Foresight

Most EU member states have launched national-level Foresight exercises in recent years. Such exercises cover a large variety of objectives, institutional settings and sizes, themes addressed and outcomes. Nevertheless, some basic features are shared by all exercises. The Foresight exercises always involve players (such as an ordering body, a steering group, several panels, and external experts) and activities (like surveys, information exchanges, panels workshops and broader conferences). The conception of such a process is the organisational design of the exercise, which is an important aspect of a Foresight methodology.

Foresight exercises consist fundamentally of a succession of 'extension' and 'concentration' steps: the participants in the exercise engage in interactive activities consisting of an exploration and hypothesis-building stage (extension), followed by a selection – convergence and synthesis stage (concentration). Foresight methodologies are the ways by which these extension and concentration steps are carried out.

Such extension - concentration sequences lead to a description of Foresight as a learning process from tacit to codified knowledge transformation cycles in the following order:

(1) Preliminary stage: setting up the objectives, scaling the exercise, defining the organisational design and members of the panels, preparing the input data and information,
(2) Central stage (a): determining the key-parameters ('drivers') and issues,
(3) Central stage (b): identifying the relevant perspectives and scenarios,
(4) Finalisation stage: strategic analysis, dissemination of the results and recommendations.

2.2. Identifying the trends and recent developments: a typology of Foresights

Some sense of the diversity of the Foresight exercises can be made by use of a typology. In what follows, we characterise S&T Foresight with respect to two axes or parameters: the first represents breadth ('extensiveness') and the second the depth ('intensiveness') of the exercises.

Axis 1: the extensiveness of the Foresight activity
This refers to the number and variety of persons or the experts involved, which can be combined to give the classes presented in table 4.

Table 4: Classification scale of the extensiveness of Foresight

Extensiveness class	I	II	III
Label	Classical S&T study	Collective process	Societal process

Source: Author's own compilation

Axis 2: the intensiveness of the Foresight activity
This refers to the quality (completeness) of the learning cycles involved in each of the four phases of a Foresight process defined in terms of:

(1) The kind of work being performed,

(2) The substance of the activities taking place,

(3) What is produced, how and by which methods,

(4) The results and impacts on the participants.

For each phase, two extreme situations can be considered:
Rating 0: The learning cycle is not taking place, resulting in no production

of collective knowledge. The work goes hardly beyond the juxtaposition of statements or opinions by the participants.

Rating 2: the learning cycle is implemented completely, in a formalised, explicit and systematic way, enabling the production of collective knowledge, through quantification or quasi-quantification (codification) and strong interaction among participants.

The classes of axis 2 are shown in table 5.

Table 5: Classification scale of the intensiveness of Foresight

Intensiveness class	I	II	III
Interpretation	Opinion exchanges, occasional knowledge production	Pragmatic process, ad-hoc knowledge production and collective learning process	Intensive, systematic knowledge production and collective learning process

Source: Author's own compilation

A graphical positioning of the Foresight exercises against the two axes allows a mapping, which highlights the major types. Such a mapping was carried out as part of the monitoring study for 15 Foresight exercises, which have been described through the criteria listed in box 5.

Box 5: Criteria for the description of the Foresight exercises analysed

1 - Objectives and overall description:
Scope, questions addressed, geographic and time scale, duration, explicit objectives, actual outputs / impact sought, and overall methodology
2 - Institutional design of the exercise:
Ordering body, steering committee, implementing agency, target audience, target sectors, number and origin of persons consulted
3 - Methods used ('tools and techniques'):
Methods used for: identifying areas and questions, gathering background information, choosing the experts, consulting the experts, identifying driving forces, presenting future developments, identifying priorities, and generating consensus
4 - Modes of communication:
Modes of communication between: ordering body and steering committee, steering committee and implementing agency, implementing agency and experts, among experts
5 - Awareness raising:
Modes of communication and type of information: during pre-Foresight phase, Foresight phase, and post-Foresight phase; between: Foresight actors, policy makers, businesses, the research community and the public at large
6 - Results and their impacts:
Modes of presentation of analysis, results, recommendations, measurement and evaluation of impact

Source: Author's own compilation

It has to be added that the measurements and classifications were undertaken in a subjective way, through expert assessment based on a systematic, but necessarily simplified description. What follows is not to be considered a static and definitive statement about those 15 Foresight exercises, but a tentative, yet reasonable assessment, which provides clues on the overall trends and recent developments.

The typology produces four types (groups) of Foresight, which can be related to two basic models of foresight (see figure 5 and table 6):

(1) The ***'social process'*** model of Foresight, constituted by:

(a) The **societal Foresight group**[71], including the UK, German and Swedish Foresights, which score high (class III) on the first axis and (almost necessarily) relatively low (class I) on the second,

(b) The **collective learning and knowledge production group**, this group comprises the Austrian and Belgian Foresights, the Finnish technology vision exercise, the environmental social demand study of France, the German Delphi, and the OCV, NRLO and AWT foresight exercises from the Netherlands, which are positioned in class II on both axes;

and

(2) The 'professional-analytic' model of Foresight, including:

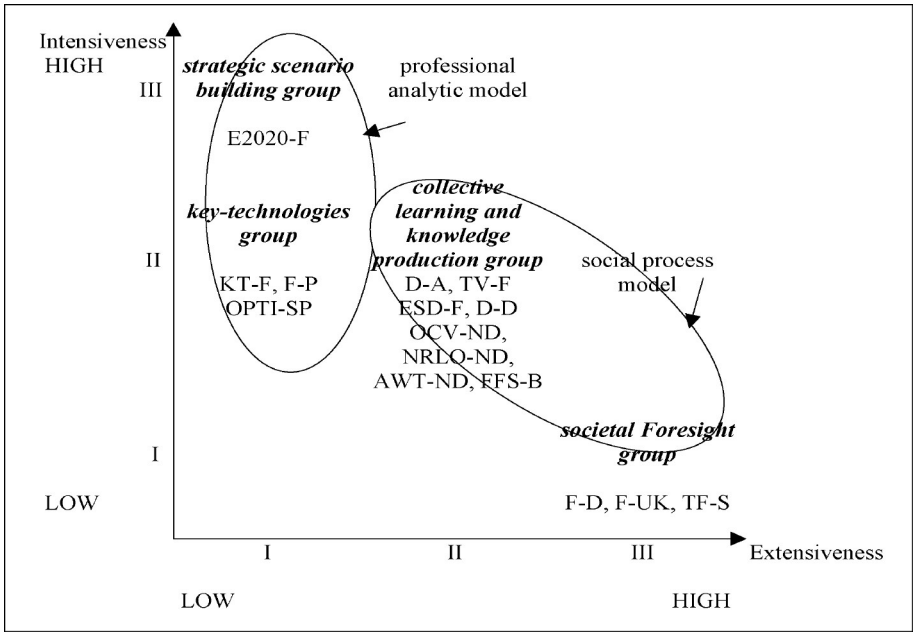
(a) The **strategic scenario building group**, at the other side of the map, which comprises the French 2020 energy study, which scores high (class III) on the second axis, and rather low (class I) on the first,

(b) The **key-technologies / industry-oriented group**[72], consisting of the French key-technologies study, and the Portuguese and the Spanish Foresight exercises, scoring rather low on the first axis (class I) and average (class II) on the second.

[71] This label means that the Foresight in itself is a societal process. But the topics it deals with are S&T topics in their relationships with society.

