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Japanese S+T Foresight 2035

Foresight Brief No. 035

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Sponsors: MEXT - The Japanese Ministry of Education, Culture, Sports, Science and Technology
The Science and Technology Council of Japan

Type: National foresight exercise

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Duration: 2003-2004 **Budget:** € 650,000 approx. **Time Horizon:** 2035

The Eighth National Japanese Science and Technology Foresight

Every five years Japan conducts a large national foresight exercise to gain new information and update insights gained from previous foresight activities. One of the most important elements of these foresight exercises is a comprehensive Delphi survey involving more than 2,200 independent experts from different disciplines. The results of this whole process serve as inputs for policy-making and provide valuable information for all interested parties including stakeholders from companies and students. In the eighth Japanese national foresight exercise a wider approach was adopted. This exercise included a study on rapidly developing technologies, scenario development and a demand-oriented study.

Method and Approach

New Foresight Instruments

Japan now has 40 years of experience applying the Delphi method to gathering intelligence for national foresight programmes on science and technology. Although the data generated from the Delphi process was used in different ways by different stakeholders and representatives from different levels of policy-making, the surveys were mainly based on science and technology 'supply' orientation. The questions framed in the Delphi surveys were not based on demand side considerations. As in other countries this approach has often been criticised for not giving due consideration to demand-side issues.

In response to this criticism of earlier Delhi surveys the instruments applied in the eighth national foresight exercise were broadened and the overall approach rested upon four main pillars.

1. A survey on demand for new technologies,
2. A study on rapidly developing technologies based on a bibliometric approach,
3. Scenario development, and
4. A comprehensive Delphi survey.

All foresight surveys conducted so far in Japan found their audience and were regarded as an input into policy-making on the one hand and general information for all interested parties, organisations and private persons on the other hand. Nevertheless it was often considered that previous Delphi surveys tended to arrive too late to serve as useful inputs for national programme development. The organisers were intent on avoiding this problem from now on.

It was therefore decided to conduct the 8th Foresight earlier than after the usual 5-year-term so that the results would be

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available as inputs for the new Science and Technology Basic Plan, a programme guideline for which development will start in 2006.

Preparations for the S&T Basic Plan

Prioritisation for the next Japanese Science and Technology Basic Plan requires a holistic approach to issues such as:

- The potential development and impact of science in terms of fields, areas, and even specific technologies,
- What society expects from science and technology, and
- The latest trends in basic research.

The NISTEP or National Institute of Science and Technology Policy provided its 'Science and Technology Foresight Survey' with the goal of:

- Contributing to the development of the Basic Plan for Science and Technology that would come into effect in the period 2006 to 2010, and
- Setting the corresponding priorities for investment and resource allocation.

The overall scheme aims to provide the foresight data and the results to a broad variety of decision-makers to be reflected in their policy-making.

Despite the accelerated agenda the budget for the eighth national S+T Foresight was fixed in good time. The different steps and the detailed approach to be used were discussed between the organisers and the main 'client' - the Japanese Council for Science and Technology. During this process the Council decided to add a literature data-base for the field analysis which the study about rapidly developing technologies could be based upon.

More Emphasis on Societal and Economic Demand

The new methodological approach was a combination of both well-established instruments and new instruments. The first three methods provided inputs for the fourth - the Delphi survey. The results, the priorities for Japanese S+T policy, were selected qualitatively using all tools as inputs but relying mainly upon the study pm rapidly developing technologies as well as the feedback from the Delphi survey.

1. The **survey on demand** looked at demand up to the year 2015 and started with an analysis of S+T needs for the future based on interviews, a survey and a workshop that also involved experts from the soft sciences and from scientific journals. A list of societal and economic need was drawn up, structured and assessed in panels using an interactive participatory approach. In a second step each topic was examined to see if it should be explicitly reflected in S+T policy and to understand the major directions in which it was likely to evolve in the future. In a third step, topics from the seventh foresight survey were analysed and corresponding level of demand formulated.

2. The study on **rapidly developing technologies** was based on a bibliometric approach. An analysis of article based on the Science Citation Index lead to the identification of 153 fields that were clustered in a map. This mapping technique allowed experts to reduce the list to 51 rapidly developing technology fields that were regarded as possible priority areas for future Japanese S+T research efforts.

3. A series of 48 **scenarios** were written by experts identified by NISTEP. These scenarios were inter-connected in the sense that there was some thematic overlap in the high priority topics that were chosen as the basis for the scenarios. They stemmed mainly from the larger clusters of life sciences, environmental sciences and frontier research domains such as space, marine and geo-science, as well as information technology and structures, production and society. These normative scenarios consisted of short one page descriptions accompanied by longer texts providing recommendations on how the scenarios as outcomes could be achieved in practice.

