Technology Foresight within the Finnish Innovation System

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1. Introduction

Technology and innovations have proved to be a key source for growth and competitiveness in the Finnish economy, and it is also believed that they will continue to be that in the future. In order to ensure technological competitiveness, technology foresight is becoming an essential element of the strategy process in many organisations. As a result, technology foresight activity is increasing rapidly in Finland.

Unlike many other countries Finland does not have a formal national-level foresight process which can be used as a background for R&D priority setting. However, technology foresight is used, applied and exploited in many ways and on many organisational levels within the innovation system.

This paper attempts to give a broad view on technology foresight in Finland:

- The first section describes the Finnish Innovation System and main technology foresight activities on different policy levels.
- Tekes, the National Technology Agency of Finland, is one of the main actors to implement technology and innovation policy, so the next section describes in detail how Tekes applies and uses technology foresight in its strategy process.
- The technology foresight process is a very powerful tool for building up new and renewing existing networks, cooperation and industrial strategy for R&D. The next section briefly describes three cases where technology foresight is used to enforce industrial cluster dynamics in Finland.
- The concluding remarks include some comments on the state of the art and the future of technology foresight in Finland.

2. Technology foresight within the Finnish Innovation System

The main elements of the Finnish innovation system performing the R&D activities, are the companies with an R&D cost of 3 284 M€ in 2001 (71 % of the national total), universities with R&D cost of 834 M € in 2001 (18 %) and public research organisations, of which VTT is the most important. There are 20 universities, 29 polytechnics and 20 public research organisations in Finland.

Public R&D policies are overseen by the Science and Technology Policy Council, STPC, an important coordinating body chaired by the Prime Minister. On the funding level are the Academy of Finland, which funds basic research with universities as main customers, and Tekes, the National Technology Agency, which funds applied and industrial R&D performed in companies, universities and government laboratories. The Academy's budget is 185 M € for 2003 while the Tekes' budget in 2003 is 383 M €. Other public sources of funds are Sitra, a venture capital fund mainly for the seed and pre-seed phase. Sitra is under the supervision of the Finnish Parliament, and it invests about 100 M € annually.

During the recent years there has been a strong move from science and technology policy towards innovation policy. This has meant that new actors have been involved in S&T policy discussion, such as regional authorities, other ministries, and also EU structural funds as a funding source for innovations. The key actors can be seen in figure 1.

Figure 1. The key actors in the Finnish innovation system.

Technology foresight is being increasingly used on all levels and by all actors of the innovation system. Technology foresight is seen as part of strategy and policy making processes. In practise this means more future-oriented planning, exploitation of existing foresight studies, and the commissioning of focused problem-oriented technology foresight projects. Networking and cooperation between actors in technology foresight issues are increasing, in order to ensure that foresight studies are available for partners and also to enforce learning by experience.

The Finnish **Parliament** established the **Committee for the future** in 1992. The

Committee for the Future also functions as a parliamentary organ assessing technological development and its societal consequences. The Committee's work has focused in recent years on the future of work and the prospects of a welfare society, competence and expertise, as well as the challenges of the Finnish information society, including science and technology policy. The Committee has recently worked on the following technology assessment projects: Independent living of elderly people, Energy 2010, Knowledge Management, Regional innovation activities, Social Capital and ICT technology, Human genome and stem cells. The Committee has also established a network of technology foresight experts to support the work of the Committee. The members of the network are from universities, research organisations, Tekes and the Academy of Finland.

The Science and Technology Policy Council of Finland determines the basic science- and technology policy lines. A new White Paper on S&T policies was adopted in December 2002 by the STPC. *The Knowledge, Innovation and Internationalisation* review examines the development challenges facing science and technology policy in the coming years and outlines relevant policy. Special attention is paid to the rapidly internationalising innovation environment and the ensuing pressures for structural and operational change in Finland.