[72] The Italian Foresight could be classified in this category, as well as the futures study presented in: Grupp, H.: "Technology at the beginning of the 21st century", Technology Analysis and Strategic Management, 6, 4, 1994, or the recent Futures Reports prepared by the IPTS (e.g.: "Technology map", Futures report Series, 11, JRC-IPTS, Seville, 1999)

Figure 6: Positioning and typology of recent foresight activities



Source: Author's own compilation

Table 6: Acronyms and position on the two axes of the 15 Foresight exercises

Name of exercise (country)	Acronym	First axis measure	Second axis measure
Delphi Austria 1998 (A)	D-A	II	II
Technology vision Finland 1997 (FI)	TV-F	II	II
Energy 2020 (F)	E2020-F	I	III
Key-technologies 2005 (F)	KT-F	I	II
Environmental social demand (F)	ESD-F	II	II
German Delphi 1998 (D)	D-D	II	II
Futur 2000 (D)	F-D	III	I
UK Foresight 2000 (UK)	F-UK	III	I
OCV Foresight (NL)	OCV-ND	II	II
NRLO Foresight (NL)	NRLO-ND	II	II
AWT foresight (NL)	AWT-ND	II	II
Portuguese Foresight (P)	F-P	I	II
Swedish Technology Foresight (S)	TF-S	III	I
Technological futures - OPTI (SP)	OPTI-SP	I	II
Belgian federal Foresight study (B)	FFS-B	II	II

Source: Author's own compilation

3. Themest Covered

The 'professional-analytic' exercises are fundamentally studies aimed at helping decision making, with consultation and appropriation by a group of persons of a relatively limited size (between a few dozen to a few hundred people). In contrast, the 'social process' exercises cannot be called 'studies' any more, since they involve several thousand people. They are socio-political processes, which make them a new breed of decision making instrument. The main themes covered by the different groups of the typology above are presented here:

(1) The ***social process*** model:

(a) The **societal Foresights group** (high extensiveness; low intensiveness):
Societal Foresights are rooted in the tradition of public participation and extended technology assessment, for which the final client is the public itself. The central focus is on whom participates and the objectives are the creation of new networks and circulation of information. The classic example of such societal Foresight is the second UK Foresight exercise, in which the number and variety of persons involved is both impressive and unprecedented. In terms of the learning cycles, it appears that such widely spread exercises end up in rather loose exchange of opinions among participants. The societal Foresights are radically new decision-making process, but their scope, complexity, cost and the political risks involved may limit their development.

(b) The **collective learning and knowledge production group** (medium position on both axes):
Like societal Foresight exercises, these also constitute an important policy making innovation, since they involve a wide constituency of stakeholders. But they are more focused, for example at the sectoral

level, which may give them the advantages of a broad approach, but without the difficulties of size. They are becoming the standard procedure for policy making in some countries (e.g. the Netherlands or Finland).

(2) The ***professional analytic*** model:

(a) The **strategic scenario building group** (low extensiveness, high intensiveness):
This group entails an important knowledge production activity, leading to a data and modelling challenge. On the other hand, exercises in this group directly involve a relatively limited number of persons, few experts and, at best, some representatives of selected social groups. Here, most of the attention is devoted to making the learning circles work, since each stage involves some sort of qualitative or quantitative modelling. The French-school of prospective studies is the classic example of such strategic scenario building Foresight. The central focus is the internal coherence and plausibility quality of the scenarios. The outcome is expressed in terms of a platform for public policy or a strategy for the public actors.

(b) The **key-technologies / industry-oriented group** (rather low extensiveness, medium to medium-high intensiveness):
These represent a more classical view of Foresight in the sense that S&T aspects are seen quite independently from societal aspects, which doesn't mean societal criteria are not addressed. Such Foresights are often quite analytic and focused, which can bring very valuable information for the formulation of technology programmes. Industry-oriented and key-technology types of exercises are often of this type.

In the social process model, the main role of Foresight is to ensure interactions and exchanges of ideas in the arena where industry, academia, government and social actors meet. Such Foresight exercises aim at setting up hybrid

networking and overcoming established boundaries, going far in the real interactions and debates among the social actors.

For the public debate, the goal is to link societal issues with science, research and innovation, so that the exploration steps concern not only possible futures, but also 'common' futures, that is futures where all segments of society have their place and their share.

Social process Foresight exercises aim at strengthening the innovation system through the reinforcement of the linkages among its constituents, and at being an opportunity to bring new actors and new persons into the process, breaking the established, dominating, networks in order to help new ones emerge. Ultimately, they could become a method for identifying new perspectives and creating new degrees of freedom.

The expected benefits include an early indication of the attitudes of the users and of the citizens regarding both the demand and the social acceptability related to the technologies under discussion. Such an early indication may be of great value for firms and governments alike. Furthermore, it can also be expected that the Foresight process itself may generate a sort of negotiation on the technologies, which would orient them at an early stage towards areas where the demand and the acceptability are strong. Again, this may be of high value.

However, the social process Foresight model faces a number of potential drawbacks and risks. The first one is that the role of users might be too great, so that the notion of 'expert' gets lost, in the sense that all opinions are legitimate, which increases the risks of inconsistency and downright factual errors. The question then is if Foresight is just an occasion for anyone to present opinions for whoever wants to hear them and what real value added could be drawn from this approach. Another issue is the type of products that could or should be expected from such exercises.

Another set of difficulties concerns the representation of stakeholders and particularly lobbyists. Foresight may be in danger of becoming a playground for lobbies, leaving out less organised interests. This issue refers to the simulation of democratic processes, which is the challenge social process Foresights purport to address. In this case, the question arises what value social process Foresights add to democratic decision-making. Social process Foresight exercises might put at risk the normal channels of political decision-making, de-legitimise the political arena or blur its role.

A third aspect involving a particular difficulty is how to deal with opposing and contradictory points of view. Trying to produce some sort of integration, which does justice to the different views, but also points out the major consensus areas is a big challenge, and mediators that can foster such processes are difficult to find and legitimise.

A main task for social process Foresight exercises is to ensure the internal consistency of the debate, which produces the risk of not being relevant for the 'real' economy and society. The value added (early identification of uses and acceptability conditions) and the risks (difficulties of implementation, misunderstanding with decision-makers, superficiality of information flows) need to be well balanced.

4. Utilisation

4.1. Foresights as an instrument of democracy in a knowledge society?

Democracy in a knowledge society is rooted in the existence and quality of the interactive processes linking a wide variety of actors regarding S&T issues and their relation to society. In turn, these processes should plug into the normal decision-making procedures. The question arises whether Foresight can be one of those interactive processes.

The so-called 'social process' model of Foresight may come close to this objective, but, as we have seen, it has risks and limitations in practice. The social process model is particularly adapted to countries with a tradition of public participation and citizen involvement, but may not be feasible in all contexts.

This is why the potential of the professional analytic model ought to be underlined. Its limitations stem from the relatively small number of persons directly involved, which could prevent from including relevant issues and objectives of a wide range of stakeholders. These issues can be addressed in two ways, while keeping the extensiveness relatively low:

(I) Through specific attention to the methods by which the participants can contribute: through formal or informal representatives, the establishment of specific panels of 'citizens', or the input of specialised social scientists,

(II) Through paying particular attention to the dissemination phase, which could develop towards a debate of the results.

We can observe an adaptation of Foresight formats to the specific needs and institutional contexts of the countries. There should be no hierarchy among the types of Foresight, but attention should be paid to specific characteristics that make then suited to certain themes or institutional contexts.

