Technology Foresight in Japan

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1. Japanese System for Science and Technology
: Factors behind Technology Foresight

The goal of Japanese technology foresight is to provide basic information for use in government-level science and technology policy, corporate R&D management and so on. The implementation of technology foresight is inextricably related to the characteristics of the governmental organizations that are involved in science and technology and to various social and economic factors current at the time of implementation. As we describe later, in Japan we are facing a drastic change of the government systems as a result of long controversy started in mid 1990's. Here we try to summarize the basic features of Japanese system for science and technology and changes of the system since mid 1990's. Also we describe that the above goal of technology foresight has been changing to some extent.

(1) Basic Features of Japanese System for Science and Technology

One of the distinctive features of Japanese science and technology administration is its diversified structure in many government ministries and agencies. They have their own research institutions and budgets, with government R&D programs as a whole implemented through their coordination. More specifically, while the Ministry of Education, Sports, Science and Culture (MONBUSHO), which oversees universities and colleges, has been allocated a budget for the promotion of basic research, ministries such as the Ministry of International Trade and Industry (in charge of the industry as a whole), the Ministry of Health and Welfare (in charge of health / medical care and welfare), the Ministry of Posts and Telecommunications (in charge of telecommunication and broadcasting), and the Ministry of Agriculture, Forestry and Fisheries (in charge of agricultural, forestry and fisheries industries) have their own research budgets and research organizations to achieve their administrative goals. In addition, the Science and Technology Agency (STA) undertakes strategic research programs that bridge basic and applied research. The 1999 government budget of science and technology, which totaled 3.16 trillion yen, was distributed among ministries and agencies as follows: the Ministry of Education 42.7%, the Science and Technology Agency 24.5%, the Ministry of International Trade and Industry 16.1%, the Defense Agency 4.6%, the Ministry of Agriculture, Forestry and Fisheries 3.5%, the Ministry of Posts and Telecommunications 2.4%, the Ministry of Construction 1.3% and other ministries and agencies 2.4%. As an organization to deliberate and decide on a general program for R&D activities undertaken by these ministries and agencies, the Council for Science and Technology (CST) has been set up, with the Prime Minister as chairman.

Japanese system for science and technology is also characterized by industry's proactive stance toward investing in R&D and by the fact that government research spending, as a percentage of the nation's total research expenditures, is low in comparison with the US and some European countries. For instance, in 1998 government spending accounted for 21.7% of the nation's total research expenditures (16.1 trillion yen). This percentage was only 17.9% in 1990, but has been rising ever since.

Against a background of the fact that many ministries and agencies maintain R&D functions within the government and that the industrial sector weighs heavily in R&D, a variety of long-term technological forecasts or visions have been prepared in Japan, centering around the government sector, to provide a direction for R&D through government policy formulation.

(2) Changes in Japanese System for Science and Technology since mid 1990's

1) Enactment of Science and Technology Basic Law
and Formulation of Basic Plan

As described above, R&D expenditures of Japan have been largely depending on industry sector. Investment of industry sector in R&D always focuses on development of some market products, which inevitably results

in less investment in basic research. This means that Japan had put stress on applied research and development. In 1990's Japan had been having a very long recession of economy, the industrial sector had not been able to maintain the level of expenditure on R&D (especially for long term basic R&D) as before. From this circumstance, the government was required to increase spending of basic research. (This had been required also from foreign countries.) In addition to that, the government had been required to be more involved in promotion of R&D applicable to socio-economic needs such as creation of new industries, solving global problems and forming comfortable social systems and community.
From the above backgrounds "The Science and Technology Basic Law" was enacted in 1995. This law emphasizes the followings.

- Responsibilities of central and local government (hereafter, "government" is used for "central government") in promoting science and technology
- Formulation of science and technology basic plan to ensure necessary funds (by STA with cooperation of related ministries)
- Measures taken by whole nation (government, local government, private sector)

(Balanced promotion of diversified R&D (putting more stress on basic research) / Improvement of research facilities / Support of personnel exchange not only between central and local government but also between sectors / Employment of more young PD researchers / Employment of more assistant technicians)

Under this law, for comprehensive and systematic promotion of science and technology policies, the first "Science and Technology Basic Plan" was established in 1996 to indicate concrete policies for five-year period from FY 1996 to FY 2000, in which the following matters are taken as goals.

- Constructing a new R&D system
- Expansion of R&D investment by government

The first basic plan requires that the government have to extend its investment in science and technology as a percentage of GDP up to a level comparable with some European countries and the US at the beginning of the 21st century. This calls for a doubling of government investment during the period of the first plan, so that the total expenditure on science and technology is required to reach 17 trillion yen. By the end of this fiscal year (FY 2000) the government will achieve this amount.

CST and STA (from January 2001, Ministry of Education, Sports, Science, Culture and Technology) are supposed to revise the basic plan every five years. Currently CST and STA are in time of revising the first basic plan to the second one covering FY 2001 to FY 2005. The circumstances have been changed a lot past several years. A record long recession of economy in 1990's has been pushing up unemployment rate to a record high level. A long-term trend of decrement of the birthrate is expected to bring decrement of total population in the near future (expected to start in 2007). Decrement of population will cause drastic impacts on the social system extending beyond merely issues associated with imbalances of supply and demand in the labor force. And the span of life of the Japanese still has been extended (this is basically welcomed), which, combined with the factor of decrement of population, will bring the most rapid aging of population the world ever had. All of these factors make people have great interest in future competitiveness of Japan and also future quality of living (including medical and welfare services). At the same time, restrictions arising from environmental problems such as greenhouse effect are becoming urgent and these also will have significant impacts on our future.

Thus the second basic plan will have the following features.

- Promotion of rapid advancing technologies for keeping international competitiveness (Including creation jobs in the era of intelligence)
- Promotion of technologies that satisfy people's needs such as improvement of health, overcoming and prevention diseases, and prevention natural disasters
- Promotion of the most advanced studies that contribute advancement of pure science, resolving global environmental issues, food supply, limited energy resources and so on

2) Government Reform in 2001

In 1990's, budget deficits has been accumulating year by year as a large amount of government debt. This large government debt had become a political issue in mid 1990's. (The budget deficit is still a large and long-continuing issue.) People became very sensitive to inefficient investment of government. Issues of bank failures combined with misleading of financial administration of government and other government related problems (successive accidents in nuclear plants etc.) also conclusively affected peoples' opinion. Thus it has become a common understanding of people that at first the government system should be changed into a smaller and more efficient one. In 1999 Japanese parliament decided to change the government system into a new one in January 2001. In this reform, the Japanese government will reduce the number of its ministries and agencies from 22 to 13. According to the program, "the Ministry of Education Science, Sports and Culture" and "the Science and Technology Agency (STA)" will be integrated into "the Ministry of Education, Science, Sports and Culture and Technology". This new ministry is responsible for a wide area of science and technology from basic science through application research and development. NISTEP is going to be an institute of this new ministry (hereafter "the Ministry of Education, Science and Technology").

At the same time the Council for Science and Technology will be bolstered as the Comprehensive Council for Science and Technology by expanding its coverage to include the humanities and social sciences in addition to the natural sciences (the present coverage). This council provides a framework for investigating science and technology policy issues from an overall perspective, incorporating not only the natural sciences as before, but also perspectives from the social sciences.

In Japan we are now in an era of drastic change of government systems with having many restrictions arising from internal issues such as a large government debt and a very rapid aging of population, and global issues. In these circumstances, a priority setting for use of restricted resources has been recognized as a very important issue. There the STA technology foresight has been expected to play a key role.