The Ministry of Trade and Industry coordinates technology foresight in Finland. The Ministry of Trade and Industry established a coordination project for technology foresight activities in Finland in 2001. The main task of the project is to produce scenarios and visions for innovation policy, analyse different evolution processes, and develop new approaches from systematic long-term research to public discussion. The project has established several networks, e.g. a 'network of experts', a foresight network of all the ministries, and a committee of the top management of MTI, Tekes and VTT as the core for technology policy issues.

The main fields of technology foresight for technology and innovation policy are as follows:

- Essential changes and trends in the economical environment.
- Key issues in globalisation, internationalisation, integration, regulation, development of the information society, development of the EU, technological change in society.
- Sustainable development and sustainable growth, aging and other long-term changes in society.
- Changes and trends in national innovation and production systems, such as dynamics and long-term development of industrial clusters and the business environment

Regional technology foresight. The Employment and Economic Development Centre helps to sustain business activities in Finland. The Ministry of Trade and Industry, the Ministry of Agriculture and Forestry, and the Ministry of Labour have jointly combined their regional forces in the Employment and Economic Development Centres (T&E Centre). Fifteen regional centres all over Finland provide a comprehensive range of advisory and development services for businesses, entrepreneurs, and private individuals.

The foresight of the T&E Centres focuses on long-term regional changes in industry, employment and demand for know-how. Their task is to identify and discover growing and declining branches, occupations, technologies and production processes as early as possible. Technology foresight activities started in a few centres on a project basis some years ago. Tools and methods, resources and processes have been developed to strengthen regional strategic planning processes.

Research funded by Sitra focuses on future challenges facing Finnish society. Sitra's research provides a source of know-how for decision-makers and national debate. Sitra's research, innovative projects and training face considerable challenges when providing information and models of action for the planners of Finland's future. Sitra provides social decision-makers with important information in order for them to develop successful national strategies, and experiments new operative models, especially at the interface between the private and public sectors. Sitra's latest research projects seek to attack the structural challenges facing Finland and get to grips with the problems affecting the welfare society, the risk society, culture and social capital.

3. Tekes implements technology policy

The policy defined by the Science and Technology Policy Council and the Ministry of Trade and Industry gives the broad guidelines for R&D priorities. Implementation of the policy is carried out by the funding agencies, Tekes and the Academy of Finland. This is mainly done by allocation of R&D funding and by pro-active measures like research and technology programmes.

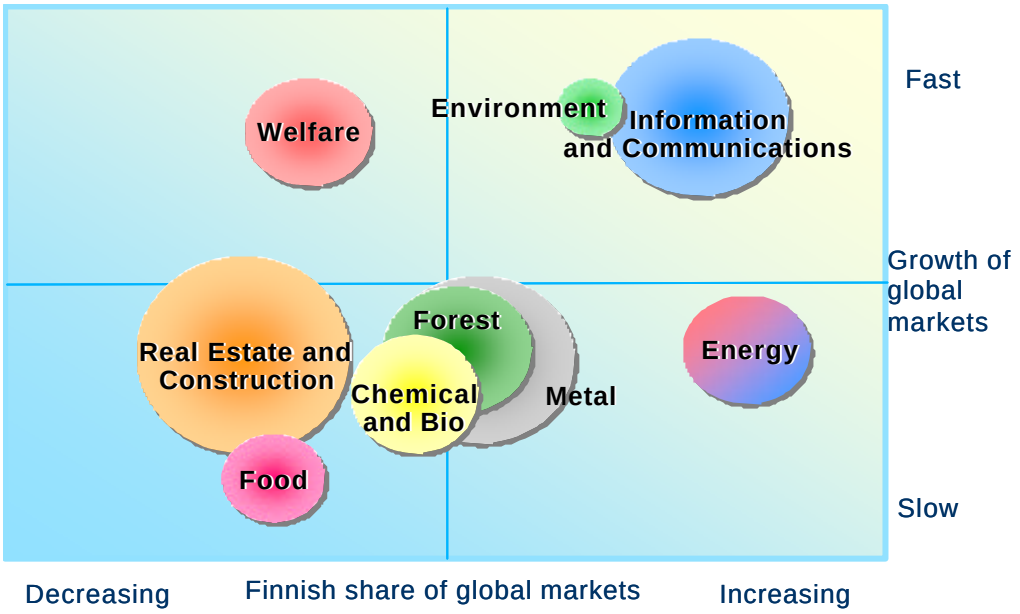
Tekes is the main public funding agency for applied and industrial R&D in Finland. Tekes also coordinates and finances Finnish participation in international technology initiatives. Tekes and its technology programmes offer channels for cooperation between key players in Finnish R&D. The technology strategy process and technology programmes are the main methods of implementing technology policy guidelines into R&D activity at Tekes.