4.2. Linkage with government decision-making

Foresight exercises in most EU-Member States are set up close to, but usually not directly within, governmental institutions. In general, Foresight activities are at a certain distance from governmental activities, which means that an independent panel presents the results and recommendations to the government and the public. In other words, the government is neither directly linked to nor associated with the results. Of course, in most cases, government has a role, usually as a co-sponsor, which ensures that the issues addressed are

relevant for the policymaker. The link to government decision-making thus exists, but is indirect. The possible uses for governmental decision-making are quite diverse, covering objectives like:

- Possible negative impacts of new technologies for some stakeholders or the society,
- Transfer of technology / dissemination of best practices,
- Socio-intellectual event for communication-interactions purposes,
- Social platform / policy testing ground,
- Preferences/visions revealing – testing - disseminating procedure.

Thus, Foresight addresses the 'new innovation challenges' and related questions, contributing to what could be called the 'new S&T governance mechanisms'.

Last but nor least, Foresight is also a potentially important instrument for open co-ordination among the EU member states with the aim of building the European Research Area (ERA).

Based on the monitoring and characterisation of Foresight exercises in most EU Member States, the following challenges and perspectives can be pointed out:

- The design and implementation of interactive processes that provide opportunities for the input from a variety of stakeholders, without falling into the potential risks and difficulties of the societal Foresight process model, nor disregarding significant contributions and interaction,

- The infrastructures needed for access to background studies and previous results of Foresights, the infrastructures and mechanisms for capitalisation of results, methodologies and experiences,
- The evaluation of Foresights, the assessment of their validity and credibility, the building of quality assurance mechanisms and of ethical norms ; the need of a systematic reflexive, evaluative and cumulative work done on the experiments and exercises that have taken place during the last years in the EU Member States,
- Taking into account the different cultures and institutional settings in the respective disciplinary fields and/or countries, the different rationales among the key-actors (e.g. scientists, policy makers, industry, or non-governmental organisations),
- The balance between the depth of analysis and openness of the discussion, and between the variety of hypothesis taken into account and the practicability of the exercise, and
- The assessment of the role for web-based methodologies and techniques for foresight exercises.

5. Conclusions

The monitoring of Foresight studies[73] points to several key-issues and challenges for Foresight, which often need to be carefully balanced:

- The definition of the proper 'distance' of the Foresight process from government. It should be close enough to include politically relevant subjects, but far enough to keep the freedom to address

[73] More detailed information can be found in the background paper at http://www.jrc.es.

real issues and alternatives and to be clearly separated from official institutional decision-making procedures,

- The need to get the commitment and interest of a wide range of stakeholders. Their background should wide enough to enlarge the vision, provide for meaningful interactions and serve as a learning social process, but yet manageable and with proven quality,
- The need to handle controversial and divergent opinions, leaving space for alternatives and unconventional hypothesis, but converging on a few relevant scenarios and identifying the areas of consensus.

The following open questions have also been identified:

- The possibility for Foresight exercises to be more cumulative, both in terms of their methods and results, and draw more benefit from previous experience and existing know-how and infrastructures,
- The objective of having proper evaluation procedures and methods for Foresight exercises. This issue is crucial, since the risks exist that a Foresight exercise becomes superficial, misleading, or influenced by a powerful stakeholder or lobby,
- The adaptation to the differing institutional forms and contexts existing in the different countries,
- The issue of handling EU-wide issues and concerns through Foresight, and in particular areas of EU policy.

We consider that democracy in a knowledge society is rooted in the existence and quality of the interactive processes linking a wide variety of actors regarding S&T issues in their relation to society. This is what is meant by the

concept of 'collective' or 'distributed' intelligence[74]. At present, we are clearly in the very early stages of experiencing this form of democracy, and there is still little experience of the proper design and handling of such processes.

It is suggested that Foresight is a potentially powerful instrument in this respect, with features that may be related to the 'social European model' of development, embedding S&T issues in a broader political framework.

This is why Foresight should be the aim of further assessment and work, especially with respect to a better use in the EU member states, putting its potential at the service of policy making at the EU-level, and also to be used as an open co-ordination instrument that contributes to building the European Research Area.

[74] See Kuhlmann et al. (1999)

V. Concluding Remarks on Strategic Intelligence

Author: **Ahti Salo** (HUT[75])

1. Introduction

The preceding chapters offer a rich picture of European activities in Technology Assessment, Technology Foresight and Technology Forecasting. Indeed, it is very appropriate that these three instruments of Strategic Intelligence should be considered together, not least because this allows for comparative analyses and makes it possible to adopt a systemic perspective in examining Strategic Policy Intelligence[76]. Here, we first make brief remarks on each of the preceding chapters and then conclude with observations on potential synergies between the three instruments.

2. Remarks on the Synthesis of Technology Forecasting

Technology Forecasting is the oldest one of the three intelligence instruments discussed in this report. Much of the early literature on technology forecasting stems from the late 1960's when the forecasting methods that had helped convert results from 'big science' into successful large-scale engineering projects formed the core of a new scientific discipline[77]. Subsequently, new methods have been developed, while the emphasis of Technology Forecasting has shifted from the production of numeric forecasts towards the implementation of continuous processes for the monitoring of technological and even socio-economic trends. This trend can partly be attributed to the increasing complexity of socio-economic systems, which makes it necessary

[75] Helsinki University of Technology (HUT), Systems Analysis Laboratory, P.O.Box 1100, 02015 HUT, Finland, e-mail: ahti.salo@hut.fi

[76] See Andersson (1998)

[77] See Jantsch (1967)

to adopt a sufficiently broad scope in Technology Forecasting as well[78]. The recent proliferation of industrial 'future watch' activities, for example, can be understood against this background.

The fact that 'Technology Forecasting' is not readily identified with specific research organisations (as is sometimes the case with Technology Assessment) or widely known exercises (as is the case with Technology Foresight) is a challenge for monitoring such activities. In many research institutes, for example, technology forecasting is not organised as a formal activity explicitly assigned to a separate unit. It is rather the case that in-house experts routinely monitor developments in their respective fields of expertise and can be requested to produce forecasts when needed. Thus, it is difficult to provide unambiguous answers to questions such as how many 'experts' are working on Technology Forecasting. The prevalence of these 'informal' approaches, together with the somewhat different definitions of Technology Forecasting, explains why researchers, industrial RTD managers and policy-makers sometimes hold different notions of what Technology Forecasting is about.

Codified information on technological developments is produced not only by publicly funded research organisations but also by consultancies, which offer intelligence products to firms and other clients. As some of these products may be relevant to S&T policy-makers, Technology Forecasting should not be considered only from the viewpoint of research organisations that carry-out contract research for public bodies (e.g. S&T ministries or funding agencies). In fact, the strengthening of contract research may not be the most expedient way to improve the utilisation technology forecasts, because this may lead to an unnecessary duplication of efforts unless effective dissemination mechanisms are in place[79]. This is also one of the reasons for investing in monitoring activities, which, by design, contribute to

[78] See Kash and Rycroft (1994)

[79] See Salmenkaita and Salo (2002)

networking, information dissemination and improved utilisation of Strategic Policy Intelligence.

Although the chapter on Technology Forecasting suggests that the general public does not take part in Technology Forecasting, the public is not necessarily excluded from the development of technology forecasts. So far, public participation has been rare because the issues addressed by Technology Forecasts have tended to be more 'technical', so that consultations have been carried out mostly within S&T communities. However, to the extent that economic and social factors are increasingly important in influencing the direction of technological development, it may be pertinent to encourage wider participation in Technology Forecasting. Among other things, this makes it possible to solicit further viewpoints into a debate on what the forecasts signify to the different stakeholders.

