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1. Topics with a high degree of importance

1.1 Overall trends

Here we shall look at forecasts for those of the 1,072 topics in all fields (referred to as all topics) that were assessed as having a high degree of importance. Respondents were asked to classify the importance of each topic as "high", "medium", "low" or "unnecessary". We calculated importance indices for the topics based on the total number of respondents and weighted values of 100, 50, 25 and 0, respectively, for the degrees of importance. Where all respondents indicated "high" the index is 100, and where all indicated "unnecessary" it is 0. Unless otherwise specified, from now on all data used are from the second round questionnaire.

$$I_{index} = (100 * N_{high} + 50 * N_{medium} + 25 * N_{low})/N_{all}$$

I_{index}: Degree of importance index

N_{high}: Number of "high" responses

N_{medium}: Number of "medium" responses

N_{low}: Number of "low" responses

N_{all}: Total number of degree of importance responses ($N_{high} + N_{medium} + N_{low} + N_{unnecessary}$)

The average index for all topics is 62.1, slightly down from the 65.3 recorded in the fifth survey. By fields, environment has the highest average index with (72.0), followed by electronics (67.7) and life science (66.1), while the lowest is urbanization and construction with (56.0), then space (56.2).

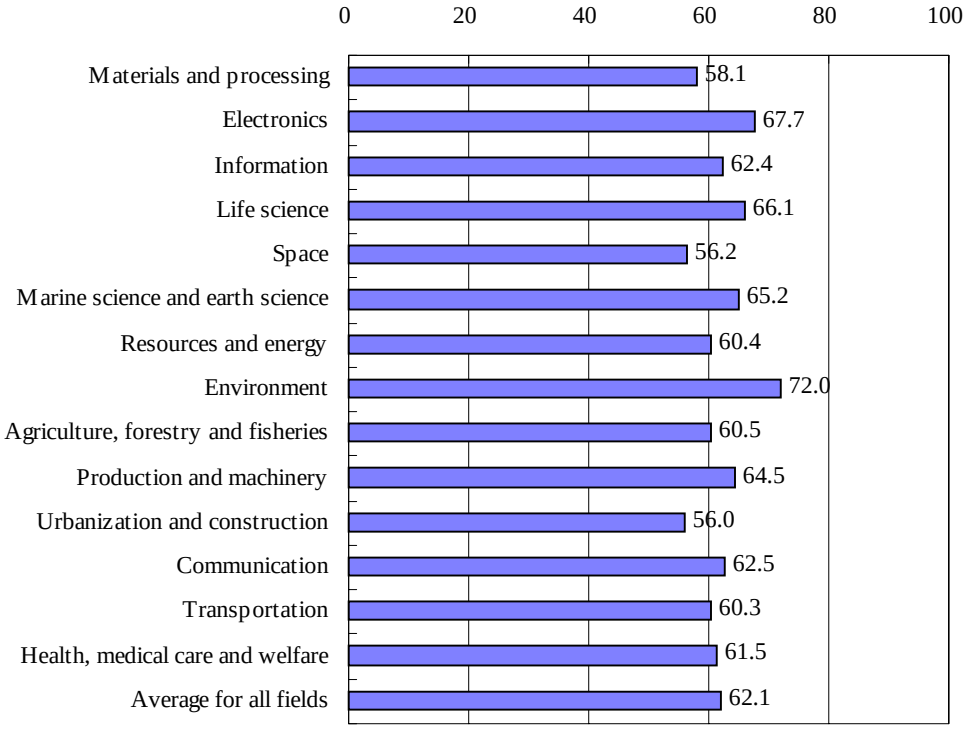


Figure 1.1-1 Importance index by field

Fields with the largest number of topics in the list of top 100 topics in degree of importance (see Table 1.1-1) are:

Electronics	15
Life science	13
Marine science and earth science	9
Environment	9
Materials and processing	8

From this we can see that while "environment" has the highest average index, it does not have the largest representation in the top 100 topics list. So although overall the environment is considered to be the most important field, relatively speaking there is not a large number of topics that are given particular prominence.

To determine any distinctive features about the top 100 topics in this survey, we compared them with the top 100 topics in the fifth survey (see Reference 3).

First we divided the 100 topics into five classifications:

i) Environment-related technologies ranging from global environmental issues to local waste disposal

ii) Information-related technologies such as memory and semiconductors, and the internet and other networks

iii) Life-related technologies such as gene technology and treatment of illness

iv) Disaster-related technologies such as prediction and prevention of earthquakes and other natural disasters

v) New energy technologies connected with the use of solar energy and other non-fossil fuel energy

This resulted in the following breakdown.

Classification	6th survey	5th survey
Environment-related technologies	25	28
Information-related technologies	24	10
Life-related technologies	17	37
Disaster-related technologies	11	9
New energy technologies	11	6
Others	12	10

What stands out here is that information-related technologies increased and life-related technologies decreased significantly. New energy technologies also recorded a considerable rise. Next we shall discuss the results for each classification in more detail.

i) Environment-related technologies

Overall, the number of topics has changed little, though the number connected with recycling, such as the greater acceptance of product design concepts that facilitate recycling and the practical use of technologies for recycling plastics has jumped from four in the fifth survey to nine in the sixth. On the other hand, topics related to the global environment, such as the practical use of CO_2 fixing technology and fluorocarbon and halon substitutes, dropped from thirteen to seven, indicating that greater importance is given to the more familiar and tangible environmental technologies.

ii) Information-related technologies

Network systems topics, such as practical use of a high-security next-generation internet and widespread use of networks that protect privacy and confidential information, jumped from two to twelve; and semiconductor-related topics, such as practical use of 256Gb memory chips and practical use of

technology for mass production and processing of 10nm patterns, also jumped, from six to eleven. Thought to be behind these rises is a much greater awareness about the diversification of services and need for safety and security with the phenomenal rise in interest in the internet in Japan and throughout the rest of the world over the five years since the last survey.

iii) Life-related technologies

While little change was seen in cancer-related topics, such as practical use of means of preventing the spread of cancer, dropping to nine from ten in the fifth survey, brain-related topics, such as treatment etc. of Alzheimer's disease, dropped from eight to one this survey. This can be put down partly to the fact that the total number of related topics were consolidated from six topics in the previous survey, of which five made the top 100 list, to three topics in this survey. The number of topics dealing with the treatment of diseases such as arterial sclerosis also dropped. The average importance index value for the life science field was high in this survey as well, so the fact there were comparatively few life-related topics in the top 100 does not necessarily mean that the degree of importance fell, rather it should be seen to be attributed to the greater importance given to information technology.

iv) Disaster-related technologies

The number of earthquake-related topics rose from four in the previous survey to eight in this survey, so overall the number of topics were up as well.

v) New energy technologies

Topics dealing with solar cell technology rose from two to four, and all are ranked in or near the top ten. There was little change in topics dealing with other technologies, such as nuclear power.