Table 1 shows the time sequence of implementation of the STA technology foresight surveys and formulation of the science and technology basic plans. Implementing years of 6^{th} and 7^{th} survey were out of phase for formulation of the science and technology basic plan. It is desirable and is requested that the STA technology foresight program should directly contribute formulation of the science and technology basic plan. Then next (8^{th}) survey have to be started in 2003 so that results of foresight survey could be used in formulation of the basic plan.

Table 1: Time Sequence of the STA Technology Foresight Surveys and Formulation of S&T Basic Plan

Year	STA Technology Foresight Survey	Science and Technology Basic Law and S&T Basic Plan
1990	preparation of 5^{th} survey	
1991	**5^{th} survey**	
1992	Reporting of 5^{th} survey	
1993		
1994		
1995	preparation of 6^{th} survey	**enactment of science and technology basic law**
1996	**6^{th} survey**	**formulation of 1^{st} s&t basic plan (1996-2000)**
1997	Reporting of 6^{th} survey	
1998		
1999	preparation of 7^{th} survey	
2000	**7^{th} survey**	**formulation of 2^{nd} s&t basic plan (2001-2005)**
2001	Reporting of 7^{th} survey	
2002		
2003	preparation of 8^{th} survey	
2004	**8^{th} survey**	
2005	reporting of 8^{th} survey →	**formulation of 3^{rd} s&t basic plan (2006-2010)**

2. STA Technology Foresight Surveys

(1) Rough Summary of STA's Technology Foresight Surveys

The following Table 2 summarizes the STA' foresight surveys.

Table 2: Changes in the coverage of STA' Technology Foresight Surveys

	Year of implementation	No. of Tech. Fields	No. of topics	Foresight period	Effective responses
First survey	1970-1971	5	644	1971-2000	2482
Second survey	1976	7	656	1976-2005	1316
Third survey	1981-1982	13	800	1981-2010	1727
Fourth survey	1986	17	1071	1986-2015	2007
Fifth survey	1991	16	1149	1991-2020	2385
Sixth survey	1996	14	1072	1996-2025	3586
Seventh survey	2000	16	1065	2001-2030	

Time Period of Foresight

The foresight time period is 30 years. This period has been unchanged from the beginning.

Survey Method

The past 6 STA surveys were conducted (and 7th undergoing survey is been conducted) using the Delphi method with answering the same questionnaires twice (for the second questionnaire with the results of first answer).

Delphi method: The Delphi method is a method of consolidating respondents' views by repeatedly giving the same questionnaire to a large number of people. In the second and subsequent questionnaires respondents receive a feedback of the results of the previous questionnaire so that they can reassess their answers to the questions in the light of the overall trend of views. This is the major characteristic that sets the Delphi method apart from ordinary survey methods. Respondents who are not confident in their answers will generally tend to support the majority view, so it is possible to consolidate their views.

Survey Items

The questionnaires covers the survey items listed below for each of the topics (Appendix 1 .

- Degree of expertise (of respondent)
- Degree of importance to Japan
- Expected effect
- Forecasted realization time
- Current leading countries etc.
- Effective measures the government should take in Japan
- Potential problems in Japan

Survey Fields

The history of changing technology fields surveyed from 4th to 7th survey is shown in the following table.

Table 3: Technology Fields Surveyed

4th		5th		6th		7th
Material / Processing (100)		Material / Processing (108)		Material / Processing (109)		Information / Communication (96)

Information / Electronics / Software (116)	Information / Electronics (106)	Electronics (74)	Electronics (69)
Communication (52)	Communication (65)	Information (79)	Life Science (88)
Life Science (96)	Life Science (98)	Communication (78)	Medical/Health care (94)
Space (39)	Space (46)	Life Science (94)	Agriculture / Forestry / Fisheries / Foods (79)
Marine (37)	Particles (40)	Space (51)	Space (40)
Earth (28)	Marine / Earth (82)	Marine / Earth (74)	Marine / Earth (65)
Mineral/Water resources (40)	Mineral/Water resources (39)	Resources / Energy (88)	Resources / Energy (78)
Energy (51)	Energy (51)	Environment (39)	Environment (40)
Environment (30)	Environment (50)	Agriculture / Forestry / Fisheries (84)	Material/Processing (103)
Agriculture / Forestry / Fisheries (75)	Agriculture / Forestry / Fisheries (74)	Production / Machinery (71)	Manufacturing (52)
Production / Labor (78)	Production (72)	Urbanization / Construction (73)	Distribution (40)
Urbanization / Construction (63)	Urbanization / Construction (65)	Transportation (60)	Business management (38)
Transportation (56)	Transportation (62)	Medical / Health care / Welfare (98)	Urbanization / Construction (73)
Medical / Health care (103)	Medical / Health care (109)	Distributed into other fields	Transportation (60)
Lifestyle / Education /Culture (87)	Community / Lifestyle (82)		Services (50)
Safety (20)			

(2) Procedure of Foresight Survey

Here we describe the implementation procedure of the Japanese (STA) technology foresight surveys. The organization structure of technology foresight committee is as the following.

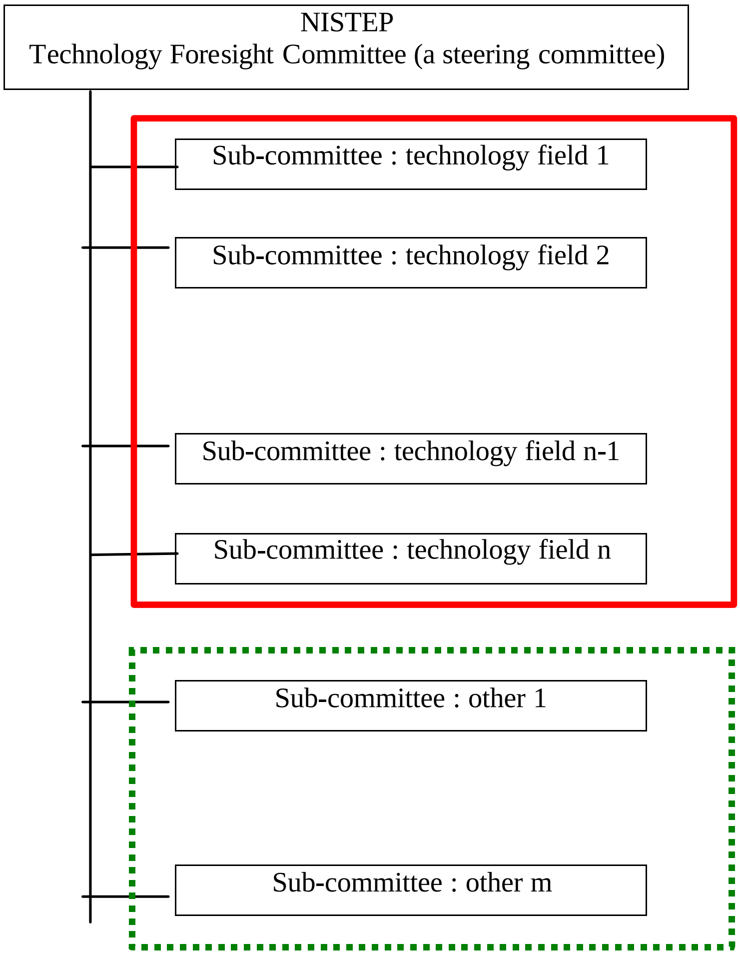


Fig.1 Organization Structure of STA Technology Foresight

The technology foresight committee (as a steering committee) consists of the chairperson of each sub-committee, which normally deals with a technology field to be surveyed. In cases of 1st to 6th foresight surveys, the steering committee had only sub-committees dealing with technology fields (technology sub-committees). In case of 7th foresight survey, which NISTEP is currently undertaking, the steering committee has also 3 sub-committees dealing with socio-economic needs in addition to 14 technology sub-committees (for 16 fields).

