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EDITED BY THE INSTITUTE FOR PROSPECTIVE TECHNOLOGICAL STUDIES (IPTS)
AND ISSUED IN COOPERATION WITH THE EUROPEAN S&T OBSERVATORY NETWORK

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C O N T E N T S

An avenue which deserves much more exploration, both because of its higher acceptability, as well as because of the gains it can generate in terms of jobs, is product and service market liberalization. The benefits from streamlining the launch of new products and services, and facilitating new firms' setting up shop, are two-fold. On the one hand the offer to the consumer is expanded and through product innovation demand can be triggered – or even latent demand can be unearthed – and new jobs can be created. On the other hand, the entry of new firms will facilitate the emergence of more competitive firms (the newcomers and/or incumbents pushed to become more competitive to face the competition); the success of these firms will generate more jobs, not only within these firms but also in their suppliers, and their economic milieu, more generally.

The role of science and technology (S/T) as a key driver of growth was underlined, not only in terms of direct input to innovation and as a generator of technical progress, but also as a key determinant of the quality of human capital, at European level. The goal here can be phrased in a way similar to the one used for the case of employment above: what is needed is more and better R&D, and the drive towards a European research area is meant to enable that. First, more research is needed, since, in terms of R&D spending as a percentage of GDP (R&D/GDP), the gap between the EU and other key technological and economic powerhouses (such as the US and Japan) is not only large but growing: hence the importance of the target of 3% for R&D/GDP spending. Second, it is important to enhance the articulation of R&D with other dimensions of the innovation process such as financing, regulatory, industry, etc. - a helpful concept here is the one of a European level cluster-type approach.

A key dimension of the above involves a rethinking of the role and action/interaction of national research organizations, for instance in terms of rethinking ways to exploit complementarities, as well as a rethinking of the role of individual researchers, and ways to enhance their mobility, trans-nationally, as well as between industry and academia, public and private sectors.

Last, but certainly not least, on the topic of sustainable growth, or development, more generally, emphasis was placed on the importance of recognizing latent demand making the provision of environment-friendly goods and services a profitable business, as well as on 'win-win' approaches, often technology-driven, which can allow raising efficiency in production and reduce environmental damage. S/T is key here in more ways than one. It affords us ways to substitute between different forms of depletable natural capital, as well as to enhance our ability to substitute natural capital by man-made one. Moreover, S/T helps us preserve the set of options available to future generations (e.g. as to the level of each natural stock) through research warning us on whether we are reaching irreversible thresholds. Finally, through its engine-of-growth role S/T can help us, and future generations, afford and cushion the short term economic cost of exercising these environmental options.

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need to devise an appropriate development strategy, together with a sound innovation policy as one of its cornerstones, and to strengthen their innovation systems.

Foresight – as a systematic, participatory process, collecting future intelligence and building medium-to-long-term visions aimed at influencing present-day decisions and mobilizing joint actions – can be a useful tool in meeting these challenges (EC, 2002). It helps in making choices – and shaping our future – in an ever more complex situation by discussing alternative options, bringing together different communities with their complementary knowledge and experience. In doing so, and discussing various visions with stakeholders, it also leads to a more transparent decision-making process. Foresight processes can reduce certain types of uncertainty, too: participants would learn about each other's broad strategic goals. Moreover, it can align their endeavours once they arrive at a shared vision. Many governments have already realized the importance of foresight activities, and thus this relatively new technology policy tool is spreading across continents (Fleissner, 1998; Gavigan and Cahill, 1997; OECD, 1996).

Foresight can also contribute to tackling yet another challenge faced by ACs. Most accession countries are struggling with 'burning' short-term issues (such as pressures on various public services, e.g. health-care, education, pensions and the resulting severe budget deficits; imbalances in current accounts and foreign trade; unemployment; etc.), while at the same time having to confront a compelling need for fundamental organizational and institutional changes. In other words, short- and long-term issues compete for various resources: capabilities (intellectual resources for problem-solving); attention of politicians and policy-makers who decide on the allocation of funds; and attention of opinion-formers who can set the agenda (and thus influence discussions and decisions on the allocation of funds). These intellectual and financial resources are always limited, therefore choices have to be made. A thorough, well-designed foresight process can help identify priorities and facilitate the process of striking a balance between short- and long-term issues.

Foresight, however, is not a panacea; it cannot solve all the above problems, and indeed on its own, cannot solve any of them.

Level and scope of foresight

Foresight has today reached a sufficient degree of maturity for it to be possible to classify different approaches (Barré, 2001, 2002, Johnston, 2002, Renn, 2002). In other words, although no 'optimal' approach or any form of 'best practice' can be identified, taxonomies can be developed to highlight 'good practices': i.e. what has worked in certain circumstances (level of development, challenges and hence policy aims), and thus the set of tools and approaches that are likely to be useful in various environments.

Foresight programmes can be either holistic or just concentrate on particular technologies or business sectors. Holistic programmes, in turn, may have somewhat different foci, ranging from the identification of priorities in a narrowly defined S&T context to addressing broad socio-economic needs. They can also have different geographical scopes, i.e. they can be conducted at international (groups of countries, collaborating regions straddling national borders), national, regional, local, sectoral or firm level.

Foresight programmes can be product or process oriented, depending on the policy needs they are intended to serve, e.g. informing specific decisions with analytical reports, lists of priorities, recommended actions vs. facilitating networking,

Foresight – as a systematic, participatory process, collecting future intelligence and building medium-to-long-term visions aimed at influencing present-day decisions and mobilizing joint actions – can be a useful tool in meeting these challenges

In many accession countries there is also considerable competition for resources between long- and short-term goals. A thorough, well-designed foresight process can help identify priorities and help strike a balance between competing goals

Although it is not possible to identify 'best practice' as such in Foresight, the techniques are sufficiently mature for various types of 'good practice' to be classified

Some countries, however, might find it more appropriate to launch sectoral or regional programmes as pilot projects to 'test' the willingness of potential participants, gather experience about various techniques, etc., that is, to use these pilot projects as 'on-the-job' training and preparation for their future national foresight programme.