Table 1.1-1 Top 100 topics in the sixth survey

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
1	Production	42 Widespread use of non-fossil energy sources (wind, geothermal, solar (photovoltaic/solar thermal) and waste heat) in all areas of life including household, industry and transportation.	94	2018	New energy	
2	Electronics	06 Practical use of VLSI with as much as 256 Gbits of memory per chip.	94	2014	Information	Semiconductors etc.
3	Electronics	30 Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.	93	2012	New energy	Solar cells
4	Electronics	05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	93	2013	Information	Semiconductors etc.
5	Space	25 The cost of rocket thrusted space transportation will be reduced to less than 1/10 current levels.	93	2014		
6	Production	50 Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.	92	2012	Environment	Recycling
7	Marine science	60 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	92	2023	Disasters	Earthquakes
8	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	92	2003	Information	Networks
9	Electronics	18 Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.	92	2010	New energy	Solar cells
10	Urbanization	13 Practical use in Japan of a safe and rational demolition technology for decommission of commercial nuclear power plants.	92	2009	New energy	Nuclear energy
11	Materials	84 Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.	91	2016	New energy	Solar cells
12	Materials	85 Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%.	91	2011	New energy	Solar cells
13	Life science	49 Practical use of effective means to prevent metastasis of cancer.	91	2013	Life	Cancer
14	Marine science	01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	91	2007	Disasters	Natural disasters
15	Environment	32 Wide acceptance of LCA-style product design concepts that encourage recycling and reuse.	91	2007	Environment	Recycling
16	Information	22 Widespread use of highly reliable network systems capable of protecting the privacy and secrecy of individuals and groups from the intrusion of ill-intentioned hackers.	91	2007	Information	Networks
17	Materials	34 Establishment and practical use of plastic recycling technology.	91	2007	Environment	Recycling
18	Production	44 Practical use of technologies that enable the direct storage of electricity (superconducting magnets, flywheels and capacitors).	90	2016	New energy	
19	Information	18 Realization of an environment in which the unlimited utilization of high-capacity networks (150 Mbps) for around 2,000 yen/month is possible.	90	2008	Information	Networks

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
20	Information	64 Establishment of social rules regarding multimedia copyrights, and expanded production and distribution of multimedia information.	89	2005	Information	Networks
21	Resources	63 Practical use of technology for the safe disposal of highly radioactives solid waste.	89	2019	New energy	Nuclear energy
22	Electronics	13 Practical use of TIPS (Tera Instruction Per Second) level microprocessors.	89	2018	Information	Semiconductors etc.
23	Environment	24 Widespread use of control technologies in virtually all types of automobiles, capable of meeting the emission control standard for nitric oxide at the order of 0.1 to 0.2 g/km. (The current level for heavy diesel motorcars is on the order of 4 to 5 g/km, and the standard control value for gasoline passenger cars in 1978 is 0.25 g/km.)	89	2007	Environment	
24	Electronics	08 Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	88	2017	Information	Semiconductors etc.
25	Agriculture etc.	84 Practical use of a system of removing almost the entire pollution load on lakes, bays and other closed water bodies that are suffering from water quality degradation by developing environmental restoration technology that utilizes ecosystems and biological functions.	88	2018	Environment	
26	Transportation	31 Achievement of a 90% recyclability for motor vehicle parts and material (scrapped vehicles).	88	2009	Environment	Recycling
27	Marine science	14 Development of a numerical model of the correlation between climatic changes and changes in marine living resources.	88	2013	Environment	Global environment
28	Production	08 Practical use of room temperature superconductors in industrial products.	88	2016		
29	Resources	19 Practical use of economical methods for separating and recycling valuable substances in urban garbage.	88	2009	Environment	Recycling
30	Electronics	49 Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.	88	2009	Information	Networks
31	Resources	17 Practical use of technologies capable of separating useful metals, such as iron, copper and aluminum, from metal-containing wastes, such as scrap cars, discarded electric appliances, to a purity level of more than 99%.	88	2011	Environment	Recycling
32	Life science	74 Identification and classification by the molecular etiology of the genes related to diabetes, hypertension, and arteriosclerosis, typical geriatric diseases which exhibit multiple-factor hereditary traits.	88	2012	Life	
33	Health	05 Elucidation of carcinogenic mutation mechanisms.	88	2013	Life	Cancer
34	Marine science	43 Establishment of scientific methods for long-range weather forecasting (1-6 months in advance).	88	2014		
35	Production	70 Widespread use of earthquake damage alleviation systems for industrial complexes, nuclear facilities, etc. based on the early operation of safety devices in response to initial mild tremors.	88	2009	Disasters	Earthquakes
36	Urbanization	05 Practical use in Japan of a mid-term (5 - 10 years in advance) prediction technique for large-scale (Magnitude 8 or stronger) earthquakes based on analyses of the distribution of strains in the earth's crust and past earthquake records.	87	2017	Disasters	Earthquakes

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
37	Transportation	07 Development of a system that detects the initial mild tremors of an earthquake at appropriate locations, and safely stops trains as necessary to avoid places that have a high risk of collapse (because of the earthquake).	87	2006	Disasters	Earthquakes
38	Electronics	09 Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.	87	2015	Information	Semiconductors etc.
39	Agriculture etc.	02 Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	87	2004	Life	
40	Life science	48 Development of drugs capable of preventing the occurrence of certain types of cancer.	87	2010	Life	Cancer
41	Production	51 Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.	87	2018	Environment	Global environment
42	Communication	72 Development of high performance batteries with an energy density of about 500 Wh/kg, capable of miniaturizing mobile phones in terms of both size and weight.	87	2009		
43	Information	48 Widespread use in all areas of security systems capable of providing emergency information to the general public in the case of a disaster.	87	2007	Disasters	
44	Environment	34 Establishment of assessing socio-economic damage/loss because of the destruction of natural environment by soil contamination and land subsidence (e.g., loss of natural beaches, forests, or fields) and incorporation of its countermeasures in regulatory system.	87	2012	Environment	
45	Health	44 Improvement in the average five-year survival rate for all types of cancer to more than 70% (currently about 40% for stomach cancer).	87	2013	Life	Cancer
46	Electronics	19 Development of processor LSIs with 10 GIPS performance and power consumption of 10 miliwatts or less.	87	2014	Information	Semiconductors etc.
47	Life science	02 Development of anti-cancer agents which target the manifestation functions of cancer genes.	87	2010	Life	Cancer
48	Life science	35 Widespread production of bioplastics using microorganisms and plants, accounting for 10% of the total volume of worldwide plastic production.	87	2013	Environment	Recycling
49	Agriculture etc.	01 Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	87	2009	Life	
50	Agriculture etc.	20 Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials.	86	2005	Environment	Recycling
51	Marine science	45 Nationwide installation of bore-hole-type observation equipment integrating various types of gauges (e.g., seismometers, tiltmeters, and strain-gauges) for use in earthquake forecasting.	86	2011	Disasters	Earthquakes
52	Life science	01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	86	2014	Life	Cancer
53	Health	06 Elucidation of cancer metastasis mechanisms.	86	2012	Life	Cancer
54	Life science	67 Become possible to cure senile dementia of Alzheimer type.	86	2016	Life	Brain