3. Remarks on the Synthesis of Technology Assessment

The review pays attention to the diversity of European Technology Assessment activities. In particular, it highlights that these activities are very much contingent on their socio-political context, whereby part of the value of Technology Assessment stems from its ability to give an impetus to the shaping of these contexts.

As with Technology Forecasting, it is difficult to appraise the extent, quality and impact of Technology Assessment in the absence of well-established institutional structures. This is probably one of the reasons for why parliamentary Technology Assessment, which is firmly institutionalised in several European countries, is relatively well known. Also, parliamentary Technology Assessment has been institutionalised at the supranational level.

The European Parliamentary Technology Assessment (EPTA) network has gradually expanded, allowing its members to share experiences and address common challenges.

It is worth adding here that the main 'client' of parliamentary Technology Assessment (i.e., the legislative) in different countries faces much the same challenges with respect to S&T policymaking. In contrast, the needs of the executive for Technology Assessment inputs are more diverse in terms of clients (e.g. ministries, funding agencies, or regulatory bodies) and content (e.g. S&T base or value base).

4. Remarks on the Synthesis of Technology Foresight

The chapter on Foresight activities builds on a large amount of empirical material, of which only a small fraction is contained in this report. For the analysis, the contributors have developed useful 'grids of analysis', based on notions such as 'extensiveness' and 'intensiveness' (which refer to the scope of the foresight exercise and level of interaction among its participants) and 'social vision' and 'professional brainstorming' (which refer to two possible approaches in which Technology Foresight can be carried out).

While such grids are quite helpful, some caution has to be taken in their application and interpretation. For example, the use of absolute numbers of participants as an indicator of 'extensiveness' may be misplaced in the sense that smaller countries would rarely be in a position to initiate an 'extensive' exercise, even if they were to mobilise a substantial proportion of their S&T communities. Furthermore, 'intensiveness' may be difficult to assess, partly because readily available quantitative measures (e.g. time spent on panel meetings) cannot be used as surrogates for the more important qualitative characteristics of intensiveness (e.g. creativity of such meetings).

The notions of 'social vision' Foresight and 'professional brainstorming' capture some of the methodological and organisational differences in recent Foresight exercises. However, in view of the diversity of Foresight exercises, these notions should not be seen as mutually exclusive but rather as two

classic forms that span a variety of approaches and combinations thereof. In addition, it must be stressed that these notions are used as labels for different types of Foresight activity and not as attributes for Foresight deliverables. For instance, professional brainstorming as an *activity* may be helpful in generating *descriptions* of social visions.

One should be wary of assuming that 'social vision' foresight exercises are more 'progressive' merely because 'social visions' have been produced in many recent exercises. Rather, the progressiveness of any Foresight exercise needs to be considered in relation to its specific objectives, and not by reference to external yardsticks which may be inappropriate or even irrelevant. Furthermore, the viability of a 'social vision' Foresight exercise depends on its socio-political environment: due to this context-sensitivity, it may be difficult, if not impossible, to successfully 'transplant' Foresight exercises from one context to another.

Although Technology Foresight is of a more recent origin than Technology Forecasting or Technology Assessment, many well-known Foresight exercises were carried out more than ten years ago, followed by a wealth of activity in the 1990s[80]. Thus, Foresight is no longer in its incipient stage, and it can therefore be expected (and even required) to move towards increasing professionalisation. This is likely to be coupled with the emergence of communities[81] with expertise and competence in the implementation of Foresight processes, development of methodological innovations and assessment of Foresight impacts. The strengthening of these communities is crucial for harnessing the Foresight potential and for understanding its limitations too.

[80] See OECD (1996)

[81] Or, more specifically, epistemic communities (see Haas (1992))

5. Challenges for Strategic Policy Intelligence

Innovation policies are implemented in a changing socio-political context that is influenced by trends such as the following[82]:

(1) Growing importance of innovation as a key determinant of the economic well being and industrial competitiveness of knowledge-based societies. This realisation alone, even if based on an admittedly narrow perspective, calls for attention to how Strategic Intelligence instruments are defined, implemented and utilised.

(2) Weak predictability of technological progress in rapidly advancing fields (e.g. telecommunication). Among other things, this makes it necessary to embed intelligence instruments in the context of strategic policy instruments[83].

(3) Need for systemic policies (including regulation, procurement, and innovation policy) in the management of innovation processes, which involve several actors and are likely to lead to pervasive societal impacts (e.g. mobile payment systems).

(4) Demands for improved transparency and enhanced legitimacy of policy-making processes, partly caused by unfortunate failures in the management of techno-economic systems (e.g. BSE).

(5) Widespread adoption of information and communication technologies (ICT), which help in the collection, synthesis and dissemination of information, and thus hold potential as vehicles for more effective implementation of Strategic Intelligence.

[82] See Kuhlmann et al. (1999)

[83] For example with respect to RTD programmes (see Salo and Salmenkaita (2002))

In this changing policy-making context, it is imperative that the instruments of Strategic Policy Intelligence should change, too. Indeed, the instruments described in the three preceding chapters can be seen as 'archetypes' which can offer advice on strategic policy issues in a legitimate, responsible and cost-effective manner. As the policy issues become increasingly complex, however, it becomes crucial to understand how these issues can best be mapped on the requirements for intelligence instruments and combinations thereof.

Arguably, there is a need for hybrid instruments designed as tailor-made configurations to specific needs in specific contexts. Strategic Policy Intelligence may therefore be moving towards increasing 'modularisation', whereby attention is devoted to characterising specific policy issues and the implementing processes for the production and communication of Strategic Policy Intelligence. In this setting, the three instruments (Technology Assessment, Forecasting and Foresight) can be seen as part of an intermediating function between the demands of policy-making on one hand, and the supply of relevant methods and processes on the other. This function may also call for the development of instruments, which do not adhere to the established definitions. Thus, for example, Technology Assessment studies need not focus on technological topics in the narrow sense of the word[84] .

The trend towards hybrid intelligence instruments (and, more generally, the fulfilment of the intermediating function) may call for a broader scope of monitoring activities, as some convenient units of analysis (e.g. Foresight exercises) have to be extended to cover the *contexts* in which Strategic Policy Intelligence is produced, disseminated and used. There is a need for sufficiently 'rich' information on questions such as why and how Strategic

[84] See Salo and Kuusi (2001)

Policy Intelligence is produced, in what ways it is used by policy-makers and other stakeholders and, how contextual factors influence the quality, perceived utility and eventual impacts of Strategic Policy Intelligence[85] .

The need for this kind of 'rich' information suggests that those involved in the production, dissemination and utilisation of Strategic Intelligence should be involved in monitoring efforts as well, because mainly them have the required contextual knowledge. On the other hand, the need for comparability calls for the deployment of research frameworks that make it possible to contrast the contexts, processes and impacts of Strategic Intelligence. Such comparative analyses are important, among other things, for inferring lessons from experiences with earlier instruments and, more specifically, for understanding under what conditions specific intelligence instruments can expected to be successful and efficient.

The above observations point to the need for multiple roles in the monitoring of Strategic Policy Intelligence. While core responsibilities for the design and management of monitoring activities can be assigned to dedicated networks, these activities should be carried out in a close dialogue with relevant stakeholders (particularly including users and producers of Strategic Intelligence). Here, a strong argument in favour of distributed monitoring activities is that these allow the participants to benefit from the monitoring results. For example, greater awareness of Strategic Policy Intelligence may improve the quality of Technology Assessment, Forecasting and Foresight activities *within* the organisations which take part in monitoring activities. Against this background, it seems that a large number of organisations should be involved in the monitoring of Strategic Intelligence, even though there are clearly some administrative and organisational challenges.