In any case, the organization and the management of any foresight programme is crucial:

- The design of the programme should take into account the level of socio-economic development; the size of the country in question; the socio-psychological legacy of central planning; the overall communication, cooperation and decision-making culture (norms, patterns, written and tacit rules); the legal, organizational and institutional framework, etc.
- Objectives should be formulated clearly at the very beginning. To juxtapose two extremes, a foresight programme can be:
  - limited to assisting the decision-making process relating to setting a narrowly defined R&D agenda (as mentioned above, that was the case in the Czech Republic, accordingly the 'key technologies' method was used); or
  - geared towards the broader socio-economic needs and problems of the country in question, i.e. defining the role of S&T developments, various policies and regulation in solving these broader problems, defining the responsibilities of the various actors: government, scientists and researchers, businesses, NGOs, families, individuals (This was the approach taken in Hungary).

Given the challenges of enlargement in general, and the very nature of the systemic changes in the case of transition countries, it seems appropriate to stress the importance of 'visions' ('futures', or fully fledged scenarios) for ACs both at panel (i.e. micro or meso) and macro levels. Visions (scenarios), however, have been mainly used at micro level so far (e.g. in the case of the UK, Portugal, Sweden and Spain), with the exception of Hungary and South Africa. Yet, combining micro and macro visions is not an elementary or self-evident task (Havas, 2003). Obviously, there is a need for methodological innovations in this respect.

If the panel method is to be applied, the decision on the issues for panel discussions and reports is also crucial in terms of the expected output. One possibility is to set up panels to analyse various disciplines and/or economic sectors (e.g. the first UK foresight programme). A different approach would be to analyse broader socio-economic issues, like human resources, health, environment, business processes, of course with a strong emphasis on technological drivers/opportunities, too, in that context (see e.g. the Swedish and the second UK foresight programmes). Again, taking into account the various accession challenges, the latter approach is clearly more appropriate for ACs.

The process of accession also calls for explicit policy recommendations (as opposed to, those of the German and Japanese foresight exercises, for example). Again, the decisions on the objective, methods and scope (if it has a technological or a broader socio-economic focus) of the programme would influence the issues for policy proposals (e.g. narrowly defined S&T policy *vs.* human resources, various fields of regulation, competition, innovation, FDI and regional development policies, institution and network building).

Besides panel discussions/reports, a Delphi-survey could also be useful in ACs. Its benefits are threefold: (i) it collects information (experts' opinions), it (ii) disseminates this information, and by doing so, contributes to consensus building or identifying dissenting views, and (iii) it usually involves a wider range of participants in the process (as opposed to the case when only panels

Given the specific accession challenges, it seems to be more appropriate to start with a holistic foresight programme at national level, although some countries might prefer to launch sectoral or regional programmes to test participation and build up expertise

The challenges of enlargement and the nature of the systemic changes being undergone by transition countries make it important to develop 'visions' or scenarios at the macro level relations, i.e. building trust through actual co-operation during the national/regional foresight programmes.

This type of regional cooperation can also help by exploiting economies of scale (compensating for insufficient intellectual resources in highly specialized fields, be they technical, socio-economic or policy expertise). Some possible ways of kicking off this cooperation include:

- producing (commissioning) joint background studies on major technological and socio-economic drivers (relevant for the cooperating accession countries). More in-depth, context-specific analyses, of course, should be conducted and policy conclusions should be drawn as part of the national foresight programmes.
- devising scenarios on European/global developments (if scenarios are to be used in the various national programmes);
- building partially aligned scenarios (the structure of scenarios might be partially coordinated, in other words some 'variables' might be the same, while their actual 'value' would differ from country to country).

Once cooperation starts, other issues to be discussed jointly and further possibilities for building capabilities and sharing resources, exploiting economies of scale are likely to be identified by the participants themselves. In other words, any rigid 'blueprint' for this cooperation might be counter-productive: insisting on a detailed plan (methods and milestones) might do more harm than good.

International cooperation, however, also poses a significant challenge: the broader the programme's geographic scope, the more difficult and costly it is to maintain its participatory character. Moreover, when participants are drawn from different countries – which vary in terms of level of development, norms, ways of thinking, values, behavioural routines – it is not only a question of the cost and time involved in travelling and in organizing meaningful workshops. In such cases potential communication problems should be taken into account carefully when preparing these meetings: possible gaps should be identified in advance, and efforts have to be made to bridge them as well as to remove other obstacles to fruitful discussions. Of course, not all the problems can be envisaged, i.e. some 'slack' (e.g. extra time for clarification, reconciliation, other means to exchange ideas) should be allowed for.

Another important direction to advance methodology – mainly via experimentation, i.e. including 'action research'[2] – is to develop and test various methods e.g. for virtual meetings; electronic discussions; arranging and exploiting feedback from a series structured, 'aligned' meetings held separately across various countries on the same set of problems (allowing for somewhat different approaches, and yet following the same broad lines of discussion); on-line questionnaires with (almost) real-time ('instant') feedback; etc.

Conclusions

To conclude, foresight can be a useful tool to help ACs devise adequate strategies for the coming years when they continue to be faced with the multiple, complex challenges of building a significantly enlarged, new EU, while fundamental changes occur in the global structures, too. However, the success of any foresight programme depends on the match between its context (level of development, and hence the policy challenges faced by a given country), scope, goals, methods and participation. In short, it has to be carefully designed. Furthermore, it is crucial to demonstrate the relevance of foresight for decision-making: its timing and relevance to major issues faced by societies, as well as the level of its 'products' – reports and policy recommendations – are critical. Only substantive, yet carefully formulated propo-

Regional cooperation can also help by exploiting economies of scale. Once cooperation starts, other issues to be discussed jointly and further possibilities for building capabilities and sharing resources are likely to be identified by the participants themselves

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of HIV positive people is currently about 560,000, and transmission rates are decreasing, while infection rates remain higher in eastern European countries (approximately 1 million people).