4. A comprehensive **Delphi survey** was conducted in two rounds with feedback in the second round. Topics formulated in short statements were derived from the other three approaches and worked out in detail in expert working groups. Classical feedback focused on issues such as the importance of the topic, the time to realisation, the leading country in the field and recommendations on measures to be taken now.

Participation in the first three activities was limited to the number of persons in the different panels and workshops. Nevertheless a few hundred participants from different backgrounds were involved. Already in the preparation of the topics for the 13 Delphi fields, more than 200 experts from industry, academia, research institutions, associations and others were asked to participate in workshops and panels or to help clarify issues on a bilateral basis. In the first round of the survey 4,219 questionnaires were sent out and 2,659 experts replied. In the second round 2,239 were sent out and the response rate was 84%.

The different instruments produced a huge amount of data and required a very high level of communication among stakeholders. The results were published in a series of four reports, in a variety of different formats.

An Overview of Results

The 'hot topic' emerging from the fifth Delphi survey was the environment, whereas that emerging from the sixth was IT security. Looking through all four reports of the eighth S+T Foresight exercise three major trends can be observed:

- Technologies concerning safety and security
- Topics concerning human resources

- Interdisciplinary or fusion fields in S+T are now developing quite rapidly.

Demand for S+T to Help Improve Daily Life

The overall results from the survey on demand were very general and not very astonishing. For daily life, *necessary* needs like a stable job, securing food, the use of energy, *safety and security,* but also *love and communication,* including welfare for underprivileged people and a good education, or *respect and dignity* were among the most important demands of the study. These and other desires provided important background information for the subsequent studies dealing with science and technology.

Priorities for Rapidly Developing Technologies

The bibliometric study identified 153 technologies, of which 51 are regarded as very important for Japan. About half of these are expected to be directly prioritised in the Basic Plan. The classification started from the traditional disciplines, although important topics often occur at the borders of the classical disciplines and have an interdisciplinary nature. These topics can be analyzed into clusters as follows:
Clinical Medicine: **S**tudies on telomerase, hormone therapy, immune disease research, viral hepatitis, glutamine receptors, stem cell regeneration, the impact of air pollution particles on the health of human beings and others.
Plant and Animal Science: Cell membrane channels, study of the biological clock, molecular biotechnology, influenza etc.
Chemistry: **P**roteomics, ionic liquids, enzyme and complex catalysis, carbon-carbon bond formation reaction, etc.
Space Science: **O**rigin and mechanism of the universe, mesoporous materials and nano-wires.
Physics: **N**eutrinos, new metallic superconductors and heavy-fermion superconductor, high temperature super conductors.
Social Science and Economics: **S**chizophrenia, decision-making and governance based on behaviourism, community development and networks under globalisation, IT-based organisational management and knowledge management. etc.
Geoscience: Paleo-climatic research, global-scale oceanic climate change research.

The 48 Scenarios

The 48 scenarios consisted of short 'pictures of the future' on specific themes referring to different disciplines and interdisciplinary issues. Well-known experts from the fields recommended strategies to realise objectives formulated in the scenarios. The scenarios represented a mixture of demand-oriented and S+T push approaches to envisioning the future. Push approaches for example had to do with mathematical research and development as well as education, the space sciences, ideas for the application of nano-biotechnology, new medicine for the needs of individual people, changes in the structures of medicine and therapies, humanoid technology, low emission cities, saving energy, satellite technology, food safety, prediction techniques for economic changes or science and technology for arts, culture and entertainment, etc.

The Results of the Delphi Survey

The Delphi survey was conducted in fields which could already be regarded as priorities. These included fields such as Information and Communication, Electronics, Life Sciences, Health, Medicine and Welfare or The Environment. New entrants were areas such as 'Nanotechnology' or 'Nanotechnology and Materials. Classical fields such as 'Management and Production' field were split into 'Organisation' and 'Basics of Production'. These covered areas such as logistics, management and administration. More emphasis was placed on societal issues than in the past. Former fields such as transport and architecture have now been integrated into the more holistic notion of the 'Societal Base'. This covers issues relating to city construction, architecture and traffic. 'Society and Technology' now covers issues such as education, school education and public services.

The most important single topics and strategies to realise scenarios as outcomes were described in detail by Japanese experts. It is not surprising that currently the most important topics related to human life, information, the environment, disasters and energy as follows:
Human life: Topics about **cancer** were very often rated as important. The same was true for illnesses resulting from the ageing society like **Alzheimer**. But also treatments for infectious diseases and allergies were becoming more important.
Harmful chemicals: In particular their impact on human health was also regarded as a relevant problem.
Information: The most important topics here were centred on process technologies for high efficient **Large Scale Integration** and **wearable equipment**, also topics about **security** in networks and **viruses** were especially relevant.
Environment: Topics about gases like **CO_2** and **NOx** as well as topics about a "**recycling society**" got high ratings.
Disasters: Half of the high relevance topics concerned **earthquakes** and countermeasures to decrease the numbers of victims by prediction and the use of simulation.
Energy: The importance of topics concerning production processes with **non-fossil energy** sources, **fuel cells** for transport means and **solar cells** increased.