[85] See Renn (2001)

The rationale for monitoring instruments of Strategic Policy Intelligence is based on the realisation that information about instruments in one context may be of interest (and possibly of immediate use) in another. The *substantive content* (e.g. factual statements about future developments), may interest users of Strategic Intelligence (e.g. policy-makers) as a source of complementary information, while the details on *process management* may interest those responsible for instrument design and implementation. These two perspectives are not exhaustive and suggest that monitoring activities should be based on:

(1) The identification of targeted clients and other potential users,

(2) The development of respective 'products' (which may be segmented), and

(3) Choices among the alternative means in which these 'products' can be supplied and used.

Also, just as in the case of Technology Foresight, explicit attention needs to be paid to the stakeholders' incentives to ensure that the monitoring activities are rewarding to all concerned[86].

The three instruments of Strategic Policy Intelligence covered by this report are essentially forward-looking. Innovation policies, however, must be based not only the recognition of future developments but also on a realistic appraisal of current RTD capabilities and competencies. As a result, the monitoring of forward-looking instruments is likely to benefit from closer links to evaluation practice and research. For instance, the objectives of extended *ex ante* evaluations can complement those of Technology Foresight[87].

[86] See Salo (2001)

[87] See, Meyer-Krahmer and Reiss (1992)

We conclude this chapter with the following remarks:

(1) Instruments of Strategic Policy Intelligence often convey a consensual view of available policy options and likely consequences thereof. Yet, in the presence of complexities and high uncertainties, it may be pertinent to purposely solicit diverging and individualist viewpoints, which helps to broaden the debate by injecting critical and surprising reflections. Indeed, one can argue that genuine 'Foresight' is a rare characteristic that is more commonly associated with individual capabilities rather than consensus-oriented group deliberations[88].

(2) While Strategic Policy Intelligence is essential for addressing complex policy issues, this very complexity does pose fundamental challenges. For instance, the adoption of a systemic perspective is likely to call for a broader framing of issues, which in turn may entail high uncertainties and vague causal relationships. Then, albeit the requirement for a systemic perspective still remains valid, even the best tools of Strategic Policy Intelligence may not deliver the kind of incontestable information that policy-makers and other stakeholders would prefer to have. In such settings, Strategic Policy Intelligence may be best regarded as a dialogue process for the validation of facts, clarification of values and definition of policy objectives, carried out in an open consultation with stakeholders in order to impart insights and provide an enhanced understanding of the issues involved.

(3) There is a well-developed marketplace for information on anticipated technological developments in some contexts, and hence it is plausible to require that publicly funded instruments do not distort these markets. In practice, this is unlikely because these instruments are typically targeted at specific issues and objectives. Also, these instruments can be

[88] See Loveridge (2000)

justified in relation to several RTD policy rationales, such as the ability to produce information that is highly conducive to innovation processes, but difficult to appropriate (i.e. market failure as a rationale for RTD policies), or because they mitigate systemic failures, structural inertia or anticipatory myopia[89].

(4) As more resources are invested in the instruments of Strategic Policy Intelligence, growing demands for the demonstration of their utility and cost-effectiveness are likely to be made. These demands may not be easy respond to, because the impacts of Strategic Intelligence are often intangible, reflected in heightened awareness and more informed policy decisions. This non-withstanding, advances in the evaluation of Strategic Intelligence instruments are called for.

(5) More generally, the call for 'immediate utility', in the sense that Strategic Intelligence instruments would invariably have to prove their value in one sense or another, is misplaced in the context of Strategic Policy Intelligence. Indeed, by way of analogies to risk management, one could equally well require that ex ante decisions to buy insurance policies, for instance, would be taken only in case the risks would in fact materialise, which is obviously impossible. Hence, Strategic Policy Intelligence must be valued by its ability to contribute to an informed policy debate and to the quality and legitimacy of decision making processes, and not only on the basis of the immediate and instrumental uses it may find.

(6) Due to their different origins, Technology Assessment, Forecasting and Foresight have evolved as relatively independent fields of research. Yet, it seems that enhanced collaboration among these research fields (including evaluation studies as well) should be encouraged, partly because these instruments draw upon similar methods and approaches (e.g. scenarios, panels, Delphi). Also, the consideration of different instruments

[89] See Salmenkaita and Salo (2002)

in parallel may provide additional insights. For instance, results of Foresight studies (which reflect general technological and societal trends) can be juxtaposed with those from evaluation studies (which reflect local RTD competencies).

(7) Advanced Information and Communications Technologies (ICTs) will become increasingly useful in the implementation of instruments for Strategic Policy Intelligence. Here, as suggested in chapter one, ICTs can have a duplicate role as vehicles for supporting the collection, synthesis and dissemination of codified information (e.g., Delphi studies on the Internet) and for enhancing the social processes through which such information is interpreted and refined. This latter role, in particular, seems promising (e.g. group systems for creativity support and policy analysis[90]), because the resolution of complex policy issues invariably calls for such interactive processes.

Instruments of Strategic Policy Intelligence are but one source of inputs to policy-making. Typically, policy-makers and members from the S&T community, industry and non-governmental organisations interact in formal and informal networks. The media influence the choice of topics that are debated, too. Decisions concerning the initiation, shaping and positioning of Strategic Intelligence instruments should therefore be taken in the full realisation that Strategic Policy Intelligence is not supplied in a 'vacuum' but as a complement to other inputs. In this perspective, many of the benefits of Strategic Policy Intelligence relate to its ability to forge new networks and new forms of interaction, direct focused attention to crucial policy issues and, perhaps most importantly, change how these issues are understood.

[90] See Hämäläinen (1991), Hämäläinen and Leikola (1996) or Bongers (2000)

References

Akrich, M.: “Beyond social construction of technology: The shaping of people and things in the innovation process”, in: Dierkes, M. and Hoffmann, U. (eds.): “New Technology at the Outset”, Campus, Frankfurt am Main, 1992, pp. 173 -190

Andersson, T.: “Managing a Systems Approach to Technology and Innovation Policy” STI Review , 22, 1998, pp.9-29

Arthur, B.: “Competing technologies”, in: G. Dosi (ed.): “Technological change and economic development”, Pinter, London & New York, 1988

AWT: “Regionaal technologiebeleid (Regional Technology Policy)”, AWT (The Netherland’s Advisory Committee on Science and Technology), Den Haag, 1995

Ayres, R.U.: “Technological Forecasting and Long-Range Planning”, McGraw-Hill Book Company, New York, 1969

Barré, R.; Gibbons, M.; Maddox, J.; Martin, B. and Papon, P.:”Science in tomorrow’s Europe”, Economica International, 1997

Barré, R.; Esterle, L.; and Charlet, V.: “Science and Governance: the case of France”, Contribution to an ESTO report, Paris, December 2000

Berloznik, R. et al.: “Integrative technology assessment”, Report to the European Commission, DG XIII, Brussels, 1998

Bijker, W., Hughes, T. and Pinch, T. (eds.): “The social construction of technological systems. New directions in the sociology and history of technology”, MIT-Press, Cambridge (MA), 1987

Böhret, C. and Franz, P.: “Technologiefolgenabschätzung durch das Parlament: Die ausländischen Vorbilder und der “Leidensweg” der Institutionalisierung in der Bundesrepublik (Technology Assessment by the Parliament: Foreign Models and the “Suffering” of Institutionalisation in the German Federal Republic”. Gewerkschaftliche Monatshefte, 9, 1985, pp.537-545.