Despite the fact that HIV has spread across the whole of society, and is not limited to particular groups, it has been surrounded by social prejudices and of the social exclusion of HIV positive individuals. The social, emotional and political aspects of the epidemic have been accompanied by rapid progress in research results and clinical treatment. In just two decades, a variety of therapies and clinical protocols have been made available to HIV carriers. Many of these treatments have serious side effects which can have a negative impact on the patient's quality of life[2]. Paradoxically, HIV positive individuals in developed countries now face an unexpected challenge: getting over the idea of inevitable death as the syndrome has turned out to be not necessarily lethal. They are often confronted with the hard task of making a new life, when part of their youth has already elapsed on stand-by.

It is not surprising that, in such stressful circumstances, many people living with HIV have been compelled to develop a variety of strategies, mostly based on social support. For most HIV sufferers, this support can be achieved, in one way or another, within the social milieu of friends, family and organization-based communities, typically NGOs (non-governmental organizations). The Internet, however, has offered them a range of opportunities complementing these resources. In many cases, it has been the only contact point with information - take the case, for example, of the newly diagnosed who are afraid to approach a social organization or cannot count on their families' support; or those living in regions where such social support organizations are not available. The ages of affected people and the development of the Information Society, together with the spread of the virus, are additional reasons to take HIV/AIDS as a very particular case amongst chronic diseases.

European context and e-Health initiatives

The health-care sector is undergoing a profound change in Europe as ISTs play an ever greater role in the delivery of health-care services. ISTs offer the potential to cut costs, deliver healthcare services remotely and avoid unnecessary duplication of medical tests. In addition, the Internet is increasingly being used by citizens to obtain medical information. At the same time, patients expectations regarding the quality of the services they receive are increasing in a context where health-care systems in the EU member states are under pressure from a number of angles due to demographic changes, technological advances creating new expectations among patients, and constraints on budgetary resources.

Considerations for e-Health: expectations and barriers

e-Health consists of applying ISTs to healthcare delivery. Its aim is therefore to enhance the health and wellbeing of the population, and the quality of healthcare services and outcomes as well as the efficiency in health-care services and management. There are many motivations for moving towards e-Health. Among them, the growing mass of retired people demanding more and more health-care services. European health-care systems are indeed facing changes resulting from the ageing of the population together with a high prevalence of concurrent chronic diseases. Recent projections indicate that these two factors are likely to increase up until the year 2020. Increased effectiveness is expected from the electronic support to a complex activity that involves many stakeholders, skills and resources, while there is a growing expectation for health systems to be more patient-focused to match

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The health-care sector is undergoing a profound change in Europe as ISTs play an ever greater role in the delivery of health-care services

e-Health consists of applying ISTs to healthcare delivery in order to boost the efficiency of health-care services while enhancing the health and well-being of the population

Barriers encountered wh ying to diffuse e-Health-related ISTs into ents and citizens' lives include incomplete r even unavailable) infrastructure for efficient connectivity; the lack of strong evidence that ISTs enhance DM or HM, i.e. the need for clinical trials demonstrating the usefulness of ISTs in given cases like chronic diseases; the complex issue is that ISTs enable new services challenging the health-care systems in terms of ways of delivering care, organization, thus facing inertia from clinical bodies and problems over reimbursement; the motivation of patients -or their compliance in the case of DM- and the security concerns that data protection arises, such as unauthorized access, disclosure, and manipulation of medical records.

Chronic diseases. The case of HIV/AIDS

Chronic diseases -estimated to affect 20% of the total population, comprising about the 5% of all sickness cases, and causing about 60% of medical costs- are of major interest to the citizens, as well as to the clinical community. Groups of chronic diseases are particularly suited to adopt new e-Health practices within the new healthcare paradigm that will emerge out of the profound transformation of health-care.

HIV/AIDS is nowadays considered as a chronic disease in the developed world[4]. Along the recent years the Highly Active Anti-Retroviral Therapies (HAART) have been the main therapeutic remedy to combat HIV/AIDS. Those therapies have evolved rapidly due to the outstanding pace of research results; so rapidly in fact that patients have had to face changing protocols as well as cope with side-effects, often undermining their quality of life. The patients themselves have partially or totally dealt with methods for alleviation of the side-effects on their own. Those effects have not always been viewed as being the top priority by immunologists, concerned with the main objective of keeping a tight rein on patients' immunological status and viral load within the complexity of a set of serious opportunistic diseases associated with the syndrome. Patients have turned to the Internet looking for information needed to cope with those effects in the hope of finding empirical knowledge shared by patients world-wide. This phenomenon, together with the information sought both on treatments and on emotional support have led many HIV carriers,

As well as the barriers created by inadequate infrastructure, the lack of strong evidence of the value of e-Health initiatives is also slowing progress

...healthcare interventions and communications for
...efforts are significant. Disease management:
...relationship and plan of care,
...complications utilizing evidence-based practice
...and
...outcomes on an going basis with the goal of

...and support-service providers
...primary prevention, behaviour modification

...and management
...communication with patient, physician, health plan

Source: the Disease Management Association of America (**http://www.dmaa.org/definition.html**)

Chronic diseases are estimated to affect 20% of the total population, comprise about the 5% of all sickness cases, and be responsible for about 60% of medical costs source of infection[7]) and highlighting its educational potential as well as the debate on the convenience of the Internet-based campaigns in poor countries.