Time Horizon of Realisation

Most topics with an estimated early realisation time stemmed from the field of 'Society and Technology'. The earliest 10 were only one from each: Environment, Manufacturing, and Energy. The short term achievable scenarios had to do with e-government services via internet, clean water technologies, e-books with multimedia support, intelligent traffic systems, systems for providing emergency housing in case of a disaster, room environment control systems for safety, security and health to name a few.

The more ambitious long term goals related to energy topics such as the fusion reactor, solar cell systems for use in space and innovative treatment of nuclear waste. It has been the pattern in previous Delphi surveys to announce such goals and postpone the estimated time to realisation.

Impact of the Exercise

The eighth Japanese S+T Foresight exercise relied as in the past on the use of the Delphi method, but adopted its approach to take into consideration demand side elements of society and the economy. It is still too early to evaluate the impact that this has had. Nevertheless a general impact can already be observed.

Important Contribution to National S&T Policy: The previous foresight or forecast surveys in Japan were mainly performed to gather information about the future and distribute it to all interested stakeholders. This had an impact but the impact was dispersed and hard to measure. Until now it was not possible to demonstrate a direct link to the policy-making processes and its contribution to policy and decision-making was indirect. This time however there was an exchange of opinion with policy and decision-makers from the very beginning. The CSTP or Council for Science and Technology Policy as well as MEXT - the Ministry of Education, Culture, Sports, Science and Technology were directly involved in the process. On this occasion as well the timing of the preliminary and final report was right was much better allowing time for the relevant bodies to use the results of the exercise as inputs for their respective policy processes.

Major Impact on the S&T Basic Plan: The major impact therefore is the direct impact that this work will have on the third Japanese Basic Plan. Until now there have only been two Basic Plans for S+T as a framework for Japanese S+T policy. The Basic Plans are not fixed plans as in socialist countries. They provide the general orientation for policy-making and set the priorities in science and technology fields. It is therefore regarded as an important indicator of success if fields prioritised through the foresight process are selected by the CSTP for inclusion in the next Basic Plan for S+T.

Identified Priorities and Focus for Action: In every thematic field mentioned above, individual topics of importance were identified. They can be used both as a basis for further basis analysis or as priorities for future research. In each field a development strategy was formulated. The formulation of the text of the Basic Plan was also influenced by the results of the exercise. The thematic fields addressed in the Delphi survey and the rapidly developing technologies can be regarded as candidates for special support in terms of financing and improved framework conditions. These will be fields for national investment and can be considered as recommended fields for industrial investment as well. The government will try to improve framework conditions in these fields even if no direct investment is made by the public sector.

Key Players in Shaping the Future: The key players in shaping the Japanese future in S&T fields were directly involved in the surveys. Especially well-known scientists were asked to formulate specific chapters of the Delphi report. Persons from different backgrounds, from policy, industry and academia were included in expert groups, took part in the surveys and were nominated to write the scenarios. These are regarded as 'multipliers' in the process. On the one hand they bring in their own knowledge and on the other hand they profit from the results obtained. The single items and topics emerging fro this work that are directly included in the Basic Plan will be known when the new Basic Plan is available for the public.

Sources and References

Four reports in Japanese language have been published by NISTEP - The National Institute of Science and Technology Policy and MEXT – The Science and Technology Foresight Center, Ministry of Education, Culture, Sports, Science and Technology. These are available at www.nistep.go.jp and English translations will be published in 2006:

- Kagakugijutsu no chûchôki hatten ni kakawaru fukanteki yosoku chôsa (The 8th Science and Technology Foresight Survey, Needs Survey) Report no. 94, Tôkyô: NISTEP
- Kyûsoku ni hattenshitsutsu aru kenkyû ryûiki chôsa (The 8th Science and Technology Foresight Survey – Study on Rapidly-developing Research Area) Report no. 95, Tôkyô: NISTEP
- Kagakugijutsu no chûchôki hatten ni kakawaru fukanteki yosoku chôsa (The 8th Science and Technology Foresight Survey – Scenarios) Report no. 96, Tôkyô: NISTEP
- Kagakugijutsu no chûchôki hatten ni kakawaru fukanteki yosoku chôsa (The 8th Science and Technology Foresight Survey – Future Science and Technology in Japan, Delphi Report) Report no. 97, Tôkyô: NISTEP