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
55	Production	49 Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on local ecosystems throughout product life cycles, from manufacture to disposal.	86	2017	Environment	Recycling
56	Marine science	58 Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.	86	2010	Disasters	Natural disasters
57	Communication	63 Practical use of integrated building management systems and home security systems which are linked to an earthquake detection system and take the necessary safety measures to protect human lives in the event of a non-direct-hit earthquake, taking advantage of the time lag to the arrival of seismic waves.	86	2011	Disasters	Earthquakes
58	Materials	62 Development of memory capacity of 1 terabit per chip.	86	2013	Information	Semiconductors etc.
59	Urbanization	04 Development of a nationwide network for detecting earthquakes, and widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50Km.	86	2011	Disasters	Earthquakes
60	Life science	91 Development of technologies which dramatically improve photosynthetic ability in order to increase food production.	86	2017	Life	
61	Transportation	17 Widespread use of motor vehicles with fuel efficiencies 30% greater than today's vehicles through the introduction of new materials that increase strength and reduce weight and development of element technologies such as one concerning engine thermal efficiency improvements.	86	2007	Environment	
62	Environment	38 Widespread use (e.g., more than 10% in the world) of automobiles as urban transportation system (e.g., electric vehicles) which do not cause air or noise pollution.	86	2013	Environment	
63	Communication	67 Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	85	2006	Environment	Networks
64	Materials	107 Practical use of processes for water decomposition by the sunlight.	85	2017	New energy	
65	Environment	23 Introduction of environment tax aiming at global environmental conservation.	85	2006	Environment	Global environment
66	Information	05 Practical use of systems which facilitate multimedia communication from anywhere in the world using pocket-size computers.	85	2003	Information	Networks
67	Marine science	12 Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan.	85	2011		
68	Agriculture etc.	55 Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	84	2016		
69	Electronics	24 Widespread use of a portable multimedia wireless terminal operated on the order of 100 Mbits/sec., which can be used throughout the world.	84	2011	Information	Networks
70	Materials	108 Practical use of carbon dioxide fixation technology necessary for protecting global environments.	84	2016	Environment	Global environment

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
71	Space	09 Realization of precision down to less than a centimeter in measurement of crustal movement using VLBI (very long baseline inter-ferometers), satellite lasers, inverse laser ranging, and synthetic aperture radar to improve accuracy in such as earthquake forecasting.	84	2009	Disasters	Earthquakes
72	Transportation	30 Practical use of heavy-duty freight truck exhaust clean-up technologies - such as diesel exhaust catalysts, particulate traps, lean-burn NOx catalysts and high precision combustion technology - to reduce the harmful components of exhaust to 1/10 of present levels.	84	2010	Environment	
73	Transportation	14 Widespread use of traffic control systems on road, for optimal control of the flow of traffic in cities based on identification of vehicles on road, speed, and level of congestion.	84	2007		
74	Communication	08 Development of a super high-speed computer communication protocol capable of achieving a throughput of hundreds of Mbps.	84	2003	Information	Networks
75	Electronics	32 Practical use of ultraviolet, blue, and green, semiconductor lasers.	84	2004		
76	Environment	08 Determination and general understanding of the impact of global warming on world agricultural production.	83	2012	Environment	Global environment
77	Materials	44 Development of superconductive materials with a transition temperature around room temperature.	83	2020		
78	Life science	72 Scientific elucidation of the factors within daily life (eating habits, air quality, etc.) which influence the process of carcinogenesis.	83	2012	Life	Cancer
79	Information	45 Advances in software inspection and verification technology, enabling quick development of error-free, large-scale software.	83	2012	Information	
80	Marine science	22 Development of safe, economically feasible technology for the removal/detoxification of sea-bottom sludges, enabling the widespread application of methods for decontamination and recovery of fishery grounds.	83	2013	Environment	
81	Electronics	67 Development of a magnetic memory hard disk capable of recording 1,000 Gbits density per square inch.	83	2017	Information	Semiconductors etc.
82	Agriculture etc.	42 Establishment of a quantitative assessment technique for the environmental conservation functions of forest ecosystems, and widespread use of a forest management technique that makes the exploitation of timber resources, while still maintaining such functions.	83	2014	Environment	
83	Urbanization	62 Establishment in Japan of a wide-area integrated water management technique covering rivers, dammed reservoirs, etc., leading to widespread use of efficient water resource utilization systems in major urban zones.	83	2009		
84	Electronics	38 Practical use of optical multiplexed communication equipment capable of multiplexing 200 channels of signals with 100 Gbits/sec. and transmitting them over a single optical fiber.	83	2014	Information	Networks
85	Resources	06 Development of a steelmaking technology that requires fossil fuel consumption less than half of the present level.	83	2014		
86	Life science	52 Development of an entirely implantable artificial kidney.	83	2013	Life	

Ranking	Field	Topic	Degree of importance index	Forecasted realization time	Notes; Classification of topic	
87	Communication	09 Widespread use of integrated information wiring and plug socket that incorporate services such as the telephone, Internet, VOD and high-definition TV in homes and offices.	83	2007	Information	Networks
88	Life science	28 Control of signal transduction in the carcinogenesis of cells, and widespread use of treatment methods for dysdifferentiating carcinogenic cells.	82	2020	Life	Cancer
89	Environment	31 Widespread use of power generation using refuse derived fuel (RDF).	82	2006	New energy	
90	Electronics	68 Practical use of optical memories with recording density of 10^{11} b/cm^2.	82	2016	Information	Semiconductors etc.
91	Communication	74 Practical use of biochip devices that have a memory density (10^{12} bit/cm^2) 1,000 times that of current semiconductor devices (10^9 bits/cm^2).	82	2015	Information	Semiconductors etc.
92	Marine science	17 Practical use of systems for monitoring water pollution on a global scale.	82	2012	Environment	Global environment
93	Electronics	28 Practical use of automated production systems in which LSI chips are produced automatically by giving LSI design data.	82	2015	Information	Semiconductors etc.
94	Life science	07 Elucidation of the environmental factors and control mechanisms of the immune response which triggers allergies such as hay fever and atopy, facilitating the complete control over immediate type hyper-sensitivity.	82	2014	Life	
95	Information	68 Widespread use of systems to unitarily handle information management (orders, design, manufacturing, maintenance) among related companies.	82	2005	Information	Networks
96	Environment	04 Practical use of materials that replace fluorocarbons and halons, that do not damage the ozone layer and cause global warning problem.	82	2007	Environment	Global environment
97	Materials	20 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	82	2011		
98	Environment	27 Widespread use, including use at home, of compact waste-water treatment systems based on biotechnology for the highly efficient treatment of persistent substances and hazardous materials.	82	2010	Environment	
99	Life science	36 Widespread production of alcohol and other fuel oils utilizing microorganisms, seaweed, etc., accounting for 10% of total worldwide fuel oil production.	81	2015	New energy	
100	Health	20 Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise).	81	2006	Life	

1.2 Trends in forecasted realization time

To examine trends in the forecasted realization time of topics assessed to have a high degree of importance, we grouped the topics as follows. Figure 1.2-1 shows differences in realization times according to importance.

i) Top 100 topics in degree of importance (importance index ≥81.3)

ii) Medium degree of importance — 476 topics (60.0 ≤ importance index ≤ 81.2)

iii) Low degree of importance — 496 topics (importance index ≤ 59.9)

While some differences can be seen among each of the groups, the overall trend is quite similar.

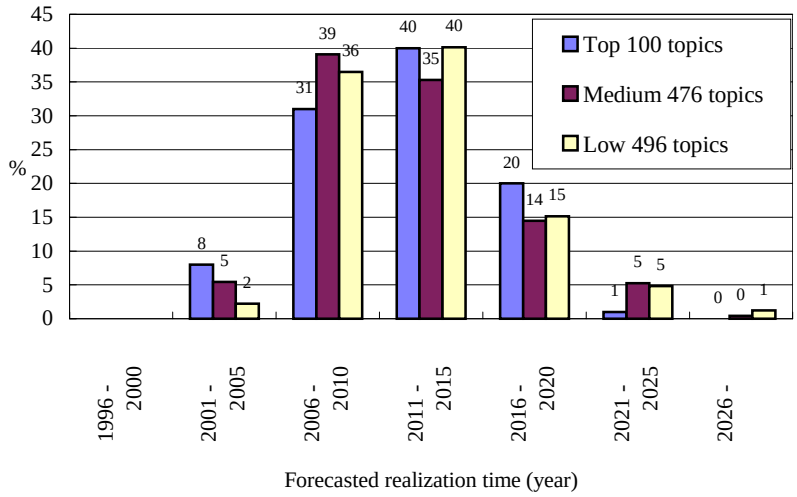


Figure 1.2-1 Forecasted realization time by degree of importance

1.3 Relationship with expected effect

Figure 1.3-1 shows the relationship between topics with a high degree of importance and expected effect. Respondent's expectation of topics in the top 100 are, compared to the other groups, considerably higher in the contribution to "resolution of global problems" and slightly higher in the contribution to "socioeconomic development," but somewhat lower in the contribution to "expansion of intellectual resources."