- In some cases HIV positive individuals are deprived of mobility. This is particularly so in the case of the prison population. Moreover the medical professionals working in prisons are not necessarily immunologists, and the follow-up of HIV carriers compromised by penitentiary constraints. Electronic communications between prison doctors and their peers outside the prison, and also communications enabling HIV positive inmates to access and follow their own clinical records as well as enabling them to access virtual communities could enhance awareness and quality of life. Indeed, projects of this kind are already underway.
- HIV/AIDS groups in developed countries, together with those bringing together sufferers of other chronic diseases, could help ensure the smooth adoption of e-Health practices, as the patients would not require in principle specially adapted interfaces to utilize them. Furthermore, the degree of digital literacy or accessibility problems, often pointed to as barriers in other social groups, does not represent a particular problem for HIV-positive individuals, unless they suffer from additional forms of social disadvantage or health deficiency. Well identified clinical applications like tele-consultations, pre-hospital care and telecare, as well as the management of personal records by patients and administrative-oriented processes such as e-prescribing, are a few examples of well suited e-Health features which HIV sufferers could use in advance of their roll-out to the general population.

In addition to all the above considerations, ISTs and, in particular the Internet, are a major focus of interest for specialists concerned with the spread of the pandemic in the third world where, due to the lack of treatment availability, AIDS remains a lethal disease and affects, in some countries, large percentages of the population (even well known preventive measures on vertical mother-child transmission are not possible in many African countries as there is no basic treatment available during pregnancies). Debates on pharmaceutical patents, first world aid to foster prevention campaigns and direct medical aid are now the main focus of interest. These campaigns of prevention are putting emphasis on the Internet as a way to make up-to-date information available and to promote awareness and prevention, although obviously, given that accessibility is minimal in third world countries, these campaigns have to be targeted on specific groups.

HIV/AIDS groups in developed countries, together with those bringing together sufferers of other chronic diseases, could help ensure the smooth adoption of e-Health practices

Addressing barriers

The main question that can be addressed to HIV/AIDS groups using e-Health-related IST technologies relates to evidence: does it make a difference when compared with the current management of their disease?

Quality of life is actually the framework where a few indicators can be observed, such as:

- their improved ability to cope with Highly Active Anti-Retroviral Therapies (HAART) side-effects
- the facilitation of healthier lifestyles that customized medical information would provide them
- the effect of their empowerment in better social integration -such as their reintegration into the labour market while feeling confident about their health management-.
- the degree of accuracy and reliability of their personal health record
- the reduction in paperwork

Their perception and understanding of data privacy threats are also most valuable. Confiden-

Confidentiality is a major issue to be addressed since disclosure, and manipulation of data could strongly dissuade HIV positive individuals from cooperating with IST-based systems

Keywords

e-Health, Information Society Technologies (IST), HIV/AIDS, Disease Management (DM)

Notes

1. See "AIDS epidemic update - December 2002" at: **http://www.unaids.org/worldaidsday/2002/press/Epiupdate.html**
2. The Body, section Quality of Live, **www.thebody.com/quality.html** shows a well structured collection of criteria on quality of live for HIV positive.
3. See the eHealth site of the Information Society DG, European Commission: **http://europa.eu.int/information_society/eeurope/ehealth/index_en.htm**
4. For the sake of accuracy, this article not being on the medical issues as such, it should be noted that HIV is at the source of AIDS, but as human system the target of the infection, carriers developing AIDS are in the end likely to get the so-called opportunistic diseases, this makes AIDS a syndrome rather than a single illness.
5. See definition at: **http://europa.eu.int/information_society/eeurope/ehealth/quality/draft_guidelines/definitions/index_en.htm#privacy**
6. **http://www.aids2002.com**
7. This is argued in relation to so-called "cybersex" activities enabled by the Internet.

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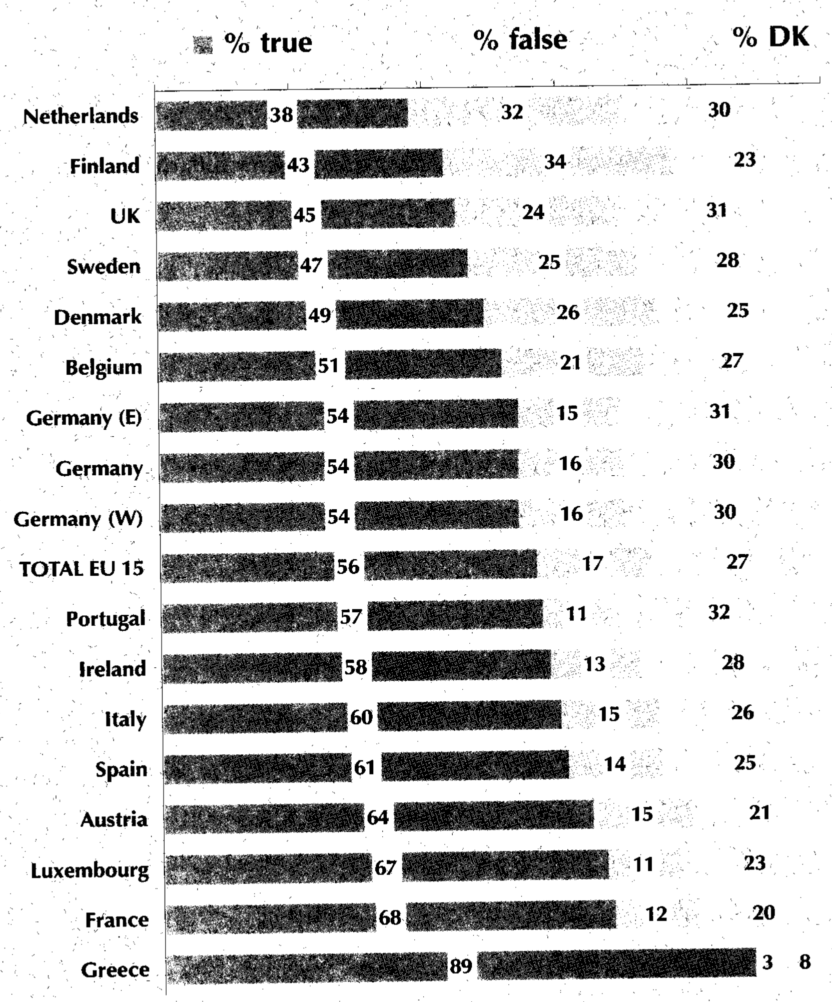
organisms (GMOs) pose numerous risks, which were seen to affect an extremely broad range of areas –food, health, the environment, the economy, society, biodiversity, geopolitics, etc. The benefits expected in return appear to be only slight or even non-existent, especially from the types of transgenic plants that have been developed so far. This perception created the impression in the public's mind that, while genetic engineering might boost profits for the handful of firms directly involved, it is of practically no benefit to the rest of society, which nevertheless has to face what are perceived

*Figure 1. Opinion of GMOs by EU country**

Answer to the question: *"Do you think it is true or false that food based on GMOs is dangerous?" (% of answers).*



(Germany (E)= New Länder, Germany (W)= Former Länder; DK= don't know).