Bongers F.; Smits, R.; Geurts, J. and Holland, C.: “GDSS-supported technology scans at the Dutch Ministry of Economic Affairs”, in: Journal of Decision Systems, 1998

Bongers, F.: “Participatory policy analysis and group support systems”, dissertation Tilburg University, yet to be published, 2000

Brouwer, H.J.: “Computer stelt economisch weinig voor (Computers Say Economically Very Little)”, Volkskrant, 4 October 1999

Brüntink, C.: “Zum Konzept der Innovations- und Technikanalyse des BMBF (The Concept of Innovation and Technology Analysis at the German Federal Ministry of Education and Research)”, Technology Assessment-Datenbank-Nachrichten, 2, 10, June 2001

Büllingen, F.: “Das Office of Technology Assessment (The Office of Technology Assessment)”, In: Bröchler, S., Simonis, G., and Sundermann, K. (eds.): “Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)”, volume 2, 1999, pp. 411-416

Callon, M.: “The sociology of an actor network: the case of the electric vehicle”, in: Callon, M.; Law, J. and Rip, A. (eds.): “Mapping the dynamics of science and technology”, Macmillan, 1987

Castells, M.: “The rise of the network society”, Blackwell Publications, 1996

Coates, J.F.: "Technikfolgenabschätzung in den USA: Vergangenheit und Perspektiven für die Zukunft (Technology Assessment in the USA: Lessons from the Past and Perspectives for the Future)", in: Petermann, T. and Coenen, R. (eds.): "Technikfolgen-Abschätzung in Deutschland (Technology Assessment in Germany)", 1999, pp. 53-64

Coates, V.: "Technology Forecasting and Assessment in the United States: Statistics and Prospects", Futures Research Quarterly, 15, 3, 1999, pp 5-25

Collingridge, D.: "The Social Control of Technology", Frances Pinter, London, 1980

Commisariat Général du Plan: "Intelligence Économique et Stratégie des Entreprises (Business Intelligence and Corporate Strategy)", La Documentation Française, Paris, 1994, ISBN 2-11-003102-6

Cooley, M.J.E.: "Architect or Bee: The Human/Technology Relationship", Hand and Brain, Slough, 1980

Coombs, R. and Miles, I.: "Innovation, measurement and services: the new problematique", in: Metcalfe, J. and Miles, I. (eds.): "Innovations systems in the services economy: measurement and case study analysis", Kluwer, Norwell (MA), 1999, pp.85-103

CPB: "Centraal Economisch Plan (Central Economic Plan)", The Netherland's Central Planning Bureau, The Hague, 2000

van Dijk, J.: "Beleidsinstrumenten in het technologiebeleid (Policy Instruments in Technology Policy)", in: Achterhuis, H.; Geurts, J., Rip, A. and Smits, R. (eds.): "Technologie and Samenleving (Technology and Society)", course book of the Open University, Heerlen., 1995

van Dijk, L. and de Haan, J.: "Moderne informatie- en communicatietechnologie en sociale ongelijkheid (Contemporary Information and Communications Technology and Social Inequality)", Working Paper, SCP, Rijswijk, 1998

Dosi, G. et al.: "Technical change and economic theory", Pinter Publishers, London and New York, 1988

Edquist, C. (ed.): "Systems of Innovation: Technologies, Institutions and Organisations", Pinter, London, 1997

van Eijndhoven, J.C.M.: "Technology Assessment: Product or Process?", Technological Forecasting and Social Change 54, 1997, pp.269-286

EIRMA (2000): "Technology Monitoring for Business Success", European Industrial Research Management Association, WG55, Paris, 2000, http://www.eirma.asso.fr/pubs/rep55/abstract55.pdf

European Commission: "Realising the European Union's Potential: Consolidating and Extending the Lisbon Strategy", COM (2001) 79 final, Brussels, 2001

European Commission: "Growth, Competitive Strength, Employment. Towards the 21st Century: ways and challenge", Office for official publications of the European Communities, Brussels/Luxembourg, 1994

Eurostat: "Second European Report on Science and Technology Indicators. Key Figures', Office for official publications of the European Communities, Brussels/Luxembourg, 1999

Fonk, G.J.: "Constructieve consumenten Technology Assessment (Constructive Consumer Technology Assessment)", dissertation, University of Twente, Twente, 1994

Freeman, C.: “Technology policy and economic performance: lessons from Japan”, Pinter Publishers Ltd, London, 1987

Frissen, P.: “De virtuele staat: politiek, bestuur, technologie: een postmodern verhaal’ (The Virtual State: politics, administration, technology: a post-modern story)”, Academic Service, Schoonhoven, 1996

Gallouj, F. and Weinstein, O.: “Innovation in services”, in: Research Policy, 20, 1997, pp.499-514

Geurts, J.: “Omkijken naar de toekomst’, lange termijn verkenningen in beleidsexercities (Looking Back to the Future. long-term Foresight studies in policy exercises)”, Address, Tilburg University, Samson H.D. Tjeenk Willink, 1993

Gibbons, M.; Limoges, C.; Nowotny, H.; Schwartzman, S., Scott, P. and Trow, M.: ‘The new production of knowledge. The dynamics of science and research in contemporary societies”, Sage Publications. 1994

Gloede, F.: “Partizipative Technikfolgenabschätzung und technikpolitische Entscheidung: das EUROPTA-Projekt (Participatory Technology Assessment and S&T Policy Decisions)”, TA-Datenbank-Nachrichten, 9, 3, October, 2000, see: http://www.itas.fzk.de/deu/tadn/tadn003/inhalt.htm

Grin, J., van de Graaf, H. and Hoppe, R.: “Technology Assessment through interaction”, Rathenau Instituut, W57, Den Haag, 1997

Grunwald, A.: “Einführung in den Schwerpunkt (Introduction to the Focus)”, TA-Datenbank-Nachrichten, 9, 3, October, 2000, see: http://www.itas.fzk.de/deu/tadn/tadn003/inhalt.htm

Haas, P.: “Introduction: Epistemic Communities and International Policy Coordination”, International Organization, 46, 1, 1992, pp.1-35

Hagedoorn, J.: "Trends and patterns in strategic technology partnering since the early seventies", in: Review of Industrial Organization, 1996, pp. 601-616

Hämäläinen, R.P.: "Facts or Values – How Do Parliamentarians and Experts See Nuclear Power?", Energy Policy, 19, 5, 1991, pp.464-472

Hämäläinen, R.P. and O. Leikola: "Spontaneous Decision Conferencing with Top-Level Politicians", OR Insight, 9, 1, 1996, pp.24-28

Hennen, L.: "Partizipation und Technikfolgenabschätzung (Participation and Technology Assessment)", in: Bröchler, S.; Simonis, G. and Sundermann, K. (eds.): "Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)", volume 2, 1999, pp. 565-571

Hennen, L.: "Technology Assessment – Does it always come "too late"?" TAB, 17, December 1999

den Hertog, P.; Bilderbeek, R.; Marklund, G. and Miles, I.: "Services in innovation: Knowledge Intensive Business services as co-producers of innovation", SI4S synthesis paper no 3, Published by STEP, Oslo, 1998

Holtmannspötter, D. and Zweck, A.: "Monitoring of Technology Forecasting Activities", VDI Working Paper, Düsseldorf, 2001

Hughes, T.: "The evolution of large technological systems", in: Bijker, W.; Hughes, T. and Pinch, T. (eds.): "The social construction of technological systems. New directions in the sociology and history of technology", MIT Press, Cambridge (MA), 1987