The technology strategy process at Tekes is a continuous process. Reports summing up the visions and strategic goals of Tekes are published every few years, the latest in 2002. The report provides solutions to the challenges posed by Finnish industrial development. It forms Tekes' vision of the future, its strategic objectives and a path for implementation. The basic goal was identifying the key technologies and knowledge base for the future, and to provide more operational sub-strategies for different technological fields to be implemented in new technology programmes.

Tekes technology strategy is based on close and intensive interaction, discussion and continuous learning with companies, research institutes, industrial organisations and other technology policy peer groups. This work also takes international trends into account by utilising Tekes' wide contact network of. Future changes in values and goals of the society, global mega trends and trends on market have also been considered.

The competitiveness and structure of the Finnish industrial and business sector have been the starting point in formulating the technology strategy (figure 2).

Figure 2. Dynamics of Finnish industrial clusters.



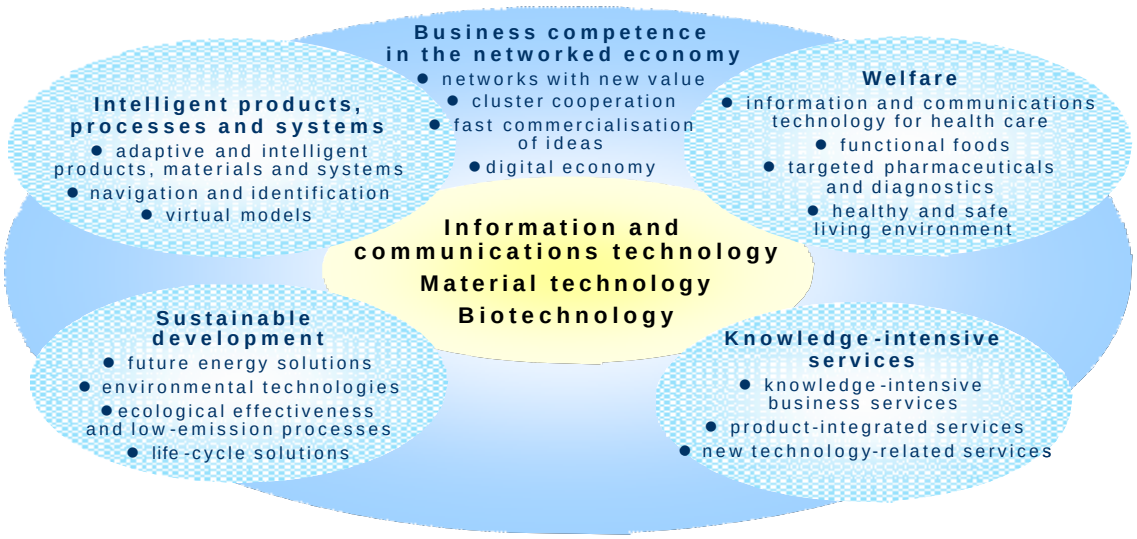
The analysis of the dynamics of Finnish industrial clusters is based on statistics and a wide cluster study made some years ago. On a general level, the ICT sector is still seen as the core for economic growth, and environmental issues are seen as a new field emerging for new businesses. The market for welfare is considered to be growing, although the Finnish share of global markets is not necessarily growing. Most of the important Finnish clusters do not seem to have so much potential, the food industry as one example of this. However, within these clusters there seem to be new and fast growing fields emerging, which have a great potential for Finnish companies. Functional food within the food industry is one example.