** Countries are ranked by increasing level of perception of GMOs as being dangerous.*
Source: Eurobarometer 55.2, organized and supervised by EC. Poll carried out from mid-May to mid-June 2001; 16,029 people questioned, an average at some 1000 people per Member State (Eurobarometer, 2001).

Although there is considerable variation between European countries, in many countries the majority of the population perceives GM foods to be dangerous

In France, the public authorities appeared hesitant and often changed tack on the subject, thereby reinforcing public suspicion of GMOs. As for public research bodies in France, they have remained relatively silent on the subject, even though the media has frequently quoted some scientists –or people regarded as scientists– with divergent points of view. Scientists are thus perceived as being divided on the issue, and the contradicting opinions given about GMOs worry many consumers. Finally, genetic engineering has had few allies or backers considered as credible by the public; whereas on the other side, it has had influential opponents supporting and strengthening the anti-GMO movement. In addition, the contradictory information received on GMOs from experts compared with the clear message of environmental groups reinforces many people's worries on the subject.

Various decisive factors in the establishment of opposition

Within the context already described, other factors have also played an important role in creating a negative perception of GMOs. Firstly, opposition to GMOs appears to be inherently attractive. Opponents put forward arguments calling upon values that *a priori* generate support, such as the need for caution and wisdom in the use of technology, care and concern for the environment, for public health, for the future of the planet, without forgetting citizen participation and involvement in technological choices. Here, the GMO theme has proved to be an excellent platform for certain associations because it has credited them with a responsible attitude, thus conferring legitimacy upon them. By contrast, companies involved in genetic engineering were often seen as greedy and rapacious. They are also felt to be irresponsible because of the rather poor management of transgenic gene flow issues and uncertainties surrounding liability issues for environmental risks. A second issue is that research carried out in recent decades on the factors involved in risk perception has shown that chosen, known risks (such as smoking and car driving) are considered to be more acceptable than imposed or poorly known risks (radioactivity, pesticides) (Slovic, 2000). Perception also depends on the level of confidence in the firms or institutions generating the risk through their activity or managing it (Siegrist, 2000).

Various concerns with regard to the trends in techno-economic and socio-economic development nowadays may be added to these determinants of rejection. GMOs sometimes come to be considered as a symbol of changes that many people perceive as negative: agricultural productivism[3], growing concentration in the agrofoods industry, increasing economic globalization, etc. These linkages are bolstered by the fact that opposing organizations and activist groups use GMOs as a springboard for expressing their opinions on much broader related points. Thus GMOs are accused of having negative characteristics which, in fact, are not specific to them: the increased commodification of goods, the concentration of firms, difficulties of procurement by poor populations, etc. These aspects are mentioned frequently and forcefully for GMOs and less so for other products to which they are also applicable. GMOs are also accused of having unfavourable effects that they actually do not cause but merely express. For example, patenting the functions of certain genes is a product of financial and economic developments, and not a requirement of genetic engineering itself. GMOs thus seem to be cast in the role of scapegoat.

Prospects: can a change of opinion be envisaged?

Given this polarization, will GMOs ever be considered in a less black and white and more neutral way? It should be borne in mind that

Genetic engineering has had few backers deemed credible by the public. Moreover, the contrast between the contradictory information received on GMOs from experts and the clear message of environmental groups further reinforced public concerns

Opposition to GMOs has also drawn upon values that a priori generate support, such as the need for caution in the use of technology, care and concern for the environment and public health, etc.

substantial agricultural production – rather than where it would be most necessary. However, what will the situation be tomorrow, or in a few years time and, above all, in one, two or three decades from now, with population growth and the risk of a reduction in certain currently cultivated areas as a result of climate change, pollution, extending urban infrastructure, etc? It seems difficult to maintain and assert that it will be sufficient simply to share out better the production obtained with the current state of technology. An increase in agricultural production with no environmental damage will then surely be necessary. Genetic engineering can be a means to this goal, especially if it could also be applied in subsistence farming areas where it could have greatest benefit. However, this assumes a favourable institutional and socio-economic context providing these populations with access to this technology, and enabling them to benefit from a production surplus with no decrease in income. Furthermore, genetic engineering is not the only means which should be examined, even if it remains a useful tool to consider (UNDP, 2001).

Other developments can also be envisaged. While genetic engineering attracts much hostility, other developments may perhaps take shape in the biotechnologies themselves. For example, scientific and technical progress in life sciences, biotech and genomics may make the transfer of genes from different species or kingdoms less useful or less necessary for plant improvement.

Thus, although opposition to GMOs is strong and entrenched in the general public in both France and a number of other EU countries, there may nevertheless be factors which could change this perception in the future.

Science and Technology Roadmapping: from Industry to Public Policy

Olivier Da Costa, Mark Boden, Yves Punie and Mario Zappacosta, *IPTS*

Issue: "Technology Roadmapping" (TRM), which broadly refers to studies encompassing visions of future possible technological developments, products or contexts, is a technique which has been developing since the mid-1980s. As the concept and methodologies have matured, it has come to be applied in an increasingly broad range of areas, from individual companies (Corporate TRM), to entire industry sectors (Industry TRM), transdisciplinary hi-tech common goals (goal-oriented TRM) or the provision of intelligence for S&T policy-making (S&TRM for Policy Intelligence).