1) Defining Survey Fields and Members of Technology Foresight Committee

Before setting up the technology foresight committee, discussions on the following issues of next foresight survey program are carried out by NISTEP members with hearing from experts.

- technology fields to be surveyed
- total number of topics (number of topics in each field) and survey items
- scheme of survey (organization scheme)
- candidates for members of technology foresight committee

STA and NISTEP have conducted six technology foresight surveys, generally one every five years since 1971. A period of five years is often long enough to change the boundaries of technology fields. Also attracted technology fields at that moment could be different from the ones at the time of previous survey. Taking these into accounts, slight rearrangement of technology fields to be surveyed has been done every survey.

Total number of topics decides size of a questionnaire survey. For respondents, the more topics are listed in a questionnaire of some field, the more work is necessary for answering the questionnaire. The size of the recent surveys (the total number of topics 1,100) is considered as a kind of larger limit.

Survey items for each topic, which are common for topics within a field at least, such as "degree of importance to Japan", "expected effect", "realization time", "current leading countries", "effective measures the government should adopt in Japan", "potential problems in Japan" etc. are directly connected to needs of policy-makers. Then taking needs of STA policy-making people at that moment into account, the survey items are pre-decided within NISTEP.

Up to 6th survey, the foresight committees had only technology sub-committees, which inevitably lead to package of topics biased largely on technology seeds side. Recently in Japan, needs for changing social and economic systems, for safer and higher quality of lives of people (including environmental issues), and for countermeasures to rapid increment of aging population etc. is becoming intense. The foresight committee for 7th survey is trying to adopt a new scheme with 3 needs sub-committees in addition to 14 technology sub-committees for integration of socio-economic needs into picking-up of topics. These needs sub-committees have roles to extract goals, for which technologies aim, to realize the above social and economic needs. The technology sub-committees pick up some portion of topics complying with the extracted goals. This approach is a trial of integration of socio-economic needs into the technology foresight.

The technology foresight committee consists of a chairperson of each sub-committee. In 7th case, the number of technology sub-committees is 16 while the number of needs sub-committees is 3. The foresight survey depends largely on what members are appointed. As shown below, a chairperson of each sub-committee decides members of the sub-committee and appointed members nominate respondents to the survey questionnaire of that field.

NISTEP carefully picks up several specialist persons (normally professors of universities) in that field as candidates for a chairperson of that field, taking their research background and their colleague network. Then appointment is done after percussion process.

2) Setting up a Technology Foresight Committee and Related Sub-committees

After deciding members of a technology foresight committee, then each member of the committee (as a chairperson of a technology sub-committee) requested to nominate members of sub-committee. Then NISTEP and IFTECH persuade the nominees to be members of that sub-committee.

The technology foresight committee and its sub-committees have the following missions.

[Technology Foresight Committee]

- adjustment of survey schedule

• decision of conditions for selection of topics
• decision of survey items
• decision of topics before implementing survey questionnaires
• evaluation of responses to the questionnaires
• reviewing important technology areas to be promoted hereafter in each field

[Technology Sub-committee in Each field]

• framework for arranging topics (taking technology trends at that time into account)
• making draft package of topics for questionnaires [selection of topics (from topics to be remained the same / topics to be modified / topics newly made)]
• listing and selection of respondents for the questionnaires
• pre-evaluation of responses to the questionnaires
• extraction of important technology areas to be promoted hereafter in each field

The typical time schedule of having meetings of the foresight committee and sub-committees is shown in Table 4.

Table 4: Typical Time Schedule of Meeting of Foresight Committee and Sub-committees

Time Period	Foresight Committee		Sub-committees	
	Meeting	Mission	Meeting	Mission
6 months	defining survey fields and members of technology foresight committee etc.			
4 months	1st	• reviewing past foresight survey programs • reviewing comments and requests of previous survey • (discussion on / adjustment of) schedule of this foresight survey program • (discussion on / making decision of) conditions of selection of topics		
			1st	• (confirmation of) schedule of this foresight survey program • (discussion on / making decision of) framework for arranging of topics • giving an order to members for investigation of previous topics whether they are to be remained the same / to be modified / to be deleted • giving an order to members for making new topics
	2nd	• reviewing discussion of 1st meeting of each sub-committee • (discussion on / adjustment of) survey items for topics in each field • discussion on draft design of 1st questionnaires for this survey		
			2nd	•(discussion on / making decision of) topics to be remained the same / to be modified / to be deleted • selection of new topics from proposed by members • reviewing the member list of respondents to the previous survey • giving an order to members for listing-up of new candidates for respondents
	3rd	• reviewing discussion of 2nd meeting of each sub-committee • discussion on temporary package of topics field by field • reviewing temporary member list of respondents to this survey • finalizing discussion on design of 1st questionnaires for this survey		
			3rd	• continued selection of new topics from proposed by members • finalizing discussion on package of topics in each field

(to be continued)

Table 4: Typical Time Schedule of Meeting of Foresight Committee and Sub-committees

<table>
<tr><th rowspan="2">Time Period</th><th colspan="2">Foresight Committee</th><th colspan="2">Sub-committees</th></tr>
<tr><th>Meeting</th><th>Mission</th><th>Meeting</th><th>Mission</th></tr>
<tr><td>4 months</td><td colspan="4">1st survey questionnaires</td></tr>
<tr><td rowspan="2">4 months</td><td></td><td></td><td>4th</td><td>• discussion on results of 1st survey questionnaires
• giving an order to sub-committee members for investigation of each topic of 1st, 2nd and 3rd surveys whether it is realized at this moment or not</td></tr>
<tr><td>4th</td><td>• reviewing discussion on results of 1st survey questionnaires
• (discussion on / finalizing) design of 2nd questionnaires</td><td></td><td></td></tr>
<tr><td>2 months</td><td colspan="4">2nd survey questionnaires</td></tr>
<tr><td rowspan="2">2 months</td><td></td><td></td><td>5th</td><td>• discussion on results of 2nd survey questionnaires
• discussion on investigation results of realization of topics of early stage surveys
• giving an order to sub-committee members for selection of areas in that field to be promoted hereafter</td></tr>
<tr><td>5th</td><td>• reviewing discussion on results of 2nd survey questionnaires
• reviewing investigation results of realization of topics of early stage surveys</td><td></td><td></td></tr>
<tr><td rowspan="2">2 months</td><td></td><td></td><td>6th</td><td>• discussion on selected areas in that field to be promoted hereafter
• discussion on draft report of this survey concerning each field</td></tr>
<tr><td>6th</td><td>• reviewing discussion on draft report of this survey concerning each field (including investigation results of realization of topics of early stage surveys and selected areas of each field to be promoted hereafter)</td><td></td><td></td></tr>
</table>

3) Setting Topics for Survey Questionnaires

The process begins with each sub-committee determining the scope of survey, categorizing the future direction of technological development, and preparing a framework table in each field that would ensure important topics were not omitted. Above framework table is defined based on the one of the previous survey with taking view of technological trends at that moment. Then members of sub-committee pick up topics with the following restrictions set by the technology foresight committee.