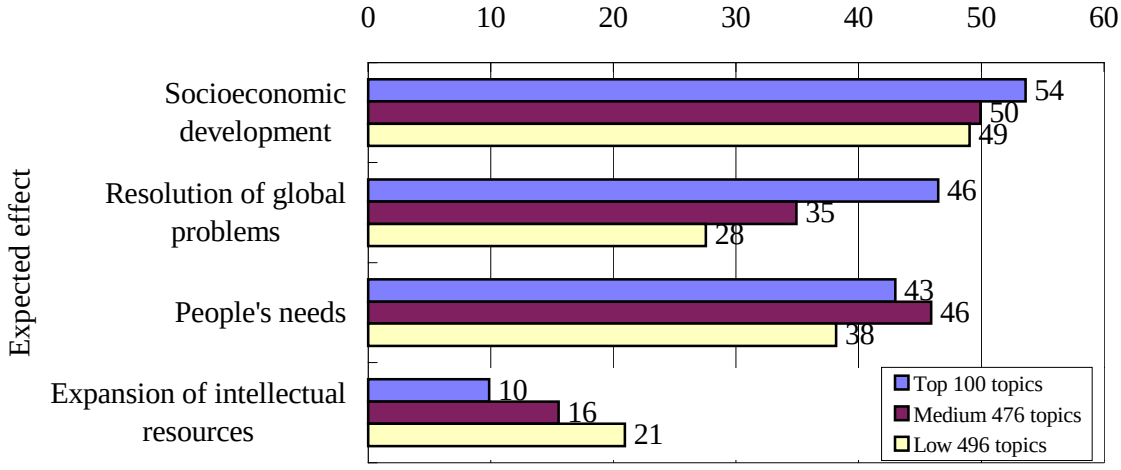


Figure 1.3-1 Expected effect by degree of importance

2. Major technological trends in expected effect

This survey examines the kind of effect expected from each of the topics. Specifically, respondents were asked to choose from the following four items for each topic.

i) Contribution to socioeconomic development

ii) Resolution of various problems of a global scale

iii) Response to people's needs

iv) Expansion of human intellectual resources

2.1 Trends in each field

Figure 2.1-1 shows the average topic response rate for the above items by field. The average value for all topics is quite high in contribution to socioeconomic development and response to people's needs, and low in expansion of human intellectual resources.

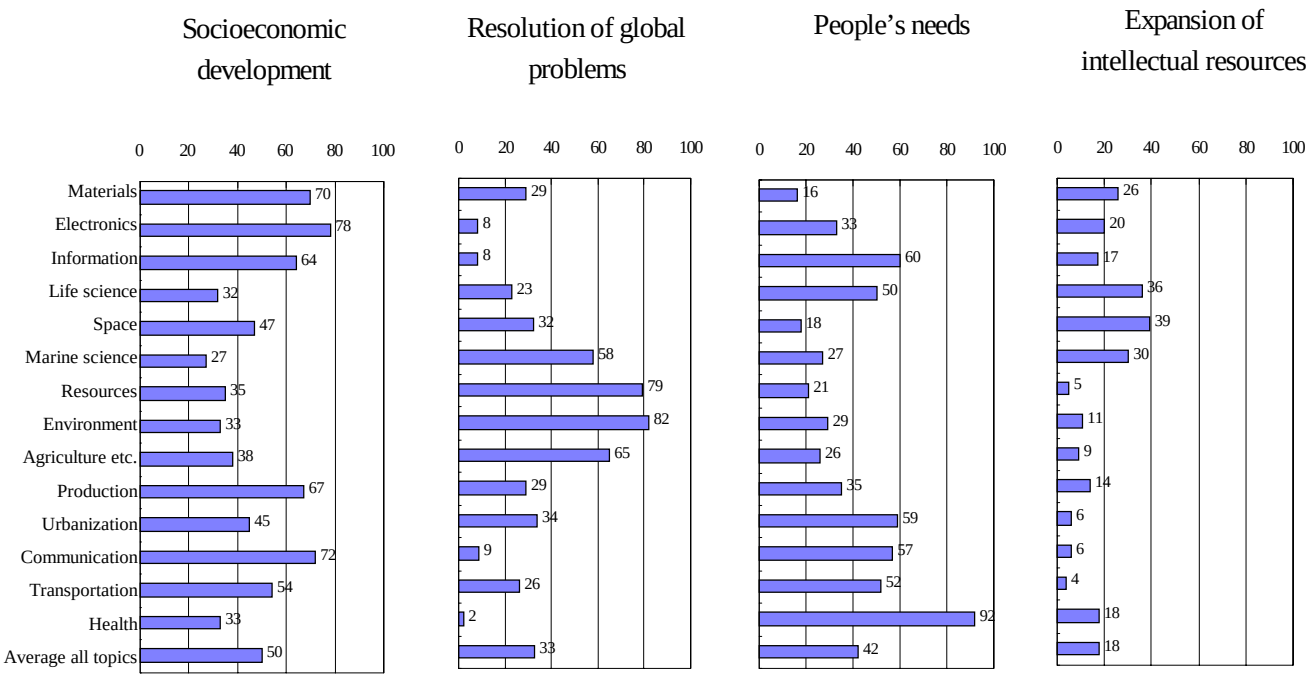


Figure 2.1-1 Trends in expected effect (by field)

Fields with a high number of topics considered to make a high contribution to socioeconomic development are "electronics" (77.6), "communication" (71.8), "materials" (69.6), "production" (67.0) and "information" (64.2); these fields also have a high number of topics thought to make only a minor contribution to resolution of global problems. Conversely, fields expected to make a high contribution to the resolution of global problems are "environment" (81.6), "resources" (78.7), "agriculture etc." (65.0) and "marine science" (57.6).

As for response to people's needs, "health" is extremely high at 92.0%, while those with a comparatively high expectation are "information" (59.7), "urbanization" (59.0), "communication" (57.2), "transportation" (52.0) and "life science" (50.4). As for expansion of intellectual resources, no field exceeded 50%, but those with comparatively high reading are "space" (39.0), "life science" (36.3) and "marine science" (29.8).

2.2 Trends in forecasted realization time

To examine trends in topics considered to have a particularly high effect on socioeconomic development etc., we looked at topics that at least 80% of respondents believe would have an effect on an item and that are considered to have a relatively high degree of importance (topics with a degree of importance index of at least 80 for "socioeconomic development," "resolution of global problems" and "response to people's needs," and at least 50 for "expansion of intellectual resources"; hereinafter referred to as important topics with a high expected effect). Table 2.2-1 shows the realization trends for those topics chronologically.

Topics with a high expectation in "contribution to socioeconomic development"

Fields with a high number of topics thought to deliver a significant effect are "information," "communication" and "electronics." It is thought that from 2001 to 2010 advances made in network-related technology will have a significant impact. In the ten years from 2011, technology for mass production and processing of microscopic patterns and technologies revolving around devices such as high-speed processors and high-capacity memory chips will steadily move ahead, and the economic effects of these technologies is expected to be substantial.