Relevance: Science and Technology (S&T) are advancing at an increasingly rapid pace and the ways in which S&T interacts with the economy, society and the environment is becoming increasingly complex. In this context, S&T Roadmapping (S&TRM) can facilitate and provide a more solid basis for decision-making. It is used to display and synthesize networks of past, present and future steps of S&T developments and to highlight temporal or causal relations and the causes of problems or potential solutions to them.

Introduction

The term "Technology Roadmapping" (TRM) is used to designate studies encompassing visions of possible future technological developments, products or contexts. Various definitions have been put forward. One common feature is that the output usually includes graphical representations in which "nodes" (past, present or future steps in S&T development) are connected by "links" (causal or temporal relations). Two key interrelated functions can be seen to emerge.

- Firstly, TRM produces representations of the state of the art of S&T at a certain point in time and of the nature, rate and direction of potential S&T developments. TRM is therefore a foresight tool.
- Secondly, the representation is put to practical use in negotiating the way forward and in informing decisions about possible future options. As such, a roadmap is also a planning tool: "a traveller's tool that provides essential understanding, proximity, direction, and some degree of certainty in travel planning." (Kostoff 2002).

Numerous studies have been devoted to the theory of TRM and S&TRM (*Boden 1992*) (*Kostoff 2002*) (*Garcia, Bray 2002*). This article puts

The term "Technology Roadmapping" (TRM) is used to designate studies encompassing visions of possible future technological developments, products or contexts. The output usually comprises graphical representations of nodes and links

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Table 1. Four Categories of Technology Roadmapping

	Corporate TRM	Industry TRM	Goal-Oriented TRM	Policy S&TRM
Diffusion	mid-1980s	early 1990s	mid-1990s	Late 1990s
Scope	One product or a family of products	A technological sector (mono-disciplinary)	Key enabling technologies for a single goal (pluri-disciplinary, business). Early appearance in the innovation process	Wide S&T areas or whole S&T landscape seen from an "issue-driven" approach and extended upstream to fundamental scientific research
Initiative & Development	A single company	Consortium of companies, national industry up to a whole international industry, public agencies, private consulting company	Public agencies often acting as facilitator or as developer in a consortium of companies	Think-tanks and public agencies
Utilization	Within the company	Companies of this consortium, whole national or international industry, other stakeholders	Various companies from various sectors sharing an interest in the same final goal, other stakeholders	Policy-makers and other stakeholders or companies
Objectives	Optimizing R&D decisions, strategic planning for development of new products	Becoming more competitive by sharing R&D investments and results in the pre-competitive domain	Creating common ground, shared identifications and visions for people from completely different backgrounds	Providing the intelligence needed for optimizing public R&D investments, underscoring their relevance to society
Methodology	Compilation of technical documentation, internal workshops	Workshops with industrial and academic experts	Brainstorming and converging workshops with various experts and stakeholders	Workshops with various experts and stakeholders, large scale semi-public or public conferences
Approach to the Future	Technology-driven and/or market-pull Descriptive and normative: "what are we going to do?"	Technology-driven Forecasting and normative: "what will happen?" and "what we should do?"	Problem-driven Prospective: "what might happen?" (complexity of the issues involved)	Problem-driven (also technology-driven) Proactive, today's policies contribute to shape the future, "the future depends on us", multiple possible futures
Time Horizon	Short term, typically 5 years	Medium term, typically 5 to 10 years	Usually longer term, up to 20 years, may be as short as 5 years depending on the industry, on the planning/vision, forecasting/foresight trade-offs	Typically 15 to 25 years, connecting long-term socio-economic issues (e.g. demographics, geopolitics, societal concerns and demands...) to shorter-term foreseeable technological developments

Besides the technological dimensions, some industry TRM may embrace organizational and human resource issues. Also, for some companies, interest in industry TRM could lie outside their core concern, i.e. in monitoring adjacent (competing, synergistic or alternative) technologies in a way they would not be able to with their internal resources.

The classic example of Industry TRM is the US-based 'National Technology Roadmap for Semiconductors' (NTRS), first developed in 1992. It has since evolved into a world-wide collective reference document for the semiconductor industry, 'The International Technology Roadmap for Semiconductors' (ITRS, 2000), first published in 1999. Its objective is to identify the technological [illegible] practice

[illegible] S&T research inspired the 'Technology Roadmap for Ambient [illegible] IPTS and the Information Society Technology Advisory Group [illegible] with the concept of Ambient Intelligence (AmI) as a [illegible]. The emphasis was on greater user-friendliness, more efficient [illegible] and support for human interactions. The underlying idea is that [illegible] interfaces embedded in all kinds of objects and by an [illegible] and responding to the presence of different individuals in [illegible] way. The report includes a technology roadmap showing [illegible] up to 2015 and lists some of the political, social and eco- [illegible]

[illegible] is currently underway at the IPTS in collaboration with the [illegible] Observatory) network. Together with studies of the practice [illegible] development of two pilot roadmaps: "*Ambient Intelligence in* [illegible] *of Healthcare in the context of an ageing society*". The [illegible] are the "trusted and universal access to the new technologies [illegible] of everyday life" and the "likely technological pathways to [illegible] ageing and diverse European society". Compatible methodo- [illegible] both cases, while recognizing that defining the relevant [illegible] is a significant challenge. Following the completion of [illegible] lessons for the continued development and application [illegible]

place after a substantial delay or through second or third order effects. In this information age, data and reports on highly specific issues are plentiful but there is insufficient time to read, understand and assimilate the various dimensions of S&T issues and their direct and indirect impacts. The business community and policy-makers cannot afford to wait until all the risks, opportunities and effects have been clarified before they come to a decision.

Since the mid-1990s, various trans-disciplinary think-tanks or public agencies have sought to adapt TRM methodologies to the process of policy-making in areas where S&T plays a prominent role (Cahill & Scapolo, 1999). The potential of S&TRM is significant in this context. Its objective is to provide the strategic intelligence needed by policy-makers to optimize public R&D investments and ensure their relevance to society. It can even be an important input in the selection of research priorities by highlighting the emerging S&T themes likely to impact on policy in the coming years.