- The final package of topics should consists of almost equal number of identical topics (to the previous survey), modified topics and new topics (each accounting for roughly $^{1}/_{3}$ of the number of topics).
- In principle, topics should be those thought to be realizable within 30 years. When necessary, topics those are thought to be realized after 30 years may also be included.
- In principle, the technological stage of each topic should be expressed by one of the four keywords of "elucidation", "development", "practical use" and "widespread use."
- As for the place of realization, unless specially mentioned, the topic should assume realization anywhere in the world (that is the country or region where realization is earliest).

- Two or more forecast particulars should not be included in one topic.
- Topics should include specific objective values and champion data whenever possible, and should present an image of specific use and application.
- When necessary, identical topics should be taken in more than one field.
- Topics relating to needs items categorized by needs sub-committee should be included as many as possible (this restriction is for 7th survey).

4) Deciding Survey Respondents

The important point for deciding survey respondents is to obtain at first as large a list as possible of experts with extensive knowledge in the relevant topics or technological fields, keeping in mind a good cross-section of representatives from academic sector (public and private universities), industry and government. The suitable experts as respondents are "people in research and development" or "research managers and others in corresponding positions" in the relevant survey fields. The breakdown of final respondents across three sectors is normally almost equal distribution. Also we consider the age structure of respondents so that as many younger people as possible are nominated. As for the proportion of female respondents has been very low (1% for 6th survey) in spite of effort of selecting as many female experts as possible.

Members of each technology subcommittee are asked by the chairperson to recommend experts in their respective fields as potential respondents. In some cases the subcommittees put forward lists of experts rather than recommendations of individual names (then NISTEP and IFTECH chose respondents randomly from the lists).

After potential respondents are listed up, we then ask each nominated person of his (her) cooperation for answering the survey questionnaires. Normally 60% of nominated respondents answers positively. Thus the final lists of respondents in respective field, to whom the first survey questionnaires are sent, is fixed. This process assures very high response rates to the survey questionnaires.

5) Implementation of the Survey Questionnaires

After setting of topics in all survey fields, a questionnaire for each survey field (in total the same number of questionnaires as the one of sub-committees) is prepared taking survey items into account. Then the first survey questionnaires are sent to the respondents in the list made as above.

For the second survey questionnaires, we exclude those who do not answer the first questionnaires. The second survey questionnaires ask respondents on the same topics as the first (wording of some topics are reviewed and revised in the light of comments by the respondents of the first questionnaires).

In the questionnaires, we announce that the following assumptions are premised.

- In principle, the foresight covers what are considered to be key R&D topics roughly over the next 30-year period.
- No wars of a global scale or natural calamities that would cause socio-economic upheaval over the next 30 years.
- Realization place of the each topic is anywhere in the world, unless indicated in the topics with such terms as "in Japan"

3. Assessment of STA Foresight Survey

The 1st STA survey was done about 30 years ago 1970-1971 , which enable us to evaluate the realization of each topic listed at that moment. This evaluation is very useful for investigating reliability of this kind of technology foresight programs. As shown below, the STA foresight survey has pretty good reliability to some extent for forecasting the future technology development.

(1) Evaluation of Realization of Technologies

Here at first, let us explain how realization of technologies (topics) listed in the past surveys was assessed. In 1996, members of the sub-committees of the Sixth Technology Forecast Survey evaluated 588 (of 644) and 549 (of 657) topics of the first (1970-1971) and the second (1976) surveys, respectively. Of the evaluated topics in the first survey, 26% were "realized," 38% "partially realized. By field, information has the highest realization rate, followed by food and agriculture, industry and resources, health and medical care, and social development. The realization rate including partially realized topics is highest in health and medical care, followed by food and agriculture, information, industry and resources, and social development (Appendix 2).

Similarly, of the topics assessed in the second survey, 21% were deemed "realized," 42% "partially realized," and 37% "unrealized." Fields with a high realization rate are space development, information, industrial production, family life, and food resources, while those with a low realization rate are water resources, software science, transportation, environment, and forest resources. The realization rate including partially realized topics is high in space development and health and medical care, and low in software science and energy (Appendix 3).

It should be noted that this evaluation considered only whether a technology was deemed "realized" as of 1996; it did not investigate whether the forecasted realization times at that moment had been accurate. Further, because some technology topics included multiple aspects and/or had ambiguities, the figures for "partially realized" include not only cases in which a technology had been partially realized, but also cases in which the experts disagreed on how to interpret the aspects of a technology. Nonetheless, realization rates including partially realized topics indicate that roughly two-thirds of the technologies are progressing in the manner forecasted - quite impressive for forecasts so long-term in scope (30 years). It should also be noted, however, that there are technologies that had significant impact upon realization but which had not been addressed by the forecasts.

1) Relationship between Degree of Importance and Realization Rate

An "importance index" was calculated for each technology topic to elucidate the relationship between assessed degree of importance and realization rate. The first through sixth surveys assessed each topic's degree of importance of by asking respondents to select one of four choices: high, medium, low, or unnecessary. The index was worked out from the following equation; the index is 100 when all respondents indicate "high" and 0 when all indicate "unnecessary".

importance index = (100*Nh + 50*Nm + 25*Nl + 0*Nu) / (Nh + Nm + Nl + Nu)

Nh = number of "high" responses

Nm = number of “medium” responses

Nl = number of “low” responses

Nu = number of “unnecessary” responses

While there is little difference between topics with a high degree and those with a low degree of importance in the realization rate, there is a significant difference in the realization rate including partially realized topics, with the more important topics showing a much higher rate. Among topics with a degree of importance index of 50 or more, there is no major difference, and for topics with a low degree of importance, the realization rate including partially realized topics is quite low indeed.

Table 5 Degree of importance and realization rate

Degree of importance index	Number of topics		Realization rate (%)		Realization rate including partially realized topics (%)		Unrealized rate (%)	
	First survey	Second survey	First survey	Second survey	First survey	Second survey	First survey	Second survey
More than 90	100	65	24	18	78	63	22	37
90-80	120	100	25	16	59	58	41	42
80-70	45	83	11	23	56	57	44	42
70-60	98	124	26	22	61	61	39	39
60-50	172	144	28	15	59	49	41	51
50-40	59	74	19	14	42	43	58	57
Less than 40	50	66	16	14	32	33	68	67

2) Forecasted Realization Time and Realization Rate

Here we classified the topics by forecasted realization time, and calculated the realization rate for each of time classification. In both the first and second surveys, the earlier the topic forecasted realization time, the higher the realization rate and the realization rate including partially realized topics. Moreover, topics that recorded a high percentage of “will not be realized” responses have an extremely high unrealized rate.

Table 6 Forecasted realization time and realization rate (first survey)

Forecasted realization time	Number of topics	Realization rate (%)	Realization rate including partially realized topics (%)	Unrealized rate (%)
-1980	29	45	86	14
1981-1985	212	37	76	24
1986-1990	244	20	59	41
1991-1995	75	9	35	65
1996-2000	47	9	26	74
2001-	37	3	22	78
Unrealized *	72	3	19	81

Table 7 Forecasted realization time and realization rate (second survey)

Forecasted realization time	Number of topics	Realization rate (%)	Realization rate including partially realized topics (%)	Unrealized rate (%)
-1985	15	40	87	13
1986-1990	217	28	71	29
1991-1995	239	16	54	46
1996-2000	130	7	30	70
2001-2005	42	2	21	79
2006-	13	0	8	92
Unrealized *	20	0	10	90

* Topics with a "will not be realized" response rate of 30% or more

(2) International Comparisons of Delphi Surveys

Although the first through fourth surveys of STA limited themselves to Japan, the surveys have become more and more international in scope since the fifth survey, which cooperated with Germany to produce Japanese-German comparisons and a joint Japanese-German "Mini-Delphi" survey. France also followed by forecast survey of identical topics with Japanese fifth one.