Jacobs, D.: "Het kennisoffensief (The Knowledge Offensive)", Samson, 1998

Jantsch, E.: "Technological Forecasting in Perspective", OECD, Paris, 1967

Johnson, B.: "An institutional approach to the small country problem", in: Freeman, C. and Lundvall, B. (eds.): "Small countries facing the technological revolution", Pinter Publishers, London, 1988

Kash, D.E. and Rycroft, R.W.: "Technology Policy: Fitting Concept with Reality," Technological Forecasting and Social Change, 47, 1994, pp.35-48

Kelly, K.: "New rules for the new economy", Viking Books US, Forth Estate UK, 1998

Kuhlmann, S. et al.: "Improving Distributed Intelligence in Complex Innovation Systems. Final Report of the Advanced Science & Technology Policy Planning Network (ASTPP)", Fraunhofer Society, ISI, Karlsruhe, 1999

Kunkle, G.C.: "New Challenge or the Past Revisted? The Office of Technology Assessment in Historical Context", Technology in Society, 17, 1995, pp.175-196

Lambooy, J.: "Economisch paradijs bestaat niet (An Economic Paradise Doesn't Exist)", Volkskrant, 27 September 1999

Law, J. and Hassards, J.: "Actor network theory and after", Blackwell, 1998

Lenk, H.; Rapp, F. and Ropohl, G.: "Wertgrundlagen der Technikbewertung (Basic values of Technology Assessment)", in: Graf von Westphalen, R. (ed.): "Technikfolgenabschätzung als politische Aufgabe (Technology Assessment as a Political Task)", 3rd edition, 1997, pp.115-136

van Lente, H.: "Promising technologies. The dynamics of expectations in technological developments", Eburon, Delft, 1993

Lintsen, H. et al.: "Geschiedenis van de techniek in Nederland. De wording van een moderne samenleving 1800-1900 (The History of Technology in the

Netherlands. The birth of a modern society 1800-1900)", Stichting Historie der Techniek, Walburg Pers, 1994

Loveridge, D.: "Foresight: Seven Paradoxes," International Journal of Technology Management, 21, 7-8, 2000, pp.781-792

Martin, B.: "Foresight in science and technology", Technology Analysis and Strategic Management, 7, 2, 1995

Martino, J.P.: "Technological Forecasting for Decision Making", North-Holland, New York, 1983

Mayer, I.: "Participatory policy analysis: debating technologies", dissertation, Tilburg University, Tilburg, 1997

Meyer, R.: "A Short History of TA Concepts", TAB, 17, December 1999

Meyer Krahmer, F. and Reiss, T.:. "Ex Ante Evaluation and Technology Assessment: Two Emerging Elements of Technology Policy", Research Evaluation, 2, 1992, pp.47-54

Millett, S. and Honton, E.J.: "A manager's guide to technology forecasting and strategy analysis methods", Battelle Press, Columbus, 1991

Naschold, F.: "Technologiefolgenabschätzung und -bewertung: Entwicklungen, Kontroversen und Perspektiven (Technology Assessment: Controversies and Perspectives)", in: Ropohl, G.; Schuchardt, W. and Wolf, R.: "Schlüsseltexte zur Technikbewertung (Key contributions to Technology Assessment)", 1990, pp.168-186

Nelson R. and Winter, S.: "In search of a useful theory of innovation", Research Policy, 6, 1977

The Netherlands' Ministry of Economic Affairs: "Industrie- en dienstenbeleid (Industrial and Services Policy)", letter to the Lower House, 26 628, session 1998-1999, Staatsuitgeverij, The Hague, 1999

OECD: 'Technology and the economy: The key relationships' report of the Technology and Economy Programme", Organisation for Economic Co-operation and Development, Paris, 1992

OECD: "Special Issue on Governmental Technology Foresight Exercises", STI Review, 17, Organisation for Economic Co-operation and Development, Paris, 1996

OECD: "Policy evaluation in innovation and technology. Towards best practices", Organisation for Economic Co-operation and Development, Paris, 1997

OECD: "Boosting innovation. The cluster approach", Organisation for Economic Co-operation and Development, Paris, 1999

Paschen, H. and Petermann, Th.: "Technikfolgen-Abschätzung: Ein strategisches Rahmenkonzept für die Analyse und Bewertung von Techniken (Technology Assessment: A Strategic Concept for the Analysis and Evaluation of Techniques)", in: Petermann, T. (ed.): "Technikfolgen-Abschätzung als Technikforschung und Politikberatung (Technology Assessment as Research on Techniques and Policy Advice)", 1991, pp.19-41

Petermann, Th.: "Technikfolgen-Abschätzung: Konstituierung und Ausdifferenzierung eines Leitbildes (Technology Assessment: Establishment and Differentiation of a Lead-concept)", in: Bröchler, S., Simonis, G. and Sundermann, K. (eds.): "Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)", volume 1, 1999, pp. 17-49

Petermann, T. (ed.): “Technikfolgen-Abschätzung als Technikforschung und Politikberatung (Technology Assessment as Research on Techniques and Policy Advice)”, AFAS Publication, volume 1, Campus Verlag, Frankfurt am Main and New York, 1991

Pieterson, M. (eds.): “Het technisch labyrint. Een maatschappijgeschiedenis van drie industriële revoluties (The Technical Labyrinth: A social history of three industrial revolutions)”, Boom, Amsterdam, 1981

Porter, A.L. et. al.: “Forecasting and Management of Technology”,. John Wiley & Sons, New York, 1991

Porter, M.: ‘The competitive advantage of nations’, The Macmillan Press, London, 1990

Rader, M.; von Berg, I.; Böhle, K., Coenen, R.; Frederichs, G. and Leßmann, E.: “Feasibility Study on Instruments for the Coordination of the European Technology Assessment Infrastructure (ETAI): Coordinating Scheme, Database and Newsletter”, European Commission, DG XIII/D2, Dissemination of Scentific and Technical Knowledge Unit, Luxembourg/Karlsruhe, 1995

Reger, G., Bürgel, H. D. and Ackel-Zakour, R.: “Technology Foresight in Industrial Firms: Learning from Experiences for Public Services Companies”, in: Burton, F.; Yamin, M. and Bowe, M. (eds.): “EIBA 99 - European International Business Academy, 25th Annual Conference: International Business and the Global Services Economy”, Manchester, 12 - 14 December 1999

Renn, O.: “The Role of Social Science in Environmental Decision Making: Experiences and Outlook”, Science and Public Policy, 28, 6, 2001, pp.427-437

Ropohl, G.: "Ethik und Technikbewertung (Ethics and Technology Assessment)", Frankfurt am Main, 1996

Ropohl, G. (1999): Innovative Technikbewertung. in: Bröchler, S., Simonis, G. and Sundermann, K. (eds.): "Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)", 1999

Rosenbrock, H.H.: "Engineers and the Work People Do", IEEE Technology and Society, 9, 3, 1981

van Rossum, W.: "Innovatie en de ontwikkeling van bedrijven (Innovation and the evolution of businesses)", inaugural address, Twente University Press, Twente, 2000

Rotmans, J.; Kemp, R.; van Asselt, M; Geels, F.; Verbong, G. and Molendijk, K.: "Transities & transitiemanagement: de casus van een emissiearme energievoorzieing (Transitions and transition management: the case of emission low energy supply)", International Centre for Integrative Studies, Maastricht, 2000

Rouach, D.: "La Veille Technologique et L'Intelligence Économique (Technology Watch and Business Intelligence)", Presses Universitaires de France, Paris, 1996