The methodological approach consists of relating major political or socio-economic issues, seen as potential outputs of R&D developments, back to the present S&T policies through various technological paths. The main characteristics of quality roadmaps are their clarity, relevance, focus on the information displayed in the graphics, and a clear synthesis and presentation of the core issues. Ideally, decision-makers can concentrate on what is relevant for the strategic decisions to be taken rather than be distracted by excessive detail.

S&TRM for policy intelligence can, in theory, be constructed through and across broad S&T fields, extended upstream to fundamental research and observed through an "issue-driven" perspective. The challenge is then to ensure coherence and a homogenous depth of analysis across such broad areas. The objective is to assist policy-makers in comparing the appropriateness, efficacy and efficiency of public investments in different fields.

One of the drawbacks of S&TRM is that it is not well-suited to evaluating fundamental research for which there are as yet no practical applications. Also, to benefit from its full potential, it is necessary not to sterilize the thinking, by considering only

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Bridging the Gap between Science & Technology Studies and R&D Programme Management

Larrie D. Ferreiro, *US Navy Office of Naval Research*

Issue: R&D programme managers often do not have a way to systematically apply the "lessons-learned' from science and technology studies (STS) in their day-to-day activities. Since risk analysis has become a standard decision-making tool to evaluate cost and schedule uncertainty, STS insights can be modelled within that framework to help programme managers mitigate "strategic surprise" in non-traditional areas such as social acceptance of science and technology.

Relevance: The insights developed through Science and Technology Studies (STS) can be used as a decision-making tool for programme managers involved in the evaluation of new developments and in allocating R&D investment. The development of a subjective "risk-rating" assessment can be a means of evaluating cultural and social factors of scientific and technological systems, as a part of the overall set of decision aids available to programme managers to estimate uncertainty in programme costs and schedule. This interface between historical insights from STS and the priorities/discourse of R&D programme managers can enrich the basis of R&D policymaking.

Introduction: speaking the language of R&D managers

When C.P. Snow wrote about the breakdown in communications between the "two cultures", he was referring to science and the humanities. Today, that breakdown is arguably between the Research and Development (R&D) culture on one hand, and the Science and Technology Studies (STS) culture on the other. The people who work in and manage R&D on a day-to-day basis usually know little of the broad body of knowledge devoted to the study of the history and sociology of their profession. R&D programme managers, even when versed in STS, do not have a way to systematically apply "lessons-learned' in their day-to-day activities, specifically to estimate programme costs and schedules.

One of the principal reasons for this divide is that the language of STS has become unrecognizable to the scientists and technologists who could most benefit from the insights gained from these studies. In order to make STS knowledge relevant

There is today something of a breakdown in communications between Research and Development (R&D) and Science and Technology Studies (STS), leaving R&D programme managers unable to apply the lessons of STS to their work

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Figure 1. Priority list of attributes for aircraft carrier

[illegible]	Priority	[illegible]	Priority
1 Reliability	0.8370	20 Aircraft Suitability	0.4777
2 External Communications	0.8254	21 Aircraft Maint/Material Spt	0.4724
3 Internal Communications	0.7926	22 Endurance	0.4695
4 All Weather/Night Capability	0.7623	23 Logistics Support Footprint	0.4420
5 Data Management	0.7369	24 Seakeeping	0.4384
6 Mission Planning	[illegible]	25 Shallow/Littoral Ops	0.4356
7 Lauch and Recovery	[illegible]	26 UNREP	0.4328
8 Sensing	[illegible]	27 Hardening & Protection	[illegible]
9 Degraded Operations	[illegible]	28 Agility	[illegible]
10 Aircraft Turnaround	[illegible]	29 Range	[illegible]
11 Wpns & CM Employment	[illegible]	30 Speed	0.3635
12 Ctl / Restore Damage	[illegible]	31 Material Distribution	0.3392
13 System Commonality	0.5446	32 Training Implementation	0.3193
14 Maintainability	0.5372	33 Habitability	0.2545
15 Battle Group Support	0.5326	34 Space Flexibility	0.2393
16 Redundancy	0.5101	35 Accessibility	0.2167
17 Upgradeability	0.4919	36 Deployment Availability	0.0822
18 [illegible]	0.4818	37 Environmental Compliance	0.0557
[illegible]	0.4804		

weighting the contribution of each technology area to each attribute by the relative importance of the attribute. This results in a ranked list of technology areas (Figure 2). As can be seen, the electric ship technology area had a relatively high impact on mission capability. In this context, "electric ship" refers to an integrated power system used to supply propulsion, auxiliary systems and mission systems.

The second phase of the process is to conduct a bottom-up analysis of the investment needed for each technology area. For the electric ship, this consists of assessing the various electric ship technologies (permanent magnet motors, high-temperature superconductors, etc.) that can be used achieve the overall goal of having an integrated power system. A product model is used to evaluate the technologies from a total-systems standpoint (Figure 3). In general, this evaluation is done against a known baseline, e.g. a ship with conventional propulsion and electric distribution. For each technology or set of technologies, a new

Figure 2. Ranked list of technology areas

[illegible]	Impact	[illegible]	Impact
1 Human Systems	0.442	15 Maintenance Concepts	0.221
2 Information Integration	0.374	16 Auxiliary Machinery	0.209
3 Electric ship	0.371	17 Elevator Improvements	0.195
4 Common Computations	0.355	18 Ship Self-Defence Air	0.189
5 Multi-Function Sensors	[illegible]	19 Nuclear Power Gen	0.171
6 Design Mod & Sim	[illegible]	20 Armor Concepts	[illegible]
7 Own Ship Awareness	[illegible]	21 Ship Self-Def - UW	[illegible]
8 A/C Servicing	[illegible]	22 Propulsion Power Gen	[illegible]
9 Weapons Throughput	0.280	23 Launch	0.132
10 Flight Deck	0.257	24 Production	0.119
11 Integrated topside	0.242	25 Quality of Life	0.115
12 Damage/CBR Response	0.240	26 Arresting Systems	0.102
13 Material Handling	0.237	27 Waste Disposal	0.067
[illegible]	0.227		

The first phase of the two-phase process in evaluating R&D requirements is to conduct a top-down analysis of requirements

The next step is to develop a series of lower-level attributes that can be correlated against the required capabilities and then, finally, to establish the relative impact of various technology areas on the list of attributes

The second phase of the process is to conduct a bottom-up analysis of the investment needed for each technology area

This risk-management model of defining likelihood, consequence and "de-risking" contingencies, is well-understood by R&D managers, and should be the model used to incorporate STS as a means of informing the technology decision-making process.