German Delphi I and Japan's fifth survey examine identical topics and so permit a direct comparison of results for both countries. As shown in Fig.1, both countries' forecasts correspond quite well with respect to forecasted realized time. Each point in Fig.1 represents a topic. The difference between Japanese and German forecasted realized times was less than three years for roughly 60% of all topics. This 60% figure can be interpreted as indicating nearly complete agreement given the fact that respondents' choices for realized time were five-year time periods. Furthermore, because this survey asked respondents about "realization in your own country," such excellent agreement in results serves as a reminder of the global scope of technology. In contrast, considerable differences exist between the two countries' assessment of the importance of topics, indicating the strong effect of social, economic, geographic and cultural factors.

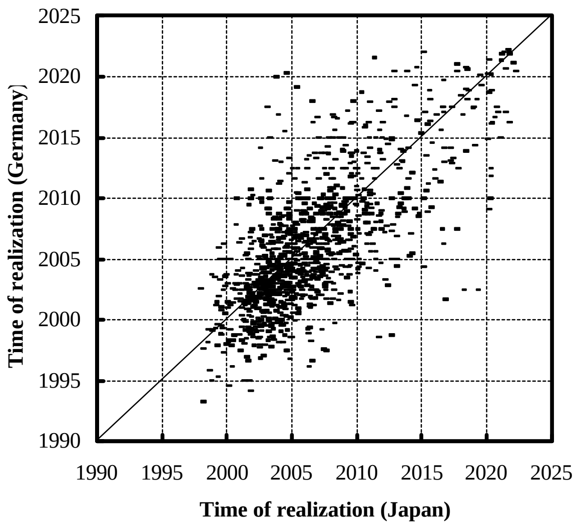


Fig.2 Comparison of the Japanese and German time of realization of all the topics

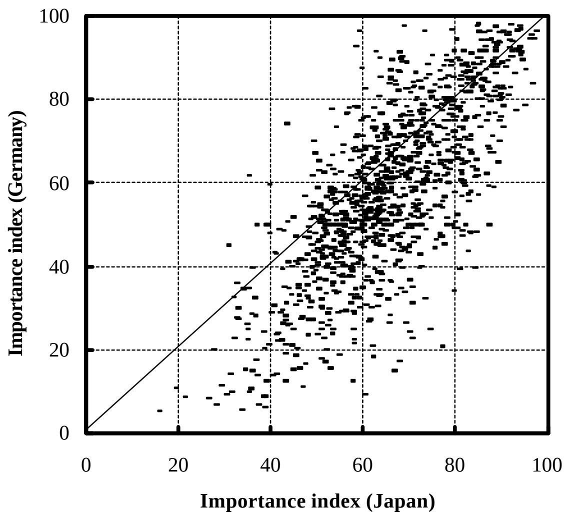


Fig.3 Comparison of the Japanese and German importance of all the topics

4. Political Implications of Technology Foresight

Because Japan's technology forecast surveys thus involve such a large number of leading experts and employs the Delphi method, which is designed to reach a consensus among a group of experts, how such consensus relates to policy formation and R&D activity, for instance, is a highly intriguing proposition.

Let us therefore consider political implications in Delphi-based technology foresight in comparison with past trends in actual R&D expenditures. Investment in R&D by Japan's public and private sectors is monitored by the Management and Coordination Agency through surveys that determine R&D expenditures by objective, and so make it possible to trace changes in Japan's overall research spending in energy, information technology and several other categories. Table 8 gives each category's share of Japan's total R&D expenditures in each survey year.

Table 8 Four category's share of Japan's total R&D expenditure

Year	Information(%)	Environment(%)	Life science(%)	Energy(%)
1971	2.7	2.1		
1972	2.8	2.9		
1973	3.7	3.8		
1974	3.3	3.5		
1975	3.4	3.6		
1976	3.5	3.2		4.8
1977	3.2	2.2		6.1
1978	3.2	3.4		6.9
1979	3.4	3.1		7.9
1980	3.1	2.7		9.5
1981	3.6	2.5	8.5	10.6
1982	3.8	2.1	9.9	10.4
1983	4.0	2.0	10.3	9.5
1984	4.9	1.8	9.9	9.0
1985	5.1	1.7	9.9	8.5
1986	5.4	1.6	10.0	9.0
1987	6.1	1.6	10.3	8.7
1988	7.0	1.6	10.6	8.4
1989	8.6	1.6	10.4	7.7
1990	8.6	1.8	10.3	7.0
1991	8.7	1.8	10.6	7.1

1992	7.8	1.8	11.3	7.5
1993	7.8	1.9	12.0	7.7
1994	7.8	2.1	12.0	7.8
1995	7.8	2.2	12.1	7.8
1996	9.4	2.3	11.9	7.7
1997	10.0	2.3	11.5	7.5

These data show that environment-related research expenditures, for instance, accounted for 3.5% of the total in the 1970s, when pollution control was an urgent domestic issue. Effective pollution-control measures allowed this percentage to drop to roughly 1.6% in the 1980s, but it rose again in the 1990s with heightened awareness of global environmental problems.

The importance indices of topics technology forecast survey were used to create an "Delphi index" showing the degree of priority of technological area by selecting the upper 30% of the topics in importance index and by grouping these topics according to their subject matter into the six categories of "information," "life science," "environment," "energy," or "other," and then determining the ratio of each category. This ratio became the Delphi index for its respective category.

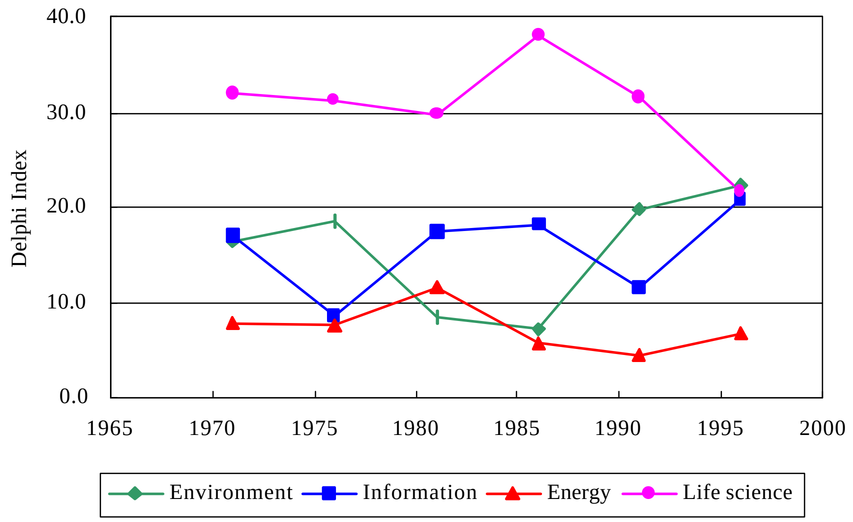


Fig. 4 Distribution of upper 30% of the important topics (Delphi index)

The ratio for the category of "environment" was high in the 1970s, declined in the 1980s, and once again exhibited a rising tendency in the 1990s, thus corresponding closely to the aforementioned trend in environment-related research expenditures. Graphs 1 through 4 visually indicate the correlation of the Delphi index in four categories to Japan's actual total research expenditures. A close correlation is seen between the two for the three categories of the environment, information technology, and energy. Research expenditures for the life sciences, however, have been included in the survey only since 1982, making comparison difficult and resulting in trends that differ someone from those of the other three categories. Furthermore, because this is the first attempt at the systematic analysis of Delphi forecasts over an almost 30-year period, analysis of further depth is required. Nonetheless, these results demonstrate how technology forecasts arrived at with the participation of numerous researchers and engineers from industrial and other sectors are an accurate indicator of national trends in research and development in Japan.