Topics with a high expectation in "resolution of various problems of a global scale"

Until 2005 there is not expected to be any significant advancement, but from 2006 to 2015 recycling of plastics, motor vehicles and the like is expected to be firmly established. Meanwhile, motor vehicle pollution is expected to drop, with a reduction of nitrogen oxides in vehicle exhausts, lower exhaust emissions by large trucks, and the widespread use of electric cars. Advances are also expected in the development of environmental monitoring systems as a global approach to environmental issues, such as a real-time global monitoring network and a world-wide marine pollution monitoring system.

Topics with a high expectation in "response to people's needs"

There is an especially large number of topics with a high expected effect in "life science," followed by "urbanization." Advances are expected in forecasting disasters and systems for transmitting disaster information by about 2010, and after 2010 developments are expected in the elucidation and treatment of cancer mechanisms. As for predicting earthquakes, 2016–2020 for magnitude 8 earthquakes and after 2020 for magnitude 7 earthquakes is the general line of thought.

Topics with a high expectation in "expansion of intellectual resources"

Fields with a large number of topics with a high expected effect are "life science" and "space". Advances are expected in gene-level analysis of cells by about 2010, and 2011–2015 in the elucidation of the human memory structure and the mechanism by which neural networks are formed. Based on these advances, progress is expected in the elucidation of the mechanisms of human logical reasoning and creation from 2021.

Table 2.2-1 Realization trends by expected effect

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
2001				
2002				
2003	(Communication) Development of a super high-speed computer communication protocol capable of achieving a throughput of hundreds of Mbps (Communication) Practical use of a highly secure next-generation internet that allows the transmission of real-time information (Information) Practical use of systems which facilitate multimedia communication from anywhere in the world			
2004	(Electronics) Practical use of ultraviolet, blue, and green, semiconductor lasers	(Agriculture etc.) Practical use in Japan of crop varieties improved by gene manipulation		
2005	(Information) Establishment of social rules regarding multimedia copyrights; (Information) Widespread use of systems to handle information management uniformly among related companies	(Agriculture etc.) Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials		
2006	(Communication) Widespread use of electronic commerce carried out via a network; (Production) Radical changes to the production and machinery area through multimedia technology	(Environment) Introduction of environment tax aiming at global environmental conservation	(Transportation) Development of a system that safely stops trains in the early stages of an earthquake to avoid places that have a high risk of collapse (Health) Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)	

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
	(Information) Widespread use of software libraries which facilitate the re-utilization of software (Information) Widespread use of electronic money to settle monetary matters			
2007	(Information) Widespread use of highly reliable network systems capable of protecting privacy and secrecy	(Materials) Practical use of plastic recycling technology (Environment) Practical use of fluorocarbon and halon substitutes that do not damage the ozone layer and cause global warming (Transportation) Widespread use of motor vehicles with fuel efficiencies 30% greater than current vehicles (Environment) Widespread use of technologies capable of meeting the emission control standard for nitric oxide in virtually all types of automobiles (Space) Development of technology for measuring, in real time, the distribution and movement of air pollution via observation from space	(Information) Widespread use of security systems that provide emergency information at the time of a disaster (Marine science) Practical use of Tsunami forecasting systems using satellites (Communication) Widespread use of integrated information wiring and plug socket in homes and offices (Urbanization) Widespread use in Japan of monitoring and control systems for enhancing the safety of essential services in a disaster	
2008	(Information) Realization of an environment in which the utilization of high-capacity networks for around 2,000 yen/month is possible (Space) Realization of a high-accuracy satellite positioning system operated by an international organization	(Space) Widespread use of a global-scale real-time environmental surveillance network	(Urbanization) Widespread use in Japan of warning systems etc. based on localized weather forecasts	
2009	(Communication) Development of high performance batteries with an energy density of about 500 Wh/kg	(Agriculture etc.) Elucidation of the whole DNA sequences of crops (Urbanization) Practical use in Japan of a safe and rational technology for decommission of commercial nuclear power plants	(Urbanization) Development of disaster forecasting and information transmission systems to prevent panic during an earthquake	

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
	(Communication) Widespread use of a security technology that monitors illicit activities involving information and communication ethics (Electronics) Production of household-use optical fiber signal transceiver units at a cost of around 5,000 yen (Production) Practical use of superprecision processing technologies that enable measurement to the angstrom order and time measurement to the femtosecond order	(Resources) Practical use of economical methods for separating and recycling valuable substances in urban garbage (Transportation) Realization of a 90% recyclability for motor vehicle parts and material		
2010		(Electronics) Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence (Transportation) Practical use of technologies to reduce the harmful components of truck exhausts to 1/10 of present levels	(Life science) Development of drugs capable of preventing the occurrence of certain types of cancer (Information) Practical use of robots which provide medical care support in homes, hospitals, etc. (Life science) Development of anti-cancer agents which target the manifestation functions of cancer genes (Marine science) Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan	(Space) Return of samples from other planets
2011	(Electronics) Widespread use of a portable multimedia wireless terminal which can be used throughout the world	(Marine science) Practical use of technologies for predicting and forecasting changes in the ocean currents in the seas adjoining Japan (Resources) Practical use of technologies capable of separating useful metals from scrap cars etc. to a purity level of more than 99% (Materials) Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%	(Materials) Widespread use of signal-responsive missile drugs capable of efficiently reaching tumor cells (Communication) Practical use of integrated building management systems linked to an earthquake detection system (Urbanization) Widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50km	(Marine science) Inauguration in Japan of international research centers for comparative planetology

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
2012	(Information) Realization of software inspection and verification technology that enables quick development of error-free, large-scale software	(Marine science) Practical use of systems for monitoring water pollution on a global scale (Environment) General understanding of the impact of global warming on world agricultural production (Production) Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials (Electronics) Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt	(Life science) Identification of the genes related to diabetes (Health) Elucidation of cancer metastasis mechanisms (Life science) Elucidation of the factors within daily life which influence the process of carcinogenesis (Communication) Development of an automatic Japanese-English-Japanese translation telephone system comparable to human simultaneous interpretation	
2013	(Electronics) Practical use of technology which allows mass processing of 10nm patterns; (Materials) Development of memory capacity of 1 terabit per chip	(Life science) Widespread use of bioplastic production so it accounts for 10% of total worldwide plastic production (Marine science) Development of a numerical model of the correlation between climatic changes and changes in marine living resources (Environment) Widespread use of nonpolluting automobiles (e.g., electric vehicles) so they account for at least 10% of all vehicles in the world	(Health) Elucidation of carcinogenic mutation mechanisms (Life science) Development of an entirely implantable artificial kidney (Health) Improvement in the average five-year survival rate for all types of cancer to more than 70% (Life science) Practical use of effective means to prevent metastasis of cancer	
2014	(Electronics) Practical use of optical multiplexed communication equipment capable of multiplexing 200 channels of signals with 100 Gbits/sec. and transmitting them over a single optical fiber (Space) The cost of rocket space transportation will be reduced to less than 1/10 current levels (Electronics) Practical use of VLSI with as much as 256 Gbits of memory per chip (Electronics) Development of processor LSIs with 10 GIPS performance and power consumption of 10 milliwatts or less	(Agriculture etc.) Development of an estimation technique for an optimum fisheries production level for each fishing area based on simulation techniques for biological propagation (Agriculture etc.) Widespread use of timber resources exploitation management techniques based on quantitative assessment methods for the environmental conservation functions of forests (Marine science) Establishment of scientific methods for long-range weather forecasting (1-6 months in advance)	(Life science) Identification of most genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis (Life science) Realization of the complete control over spontaneous allergies through the elucidation of the immune control mechanisms	(Life science) Development of technology to analyze the genes manifested in a single cell in higher animals with an accuracy in the order of 1 mRNA molecule