Rutten, P.: "De toekomst van de verbeeldingsmachine: de culturele industrie in de twintigste eeuw (The Future of the Imagination Machine: Cultural industry in the twentieth century)", Boekmancahier, 1, 2000 (1999)

Salmenkaita, J.-P. and Salo, A.: "Rationales for Government Intervention in the Commercialization of New Technologies", Technology Analysis and Strategic Management, 14, 2, 2002 (forthcoming)

Salo A. and Salmenkaita, J.P.: "Embedded Foresight in RTD Programs" International Journal of Technology, Policy and Management, 2002, (forthcoming)

Salo, A.: "Incentives in Technology Foresight", International Journal of Technology Management, 21, 7-8, 2001, pp.694-710

Salo, A. and Kuusi, O.: "Developments in Parliamentary Technology Assessment in Finland", Science and Public Policy, 28, 6, 2001, pp.453-464

Saretzki, T.: "Technology Assessment als diskursiver Prozeß (Technology Assessment as a Discursive Process)", in: Bröchler, S., Simonis, G. and Sundermann, K. (eds.): "Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)", 1999

Schot, J. et al.: "Techniek in Nederland in de twintigste eeuw (Technology in the Netherlands in the Twentieth Century)", Stichting Historie der Techniek, Walburg Pers, 1998

Schot, J.: "Constructive Technology Assessment and Technology Dynamics: The Case of Clean Technologies", Science, Technology and Human Values, 17, 1, 1992, pp.36-56

Schumpeter, J.: 'The theory of economic development", Oxford University Press, London, 1980 (1934)

Schwarz, M. and Thompson, M.: "Divided we stand: re-defining politics, technology and social choice", Pinter, London-New York, 1990

Shapiro, C. and Varian, H.: "Information Rules", Harvard Business School Press, Boston, 1999

Shapley D. and Roy, R.: “Lost at the frontier: US science and technology policy adrift”, ISI-Press, Philadelphia, 1985

Smits R.: “De rol van de contract research organisatie met een publieke missie op de vrije markt (The Role of the Contract Research Organisation with a Public Mission on the Free Market)”, in: Zwetsloot, F. (ed.): “Sturing van wetenschappelijk onderzoek (The Shaping of Scientific Research)”, Uitgeverij Delwel, The Hague, 1997

Smits R. and Leyten, A.: ‘Technology Assessment: waakhond of speurhond? Naar een integraal technologiebeleid (Technology Assessment: watchdog or tracker dog? Towards an integral technology policy)”, Dissertation, Free University, Kerckebosch, Zeist, 1991

Smits R., Leyten, A. and den Hertog, P.: ‘Technology assessment and technology policy in Europe: new concepts, new goals, new infrastructures”, Policy Sciences, 28, 1995

Smits, R.: “Elk land krijgt de technologie die het verdient, maar lang niet altijd die welke het nodig heeft (Every Nation Gets the Technology it Deserves, But Not Always the Technology it Needs)”, Address, Tilburg University, Tilburg University Press, Tilburg, 1994

Smits, R., Hekkert, M. and van Lente, H.: “Intermediairen en transitiemanagement: nieuwe rollen voor NOVEM? (Intermediaries and transition management: new roles for NOVEM?)”, report of the Department of Innovation Studies commissioned by NOVEM, Utrecht, 2001

Snijders, H.: “Eendimensionale wetenschap. Bespiegelingen over bruggen tussen berekenen en beschouwen (One-dimensional Science. Reflections on bridges between calculating and contemplating)”, Uitgeverij CREON, 1997

Soete, L.: “Infonomie, contouren van een nieuwe discipline (Infonomy, Contours of a New Discipline)”, address at the opening of the academic year, Utrecht University, 1999

van der Steen, M.: “Evolutionary systems of innovation”, Van Gorcum, Assen, 1999

Steinmüller, K.; Tacke, K. and Tschiedel, R.: “Innovationsortientierte Technikfolgenabschätzung. (Innovation-oriented Technology Assessment)”, in: Bröchler, S., Simonis, G. and Sundermann, K. (eds.): “Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)”, 1999, pp. 129-145

Sundermann, K.: “Constructive Technology Assessment”, in: Bröchler, S., Simonis, G. and Sundermann, K. (eds.): “Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)”, 1999

Twiss, B.C.: “Managing Technological Innovation”, Longman, London, 1980

VDI: “Technikbewertung: Begriffe und Grundlagen (Technology Assessment: Definition and Basic Principles)”, VDI-Richtlinie 3780, VDI Verein Deutscher Ingenieure, Düsseldorf, 1991

VDI: “Aktualität der Technikbewertung”, VDI - Verein Deutscher Ingenieure, Düsseldorf, 1999

Wachlin, K.D. and Renn, O.: “Diskurse an der Akademie für Technology Assessment in Baden-Württemberg (Discurses at the Academy for Technology Assessment in Baden-Württemberg)”, in: Bröchler, S., Simonis, G. and Sundermann, K. (eds.): “Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)”, 1999, volume 2, pp. 713-722

Ziman, J.: “Science in a steady state. The research systems in transition”, SPSG draft paper, 1, 1987

Zweck, A.: “Technologiefrüherkennung: Ein Instrument zwischen Technikfolgenabschätzung und Technologiemanagement (Technology Forecasting: an instrument between Technology Assessment and technology management)”, in: Bröchler, S., Simonis, G. and Sundermann, K. (eds.): “Handbuch Technikfolgenabschätzung (Handbook Technology Assessment)”, 1999

CONTACT INFORMATION

Alexander Tübke

Researcher
European Commission, Joint Research Centre (JRC)
Institute for Prospective Technological Studies (IPTS)
Edificio Expo-WTC
C/ Inca Garcilaso, s/n
E-41092 Sevilla, España (Spain)
Tel: +34 95 448 83 06, Fax: +34 95 448 83 26
e-mail: Alexander.Tubke@jrc.es
Personal webpage: www.jrc.es/~tubke
IPTS webpage: www.jrc.es/welcome.html.en
JRC webpage: www.jrc.org

Ken Ducatel

Futures Project Leader
European Commission, Joint Research Centre (JRC)
Institute for Prospective Technological Studies (IPTS)
Edificio Expo-WTC
C/ Inca Garcilaso, s/n
E-41092 Sevilla, España (Spain)
Tel: +34 95 448 83 82, Fax: +34 95 448 83 26
e-mail: Ken.Ducatel@jrc.es
Personal webpage: www.jrc.es/~ducatel
IPTS webpage: www.jrc.es/welcome.html.en
JRC webpage: www.jrc.org

James P. Gavigan

Futures Project
European Commission, Joint Research Centre (JRC)
Institute for Prospective Technological Studies (IPTS)
Edificio Expo-WTC
C/ Inca Garcilaso, s/n
E-41092 Sevilla, España (Spain)
Tel: +34 95 448 83 19, Fax: +34 95 448 83 26
e-mail: James.Gavigan@jrc.es
Personal webpage: www.jrc.es/~gavigan
IPTS webpage: www.jrc.es/welcome.html.en
JRC webpage: www.jrc.org

Pietro Moncada-Paternò-Castello

ESTO Network Manager
European Commission, Joint Research Centre (JRC)
Institute for Prospective Technological Studies (IPTS)
Edificio Expo-WTC
C/ Inca Garcilaso, s/n
E-41092 Sevilla, España (Spain)
Tel: +34 95 448 83 88, Fax: +34 95 448 83 39
e-mail: pietro.moncada-paterno-castello@jrc.es
Personal webpage: www.jrc.es/~moncada
IPTS webpage: www.jrc.es/welcome.html.en
JRC webpage: www.jrc.org