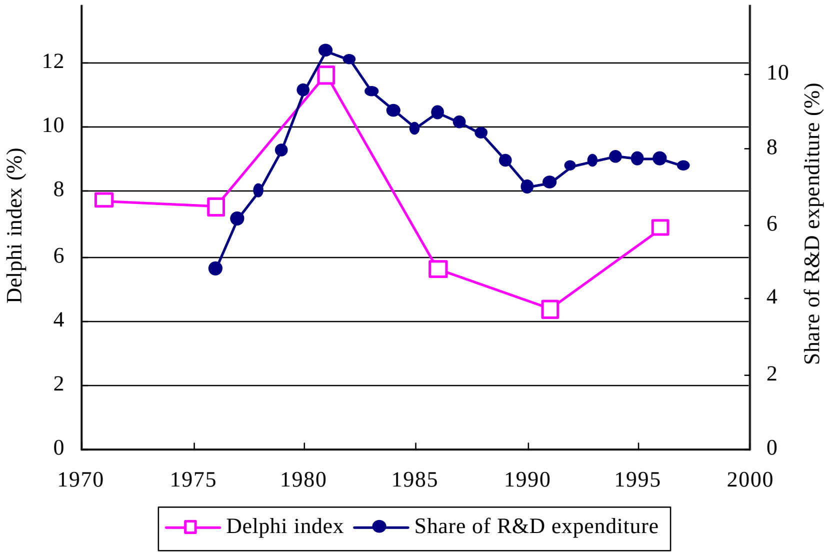
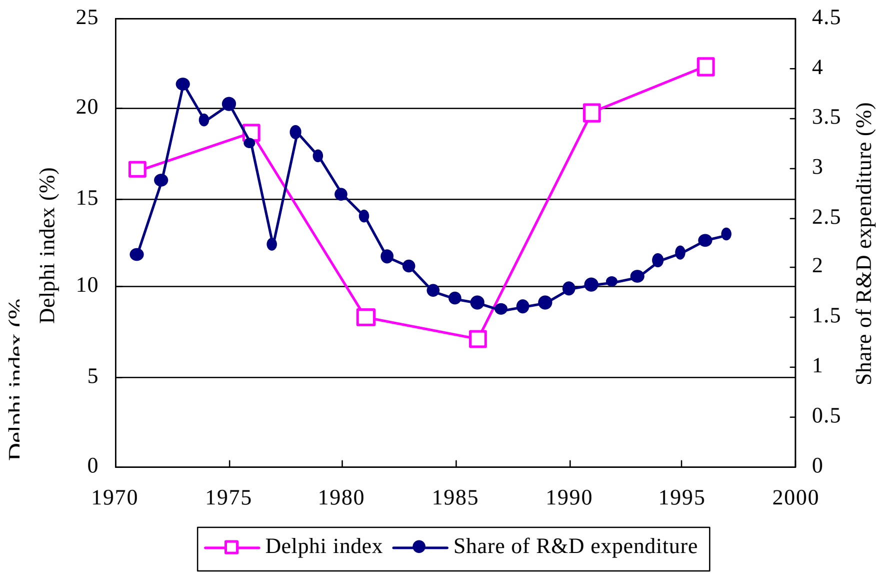
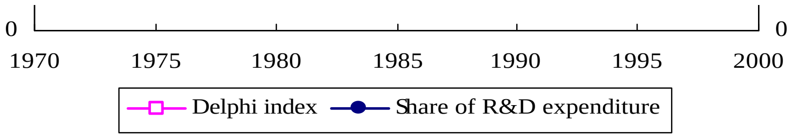


Fig 5 Energy

ig.6 Environment





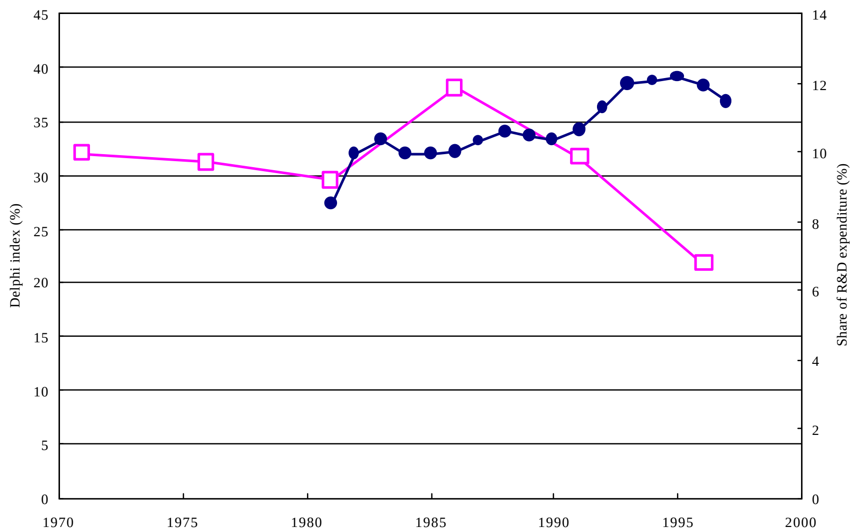


Fig.8 Life science

5. Integration of Socio-economic Needs into Technology Foresight

We described about the common understanding of citizens in Japan that the government system have to be changed. In addition to this, another common understanding has been becoming more and more clear in 1990's, that science and technology should satisfy social and economic needs. (More strictly speaking, a desire of social scientists and economists (as representatives of citizens) for their direct and systematic participation in the process of making policies of science and technology has been becoming strong.)

From this background, in the second basic plan, a following item will be emphasized

measures to meet people's needs such as improvement of people's health, overcoming and preventing diseases, and preventing disasters

in addition to

dealing with issues regarding rapid advancement of information and communication technology and creation new industries

contribution to settlement of world wide scale problems, such as environmental issues, food supplies, and limited energy and resources.

The above things requires efforts for integration of socio-economic needs into the technology forecast survey program with the procedure we had so far. On this background, the STA technology foresight program is now challenging a new survey scheme with integration of socio-economic needs.

However because all these issues cover a very range of human needs and are relating to an era of social change resulting from the demographic change of Japan, a comprehensive review of socio-economic issues spanning the medium and long-term is required in advance.

(1) A Needs Oriented Approach in the Past Survey

There had been an awareness of needs analysis approach even in the sixth STA survey. In the sixth survey, we extracted the topics related the following items which would be thought to constitute socio-economic needs.

Counter measures for aging society (creating a barrier free environment, maintaining quality of life, assisting aged people to be independent etc.)

Maintaining safety (prevention of natural disasters, reducing crimes including computer crimes etc.)