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
		(Resources) Development of technology that requires fossil fuel consumption less than half of the present level (Marine science) Elucidation of the impact on the ecosystem from ocean development through the establishment of a numerical model		
2015	(Electronics) Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less (Electronics) Practical use of systems in which LSI chips are produced automatically from LSI design data (Communication) Practical use of biochip devices that have a memory density 1,000 times that of current semiconductor devices	(Life science) Widespread production of fuel oils utilizing microorganisms, etc. so it accounts for 10% of total worldwide fuel oil production	(Life science) Widespread use of methods of multiplying stem cells in test tubes and using them for treatment purposes	(Life science) Complete elucidation of the molecular mechanism explaining the cell cycle in higher order mammals (Electronics) Development of X-ray microscopes capable of 10-100nm resolution (Life science) Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells
2016	(Production) Practical use of room temperature superconductors in industrial products (Electronics) Practical use of optical memories with recording density of 10^{11} b/cm^2	(Materials) Practical use of multi-layer solar cells with a conversion efficiency of more than 50% (Agriculture etc.) Development of fishery production systems based on predictions of long term (10 to 20 years) changes major fishery resources (Production) Practical use of technologies that enable the direct storage of electricity (Materials) Practical use of carbon dioxide fixation technology necessary for protecting global environments	(Life science) Realization of cure for Alzheimer's disease (Environment) Elucidation of the long-term exposure effects of small quantities of harmful chemical substances on human beings	
2018	(Electronics) Practical use of TIPS level microprocessors	(Production) Widespread use of global environmental conservation measures throughout the world based on carbon dioxide recovery technologies (Agriculture etc.) Practical use of a system of removing almost the entire pollution load caused by environmental degradation on closed water bodies		(Life science) Elucidation of the molecular mechanisms for formation of neuronal networks at the molecular level (Life science) Elucidation of the whole molecular mechanisms for synaptic plasticity in the mammalian brain

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People's needs (32 topics)	Expansion of human intellectual resources (17 topics)
		(Production) Widespread use of non-fossil energy in all areas of life including household, industry and transportation		
2019	(Production) Widespread use of highly functional materials and super materials that control structures at the atomic and molecular level	(Resources) Practical use of technology for the safe disposal of highly radioactive solid waste		(Marine science) Development of a positron microscope
2020	(Materials) Development of room temperature superconductors		(Life science) Widespread use of treatment methods for dysdifferentiating carcinogenic cells	
2021			(Life science) Clinical application of technology enabling organs to regenerate through the multiplication of their own cells	
2022		(Environment) Reduction of global carbon dioxide emissions to 20% below the 1990 level		(Life science) Complete elucidation of the molecular mechanisms of development and differentiation
2023			(Marine science) Development of technology capable of forecasting the occurrence of earthquakes of magnitude 7 or above several days in advance Expansion of intellectual resources	(Life science) Elucidation of brain mechanisms for logical reasoning; (Life science) Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest (Marine science) Practical use of high-luminosity radiation with emission of 0.1 nano radians or less (Information) Elucidation of human creative mechanism to such an extent that it can be applied to computer science

Year	Socioeconomic development (35 topics)	Resolution of global problems (45 topics)	People’s needs (32 topics)	Expansion of human intellectual resources (17 topics)
2024				
2025		(Resources) Practical use of fast breeder reactor systems including nuclear fuel cycle		(Life science) Elucidation of the molecular mechanism of life creation
2026 or later		(Resources) Development of fusion reactors		

2.3 Relationship with current leading countries etc.

The graphs at Figure 2.3-1 show current leading countries and regions in topics with a high expected effect highlighted in 2.2.

For topics with a high expected effect in “contribution to socioeconomic development,” USA ranks highest, while Japan ranks above its average for “all topics.” A similar pattern can be seen in “response to people’s needs.” In the “resolution of global problems” though, the percentage for the USA has dropped, while that for the EU is relatively higher. In the “expansion of intellectual resources,” the USA percentage was particularly high, and the EU was also above its overall average, whereas Japan fell well below its overall average.

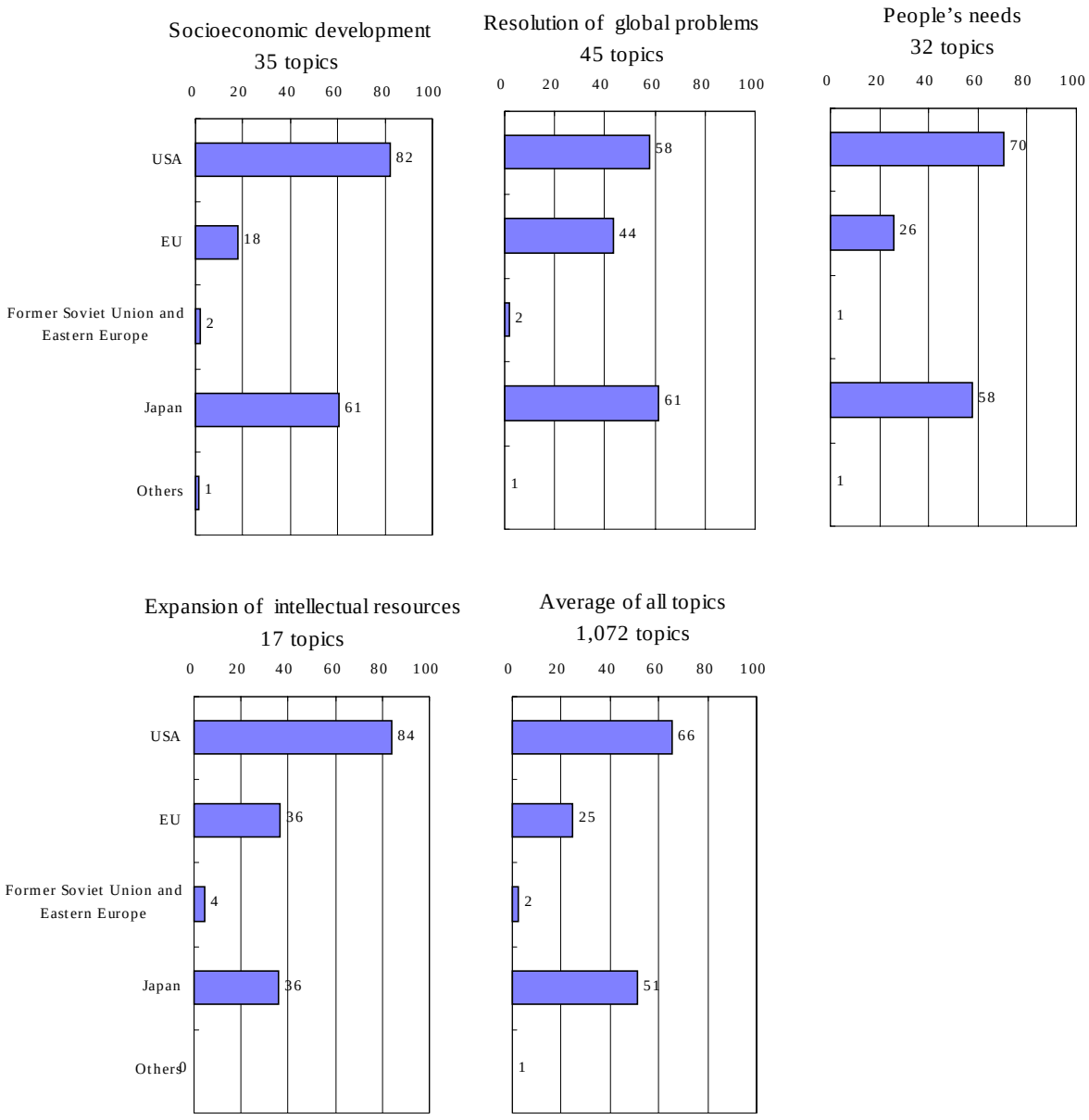


Figure 2.3-1 Expected effect and leading countries etc.