The industrial cluster-based assessment was targeted to find new business opportunities through networking and cross-scientific and cross-technological cooperation. Tekes believes that new competitive advantages and elements for increasing productivity and welfare will be found by placing emphasis on cooperation. Technology strategy focuses on five issues: networking, cross-technological cooperation, long-term commitment, innovativeness and productivity.

Information and communications technology, biotechnology and material technology are the global technologies that seem to promote change in the future. Finland has a good competitive edge in some sub-sectors within these technological fields, both in industry and in research institutes. Therefore these also provide a good opportunity for the future.

The goal of technology strategy was set to identify the key areas for industrial renewal and welfare-promotion for the economy. By analysing the industrial cluster dynamics and technological competitive edge, the technology strategy process identified five very potential application areas for future R&D (figure 3): Intelligent products, Processes and systems, Sustainable development, Knowledge-intensive services, Welfare and Business competence in the networked economy.

Figure 3. Key areas for industrial renewal and welfare promotion.



Tekes technology programmes are used to promote development in specific sectors of technology or industry, and to pass on results of the research work to business in an efficient way. The programmes have proved to be an effective form of cooperation and networking for companies and the research sector.

The number of technology programmes has been decreasing; in 2000 there were about 65 technology programmes in progress, while in 2003 there are only 35. Each programme lasts 3 to 5 years. Tekes usually finances half of the programme costs; the other half is mainly financed by industry and companies. Tekes funding for the programmes is 200 M€, half of Tekes' total funding for R&D. About 2000 company participations and 800 research institute participations are recorded annually. Each programme consists of numerous R&D projects (40 to 200).

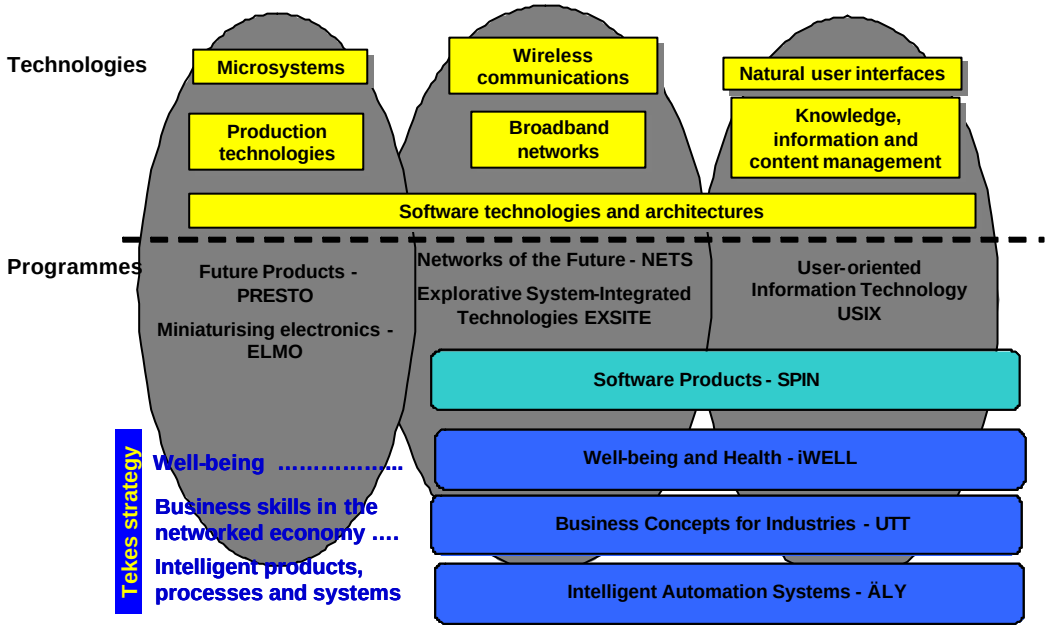
Technology programmes are initiated by Tekes on a bottom-up and on-demand basis. Programmes mainly focus on some key technology sector. They are planned and implemented in cooperation with companies and research institutes. Cooperation with the Academy of Finland and other ministries in programme activities is increasing.
The next figure gives an example of the linkage between the defined technology strategy and technology programmes within ICT-technology. The programmes mentioned here are in progress in 2003 (figure 4).