Environmental preservation and recycling (developing new energies, low energy consumption initiatives, recycling technologies etc.)

Shared fundamental technologies (design techniques, processing technologies, handling systems, and techniques for making observations and taking measurements).

Each technology sub-committee was instructed to include consideration of important technologies related to these four items when they had set the topics. Report of each sub-committee was arranged to incorporate consideration for above four items.

Using the data of forecasted realization time and importance indices, we arranged the related (group of) topics in two dimensional diagrams (realization years, importance indices) so that we could see the relations between average relation time and importance indices of the technology groups. The committee of 6th technology forecast survey also analyzed the measures what government should take.

However these were all done by members of technology sub-committees, who were all engaged in research study and development. And the data used were answered by basically the experts of each field. Then a participation of social scientists and economists was not done.

(2) A Trial for Integration of Socio-economic Needs into the Survey

We has started the 7th technology forecast survey, where NISTEP has been trying an explicit participation of social scientists, economists and journalists and so on. The 7th technology forecast survey is characterized with the following points.

Setting up of needs panels

As shown in the following page, we newly set 3 needs panels (sub-committees), which have roles to extract the future socio-economic needs related to demographic change of Japan (very low birthrate and aging), globalization of economy with rapid advancing information technology, world wide environmental / food / energy issues, safety and security of society and human lives (including mental cares). The extracted items of socio-economic needs are presented to technology panels, which are obliged to include the topics related to the needs items

Setting up of service, distribution and management panels

Taking rapid growth of service and distribution sectors within the economy and importance of business management, we set up panels dealing with these matters. These are service, distribution and business management panels.

Grouping of panels (6 technology groups and 1 needs group).

In order to make the survey items (in the case of 6th survey, these items were common for all fields) able to be changed flexibly, we made 6 technology groups of panels collecting a few panels into a group.

Rink between needs and technology

It is recognized that relating technologies with the needs items is very important for integration of socio-economic needs into the survey. The survey questionnaire is answered by experts in each technology field. Then another survey investigating the priority of needs items extracted by 3 needs panels is going to be conducted. If the priority setting of these needs items were done by another survey, we could find degree of each topic contribute to the needs. For this, an evaluation of each topic to what extent applies to each item of needs.

Introduction of non-technological topics(institutional issues, lifestyle etc.)

As necessary, issues that are thought to have substantial impacts on development of some kind of technologies can be taken as topics (these are non-technology topics) into the survey questionnaires. For example, in the field of the environment, items regarding institutional systems, such as introduction of an environmental tax could be added for investigation.

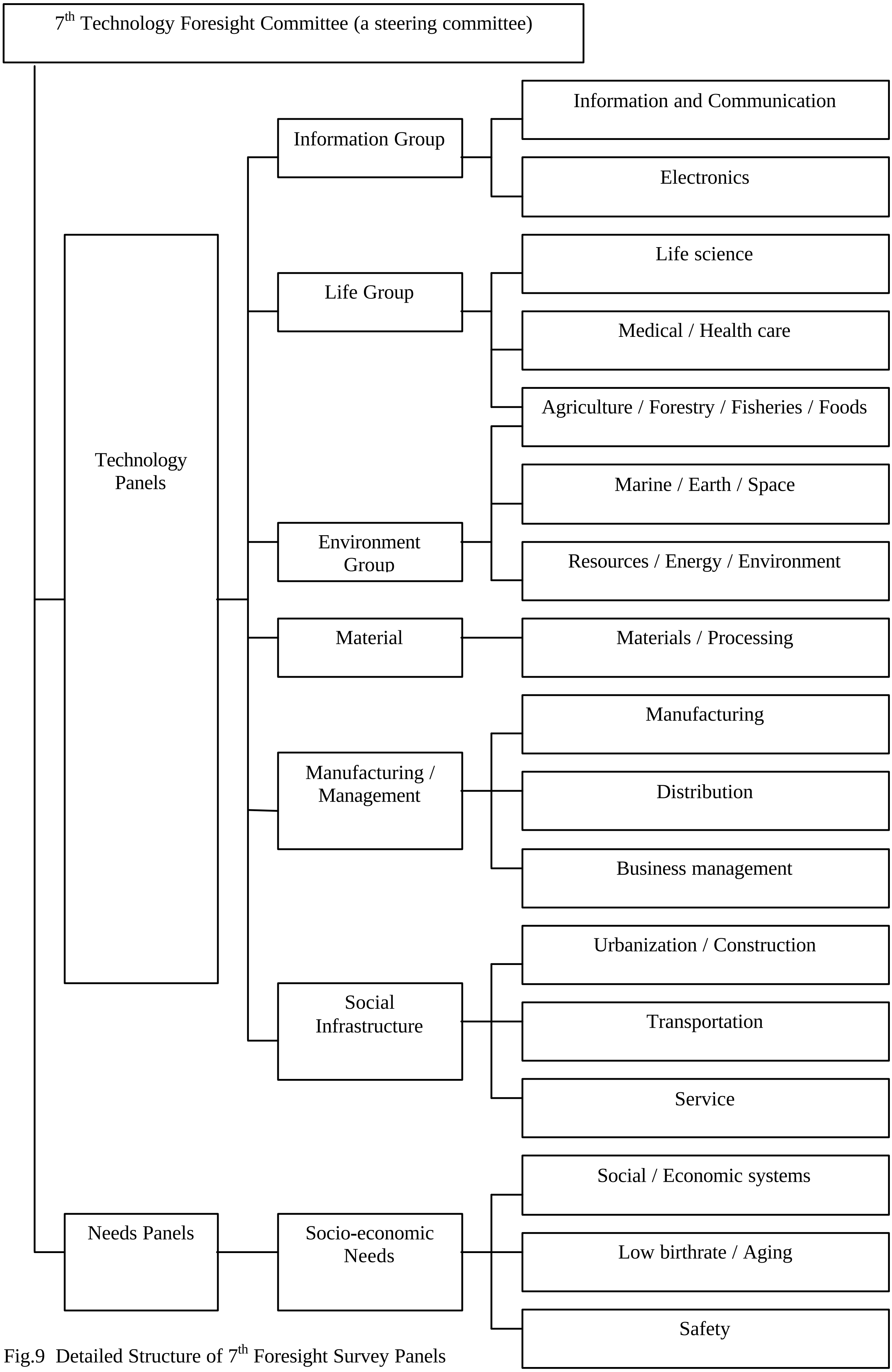


Fig.9 Detailed Structure of 7th Foresight Survey Panels

[Procedure of Integration of Socio-economic Needs]

In the 7th survey, we are taking the following procedure as a trial for integration of socio-economic needs into forecast survey.