Cultural and social factors of technological systems

How can STS insights be formulated in terms of risk? The approach would be defined by STS researchers on a case-by-case basis, but in order to provide a notion of how a risk-rating system for STS factors could be applied within the R&D evaluation process, I will use three approaches derived from STS research — normal accidents, technological momentum and symbolic meanings — to develop the outlines of a possible risk-rating scheme.

- *Normal accidents* (Perrow, 1999): This theory argues that an engineering approach to ensuring safety – that is, by adding safety systems and increasing redundancy — fails because systems complexity makes failures inevitable. Rather than protecting the system, safety precautions may lead to new types of accidents. The theory examines two factors in determining risk:
- Coupling
  - Tight (direct and immediate interaction between components)
  - Loose (buffering of interactions between components)
- Interactions
  - Linear (orderly, step by step, easy isolation of components)
  - Complex (many connections and inter-relationships)

Risk increases as the system becomes more tightly coupled and the interactions become more complex.

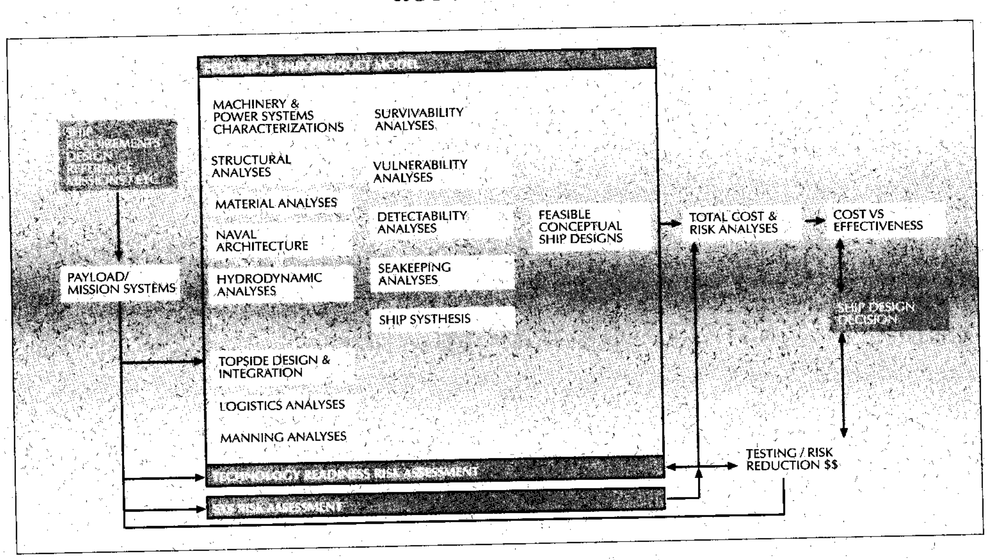
- *Technological momentum* (Hughes, 1994): This theory argues that the amount of capital invested in a system has a direct effect on the continued reliance on the system. At the beginning of system development, when investment is generally small, social factors play a larger role in technology development and it is relatively adaptable to change. As the technology evolves and supporting infrastructure

This results in a risk management plan and assessment of the cost required to "de-risk" the technology. This approach is well-understood by R&D managers, and should be the model used to incorporate STS as a means of informing the technology decision-making process

The normal accidents theory argues that an engineering approach to ensuring safety – that is, by adding safety systems and increasing redundancy — fails because systems complexity makes failures inevitable

The technological momentum theory argues that the amount of capital invested in a system has a direct effect on the continued reliance on the system

Figure 4. Total system product model with STS risk assessment



... evaluated for the electric ship. The three

... safety systems or intrinsic in the ... other systems, on the continuum ... coupled / complex (risk level = 9)?

... changes in the motor development?

... and other systems be made more loosely-

... What is their state of development? ... higher costs for this motor (risk level = ... Conversely, is there another utility for this

... cost be (specialized training, unique

... other motor types gain momentum? Are there

... proposed motor technology, especially in the ... coverage, risk level 9 = major press coverage)?

... components of the system that have lagged ... over by R&D managers?

... the motor technology is clearly laid out. ... and these would have to be subjectively weighted ... these factors are already considered indirectly by ... scheme is that it provides a systematic framework ... decision-making process. This proposed process ... parallel with technology readiness to evaluate

... second (bottom-up) phase of individual technol- ... could be incorporated as part of the first (top-down) ... mission capabilities.

The most obvious limitation to this risk-based approach is that, compared with the CTA approach, the breadth of input into the decision process is greatly reduced, although this may make it more attractive as it is easier to integrate into the linear decision-making process

Nevertheless, the first step in incorporating a risk-based STS assessment into the R&D management process would be to organize workshops or conferences at the university level that bring R&D managers and STS researchers together, in order to help the former understand how STS research can help them avoid strategic surprise, and to help the latter frame their investigations for use by R&D decision-makers. In order to enact the concept on a broad scale, the second step could be to enact pilot programmes to demonstrate the actual utility of this approach. These could be joint efforts by both the STS and engineering/science faculty at a university as part of an industrial product development team. Should those programmes prove successful, guidelines for incorporating STS into R&D management should be developed and promulgated on a wider scale.

STS can help avoid "strategic surprise" in areas not normally considered by R&D managers, such as social factors of acceptance

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