2.4 Relationship with measures the government should adopt

Figure 2.4-1 shows in graph form the effective measures respondents believe the government should adopt for topics with a high expected effect.

For topics with a high expected effect in "socioeconomic development," "foster human resources," "increase government research funding" and "promote exchanges among industrial, academic and government sectors and different fields" are ranked the highest, but all are below their respective averages for all topics. In contrast, a greater proportion of respondents want the government to "adjust regulations (relax/toughen)" than the average. Typical examples of this are topics related to multimedia and networks, such as "603066: Widespread use of electronic money to settle monetary matters" (adjust regulations (relax/toughen) — 84%), and "603064: Establishment of social rules regarding multimedia copyrights" (adjust regulations (relax/toughen) — 83%).

As for "resolution of global problems," the percentage calling on the government to "promote exchanges among industrial, academic and government sectors and different fields," "increase government research funding" and "adjust regulations (relax/toughen)" are higher than their respective averages for all topics, especially government funding, which is 11% higher than its overall average. Typical examples include topics related to the management and assessment of the environment and biological resources, such as "609084: Practical use of a system of removing almost the entire pollution load caused by environmental degradation on closed water bodies" (increase government research funding — 78%), and "609054: Development of an estimation technique for an optimum fisheries production level for each fishing area based on simulation techniques for biological propagation" (increase government research funding — 78%).

In the "response to people's needs" item, "foster human resources" and "increase government research funding" are especially high. "Develop a research base" is also higher than its averages for all topics. Topics for which the voices calling for greater government spending are loudest are those connected with earthquakes, including "612063: Practical use of integrated building management systems linked to an earthquake detection system" (increase government research funding — 78%) and "611004: Widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50km" (increase government research funding — 74%).

Regarding the "expansion of intellectual resources," percentages for "foster human resources" and "increase government research funding" are quite high, while "upgrade advanced facilities and equipment" is also above its all-topics average. "Foster human resources" is very high at 71%, and specific examples include topics connected with the elucidation of life phenomena, such as "604041: Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells" (82%) and "604084: Complete elucidation of the molecular mechanisms of development and differentiation" (82%).

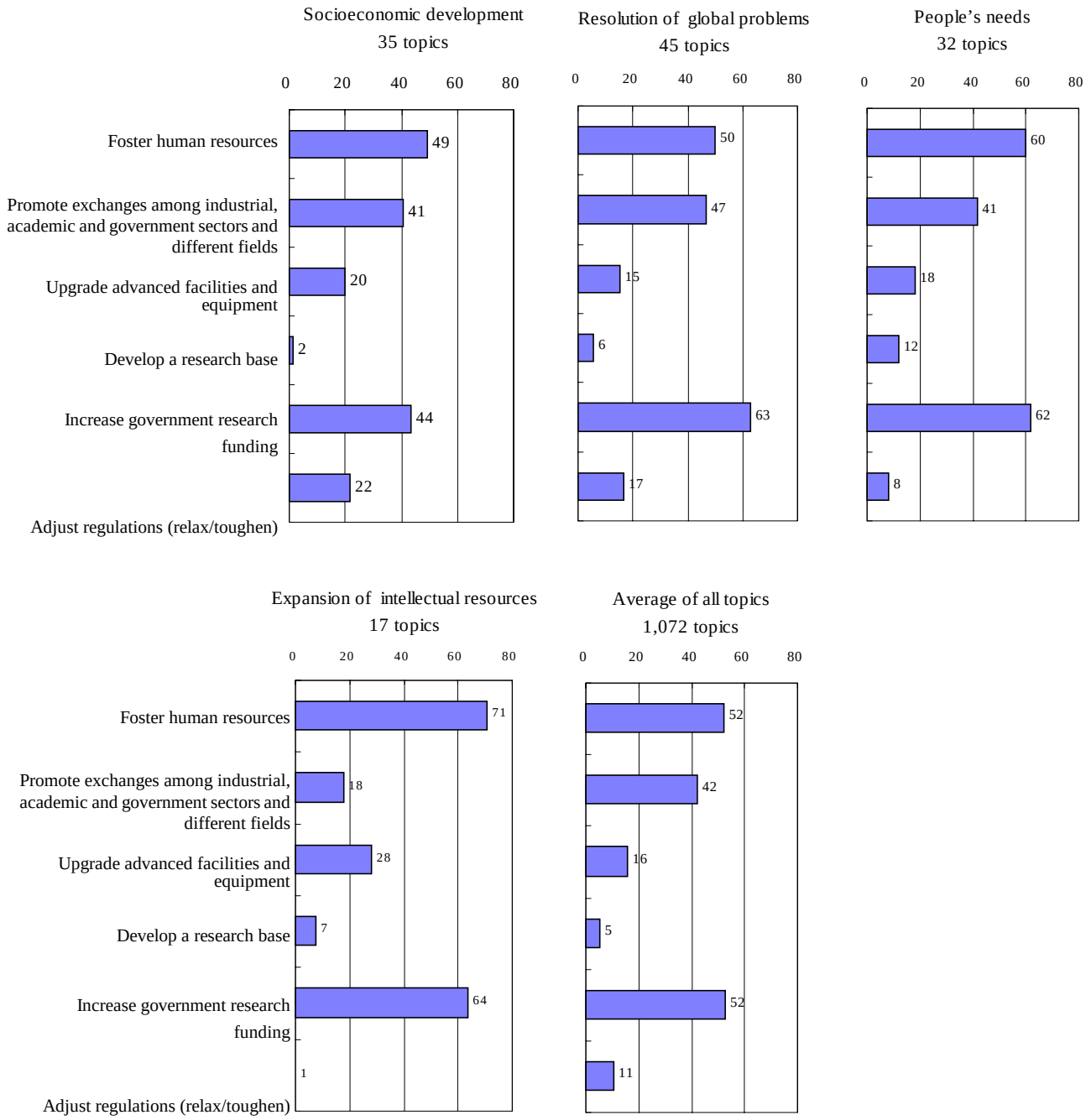


Figure 2.4-1 Expected effect and effective measures the government should adopt

2.5 Relationship with potential problems

Figure 2.5-1 shows in graph form concerns respondents have with the realization of topics with a high expected effect.

Respondents expressed a higher-than-average concern over the "adverse effect on safety" regarding topics with a high expected effect in "contribution to socioeconomic development," which include many network- and device-related topics, as can be seen by "603066: Widespread use of electronic money to settle monetary matters" (67%) and "612067: Widespread use of electronic commerce carried out via a network" (67%).

As for topics with a high expected effect in "resolution of global problems," respondents expressed considerable concern over the "adverse effect on the natural environment" regarding technologies connected

with nuclear power, such as “611013: Practical use in Japan of a safe and rational technology for decommission of commercial nuclear power plants” (70%) and “607063: Practical use of technology for the safe disposal of highly radioactive solid waste” (54%), and technologies connected with improving crop quality through gene manipulation, such as “609002: Practical use in Japan of crop varieties improved by gene manipulation” (60%) and “604091: Development of technologies which dramatically improve photosynthetic ability in order to increase food production” (47%).