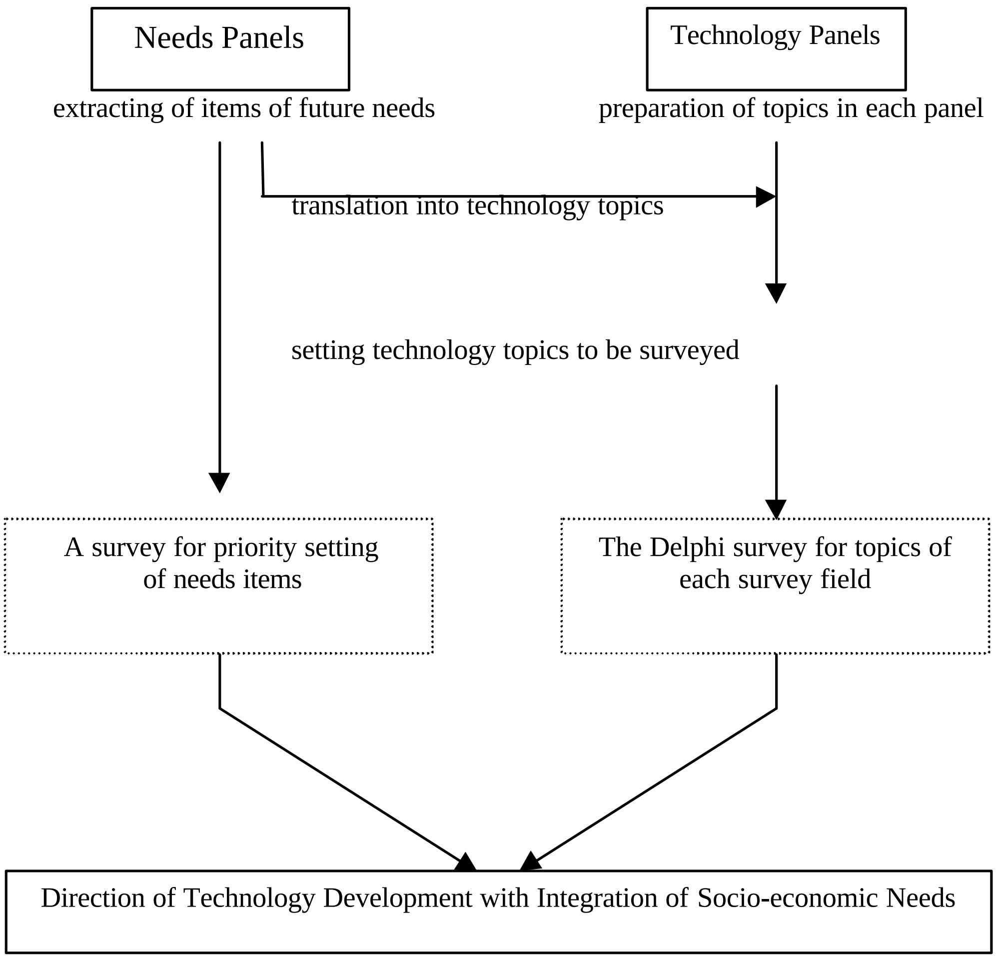


Fig.10 Procedure of Integration of Socio-economic Needs

Needs panels are required to ascertain issues that must be solved by technology in the future and then present their findings on the needs items to the technology panels. If possible, they also make suggestions on the survey topics. In the survey process, we are going to conduct another survey for setting the priority of needs items. Each topics is going to be evaluated its degree of relation with each needs item at the same time by members of each panel.

Combining the data of the survey for needs priority setting, the results of above evaluation and the results of Delphi survey, we are able to obtain information, for example, of the technologies with high needs score but taking a very long realization time. (These technologies are to be promoted at first.)

6. Conclusion

In Japan, technology forecasts that are based on the participation of and consensus formed among large numbers of experts have followed a unique path of development owing to the unique characteristics of Japan's R&D infrastructure. Historical experience has shown this approach to have considerable reliability, while its connection to the evolution of macro-level R&D activity is also evident from the correlation with actual research expenditures. In an international context, this approach has also been adopted in other countries beginning in the 1990s, and comparative research has revealed that the nations of the world now share a common awareness of the future outlook of technology. At the same time, however, considerable differences — originating in each nation's social and economic circumstances — have also been quantitatively shown to exist with respect to how each nation assesses the importance of various technologies. Such knowledge bespeaks not just the need for efforts to increase the depth and validity of technology foresight, but also the potential benefit of such efforts. NISTEP has begun the Seventh Technology Forecast Survey, and intends to develop a new methodology through it.

Appendix 1: Survey Parameters of Sixth survey

Degree of expertise	High/Medium/Low/None
Degree of importance to Japan	High/Medium/Low/Unnecessary
Expected effect	Contribution to socioeconomic development
	Resolution of various problems of a global scale
	Response to people's needs
	Expansion of human intellectual resources
Time of Realization	2000-2004/2005-2009/2010-2014/2015-2019/2020-2025/2026-/Never/Don't know
Current leading countries etc.	USA/EU/Former Soviet Union and Eastern European countries/Japan/Other countries/Do not know
Effective measures the government should adopt in Japan	Foster researchers, engineers and research assistants
	Enhance systems to promote personnel exchanges among the industrial, academic and government sectors and cooperation among different fields of science and technology
	Upgrade advanced R&D facilities and equipment and make them available for more widespread use (covers facilities and equipment at national research institutions, universities and other public research institutions)
	Develop a research base comprising data bases, standard reference material, genetic resources and the like
	Increase the government's funding for research (including research subsidies for private companies etc.)
	Adjust relevant regulations (relax/toughen/establish/abolish; including such tax measures as promoting the widespread use of electric cars by introducing a carbon tax)
	Others (enter specific measures in the response column)
Potential problems in Japan	Adverse effect on the natural environment
	Adverse effect on safety
	Adverse effect on morals, culture or society
	Other adverse effects

Appendix 2 Realization rate of assessed topics in the first technology forecast survey

Division	Field	Assessed topics	Realization rate (%)	Partially realized rate (%)	Unrealized rate (%)
Social development	Improvement of clothing standards	20	30	45	25
	Improvement of housing standards	18	17	27	56
	Leisure	20	25	30	45
	National land and urban development	17	0	65	35
	Improvement of traffic and transportation	20	10	15	75
	Prevention of pollution	20	10	50	40
	Improving education	15	13	40	47
	Subtotal	130	15	39	46
Information	Socioeconomic demands	40	20	50	30
	Information technology	47	40	22	38
	Basic technology	18	50	11	39
	Subtotal	105	34	31	35
Health and medical care	Progress of medical diagnosis and treatment	37	24	54	22
	Development of preventive medicine	9	11	45	44
	Development of the medical care system	12	25	75	0
	Elucidation of life phenomena	9	11	89	0
	Humans and the environment	10	10	70	20
	Medical education	5	0	80	20
	Others	1	100	0	0
	Subtotal	83	19	63	18
Food and Agriculture	Development of food material	30	33	37	30
	Systems development	33	24	58	18
	Development of control methods	20	30	60	10
	Machinery development	13	31	31	38
	Subtotal	96	29	48	23
Industry and Resources	Space development	23	35	22	43
	Marine development	25	24	40	36
	Energy development	24	13	12	75
	Resources development	27	11	22	67
	Increasing mining production	38	34	27	39
	Material development	37	49	29	22
	Subtotal	174	29	26	45
Total		588	26	38	36

Appendix 3: Realization rate of assessed topics in the second technology forecast survey

Field	Assessed topics	Realization rate (%)	Partially realized rate (%)	Unrealized rate (%)
Food resources	69	26	46	28
Forest resources	11	9	64	27
Mineral resources	19	16	42	42
Water resources	8	0	38	63
Energy	21	14	10	76
Environment	47	6	49	45
Safety	18	17	55	28
Family life	29	28	31	41
Leisure	10	10	30	60
Education	24	13	50	38
Health and medical care	41	17	66	17
Labor	10	20	50	30
Transportation	20	5	35	60
Information	53	42	22	36
Construction	20	15	55	30
Industrial production	54	30	39	31
Space development	18	44	50	6
Marine development	28	21	50	29
Life science	22	23	54	23
Software science	27	4	18	78
Total	549	21	42	37