These ICT technology programmes are based on a 5 to10 years perspective of

technological development. Technologies emerging, like nanotechnology, next generation wireless and optical networks, active environment and adaptive software will provide the basis for future programmes.

Programmes are the main tool for putting technology strategy into practise. However, technology strategy only provides a starting point for planning a new programme, that is why technology foresight is an essential part of the programme process as such. Technology foresight is part of the concept phase of the programme, when the rationale and goals for the new programme are analysed and set. Many programmes use foresight tools and mechanisms at the beginning of the programme, to ensure a common vision between participants. The technology foresight approach is also used in mid-term and ex-post evaluation of the programmes. Use of technology foresight is increasing. However, experience and external resources for technology foresight studies in Finland are limited. Some special methods and tools for the technology programme process have been developed, but the supply side is still too narrow.

Figure 4. ICT sector technology programme portfolio enforces the knowledge base and innovations within its own field. It also implements the general technology strategy goals of Tekes.



4. Technology foresight projects as a way of strengthening cluster dynamics

Tekes also commissions more focused industry- or technology-oriented technology foresight studies in order to initiate new programmes, and develop a common vision and industrial strategy.

The food industry, the forest, pulp and paper industry, media as the content business

within the ICT-sector, and chemical and bio clusters are examples of sectors that have been studied recently. Industrial cluster dynamics analysis shows that these sectors seem to have only modest business and growth potential. They can probably benefit most the new ideas for the future; companies and businesses in fast growing sectors do not need to renew their strategies.

As Finland is a small country, all the key actors in industry and research organisations have been involved. The technology foresight studies typically include a lot of interviews, workshops, lively and wide discussions, and have also internet-aided sections.

The projects are often linked with an evaluation of technology programmes in the same field. This type of foresight studies can be characterised as embedded studies which integrate evaluation, technology foresight and technology assessment. These projects also provide a platform for developing tools and methods of technology foresight for technology programmes.

The technology foresight study for the food industry (Hjelt et al. 2002) is part of the evaluation of the 'Innovation in Foods' technology programme. The basic idea is analysis of the future challenges of the industry and its research and technology system. The evaluation of the programme and research system was made in parallel with the industrial foresight process.

The work started with a literature survey and numerous interviews. These data were analysed and reported by picking out over ten important issues. These issues were discussed and further analysed in a workshop, which resulted in 6 crucial themes and questions for analysis in separate future workshops. The titles of the six workshops were as follows: Consumer needs and new technology; Level of technology in SMEs; Product information management through the production chain; Business opportunities of health and functionality; Clean and safe; Commercialisation of research-based innovations.

Participants in all workshops were invited from different sectors: the food industry, food technology and research, other industrial and technological fields, marketing, consumer associations and commerce. Over 100 experts participated in these workshops, and the results were assessed by experts in Japan. The process resulted in finding potential new technologies for the food industry. New ideas for innovations were put forward. The most important impact of the project was new and wider networks and new partners for the food cluster.

Embedded foresight methodology has been developed and used in several technology programme evaluations recently, in mid-term evaluations and in the early phase of new programmes in particular, when the goals of the programme have to be set or changed, and the project portfolio analysed. This method has been developed to integrate technology foresight into programme evaluation by Professor Ahti Salo at the Helsinki University of Technology. The key issues are finding quantitative measures for the evaluation, evaluating the importance of the programme, analysing and discussing the

future and trends within the programme field, and setting the common vision and goals for the programme.

The method includes an Internet-survey for collecting data before and during the workshops. Answers are entered into a database, and the results and aggregate data are available in real-time. Typical questions deal with project data, e.g. position of the technology developed in the project, timing of possible innovations, etc. The system also often includes participants' views on innovation processes and their experiences of programme management.

The embedded technology foresight process is based on ICT aided workshops. The workshop environment includes lap-top computers, WLAN-network, video projector and video and audio recorder for data collection. The system also includes the Opinions-Online programme for internet-based voting. Typical tasks within the workshops include grading technologies, projects, goals etc. Grading also includes free text arguments, but comments are anonymous. Summaries and structures of opinions are made in real-time and are available for further discussions by the participants.

This type of methodology has been used in several technology programmes; i.e. electronics and telecommunications programmes, wood and forest programmes and biomaterial programmes. The main impact of this type of technology foresight is to build up a common vision and to strengthen the programme strategy within the programme frame.

The media sector and content creation business within the ICT cluster is not the most potential sector for growth for many reasons. However, this sector is also looking for new industrial strategy and innovations based on technology. The technology foresight study which investigated innovation potential for this sector used several methods and approaches: media holes analysis, weak signals analysis, scenarios of the society, innovation process analysis, and screening technology foresight studies all over the world. These known methods were applied during the study by the research group at VTT Media technology (Siivonen et al. 2003).

The study discovered a lot of potential innovations. The company structure within the media cluster seems to be the challenge for these innovations. Many technology-based companies worldwide are broadening their business into content creation, and content creation companies are networking with technology companies. The most important impact of this type of technology foresight study is forming a platform to enable different types of companies to build up new networks.

Technology foresight studies can be seen as process. The goal is to develop a common vision and strategy, to build up new networks, and to look for innovations. As Finland is a small country, it is relatively easy to collect the key actors and innovators for panels and expert groups. Special attention has been paid to forming new groups, based on cross-clustering and cross-technologies. An example of this kind of activity is an ongoing study investigating **innovations in the interface of chemical, telecommunications, biotechnology and forest clusters**.

5. Concluding remarks

The Finnish technology foresight culture is mostly based on the use and exploitation of existing knowledge. The system is effective; it runs with minimum resources and organisation. Implementation of results in the strategy is well organised.

The system does not produce much new knowledge of technological potential, and it is based on and strengthens present structures. This system may not discover new markets or new ideas for technology and innovations. The system does not cover broader views, such as the perspective of consumers and citizens.

Technology foresight activities in Finland have been analysed and compared with European practices in some studies (Eerola & Väyrynen 2003, Salo 2001). These studies identify some challenges for Finland: systematic and comprehensive analysis of the potential and risks of technological development, balanced assessment of different R&D fields, good, transparent and well documented foresight processes, and that all interest groups should be involved in foresight, assessment and evaluation processes.

The STPC comments on technology foresight in Finland in the new White Paper on S&T policy: "After an in-depth investigation of the national organisation of foresight and relevant needs, it is evident that it is time to proceed to more extensive and concrete projects. Finland has the prerequisites for a national foresight exercise. Network-building and monitoring of foresight methods and needs are not enough to sustain interest in the future outlook among researchers, business enterprises and other players and to encourage them to contribute to foresight." The Evaluation of the Finnish Innovation Support System's summary of conclusions explain that: "There is the need for a combination of foresight and other strategy-setting activity in the Finnish system and its agencies and a need to create an 'active change agent' to translate visions into forward-looking actions." (Georghiou et al 2003).

It seems that technology foresight is in a very early and very fast growing phase in Finland. Experiences and lessons from countries with a longer tradition in foresight is important; international cooperation and networking in technology foresight issues will probably provide the best results for all.

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