Regarding “response to people’s needs,” higher-than-average concern was expressed over “adverse effect on safety” and “adverse effect on morals, culture or society.” Topics that attracted a high response rate on “adverse effect on safety” include “611001: Widespread use in Japan of warning systems etc. based on localized weather forecasts” (52%) and “611003: Development of disaster forecasting and information transmission systems to prevent panic during an earthquake” (50%), while those attracting a high response rate on “adverse effect on morals, culture or society” include “614020: Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)” (54%), “604001: Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis” (49%), and “614005: Elucidation of carcinogenic mutation mechanisms” (45%).

As for topics with a high expected effect in “expansion of intellectual resources,” the response rate for “adverse effect on morals, culture or society” was higher than its average for all topics; specific examples include topics connected with the elucidation of life phenomena, such as “604019: Elucidation of the molecular mechanism of life creation” (45%), and “604023: Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest” (44%).

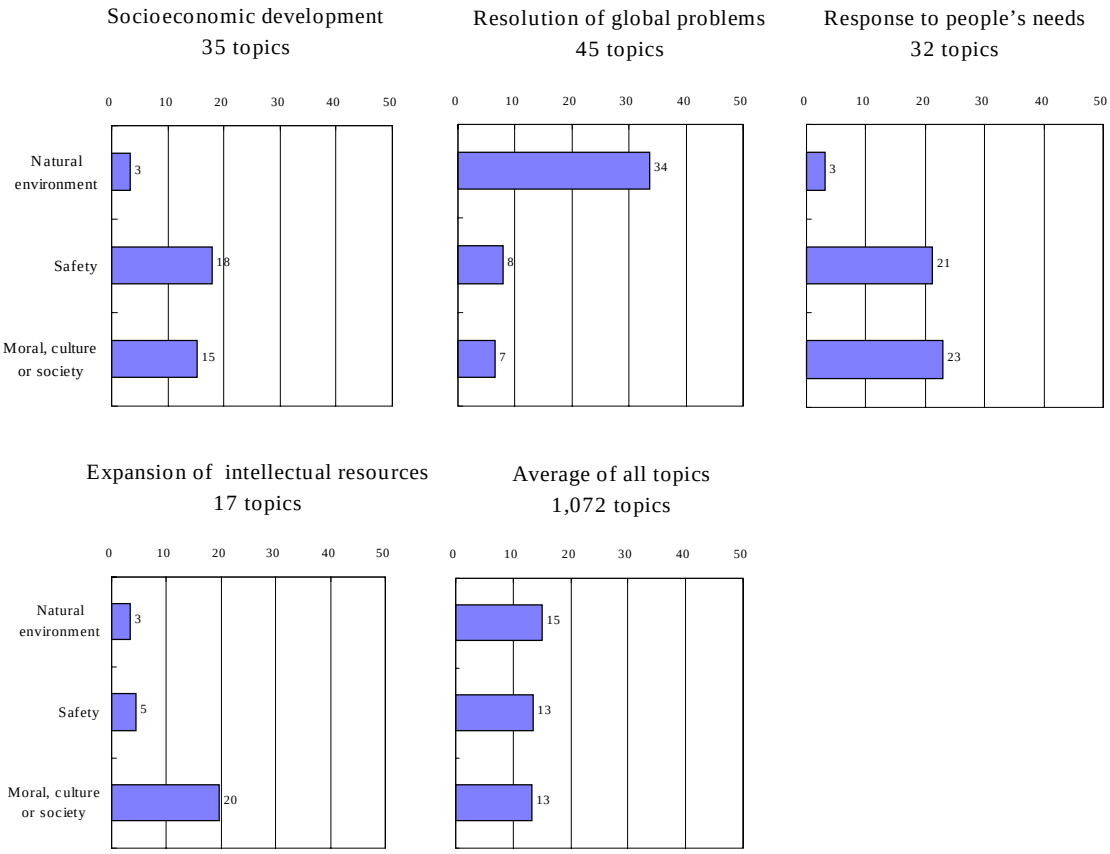
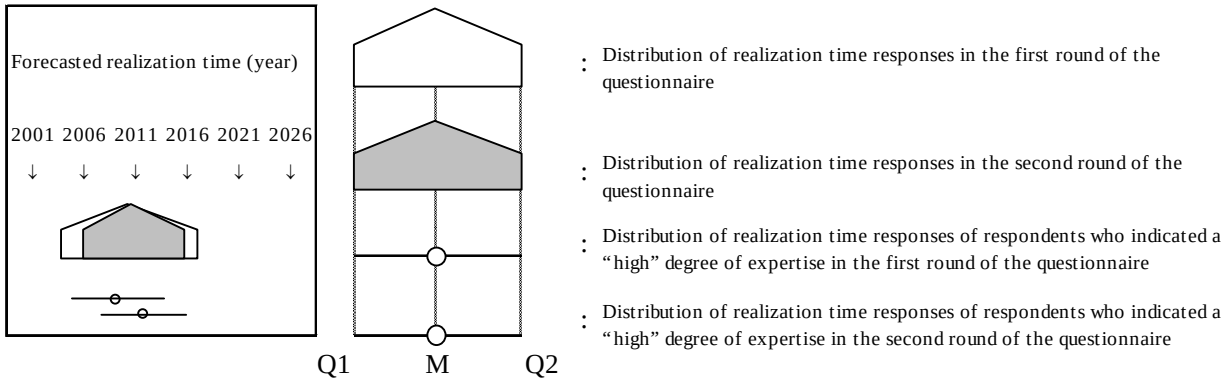


Figure 2.5-1 Expected effect and potential problems

3. Trends in forecasted realization time

3.1 Overall trends

Figure 3.1-1 shows the distribution of forecasted realization times of all 1,072 topics, and Table 3.1-1 shows the average forecasted realization time and the average range of forecasted times for each field. Here the “range of forecasted times” is the width between Q1 (forecasted realization year of the response at the 25th percentile of all responses) and Q2 (forecasted realization year of the response at the 75th percentile of all responses). A narrow width (responses from the half of all respondents who were positioned around the middle value) represents a strong consensus among respondents. The survey forecasts technologies up to the year 2025, so the questionnaires gave respondents realization time choices of five-year increments to 2025, after which the time was left open with “2026-”. Consequently, Table 3.1-1 omits any topics for which Q2 in the second round questionnaire (R2) is after 2026.



A mere 4.2% of topics (45 topics) are forecasted to be realized by 2005. And as shown in Figure 3.1-1, the “information” and “communication” fields have the largest proportions of these topics. In the five years between 2006 and 2010 and also between 2011 and 2015, respectively 37.1% (398 topics) and 38.0% (407 topics) of topics are expected to be realized, so over this ten-year period respondents forecast that 75.1% (805 topics) of all topics will be realized.

By fields, trends show us that “information” and “communication” contain many topics likely to be realized relatively early, whereas at the opposite end of the scale, “resources and energy” and “life science” have many topics that will be realized much later. Respondents forecast that 20.7% (222 topics) of topics will be realized after 2016, and the highest percentage of these are in the “life science” and “resources and energy” fields.

The range of forecasted times is narrow in the “communication,” transportation” and “information” fields where the forecasted realization time is relatively early, and broader in the “life science” and “resources and energy” fields where realization is expected to be later.

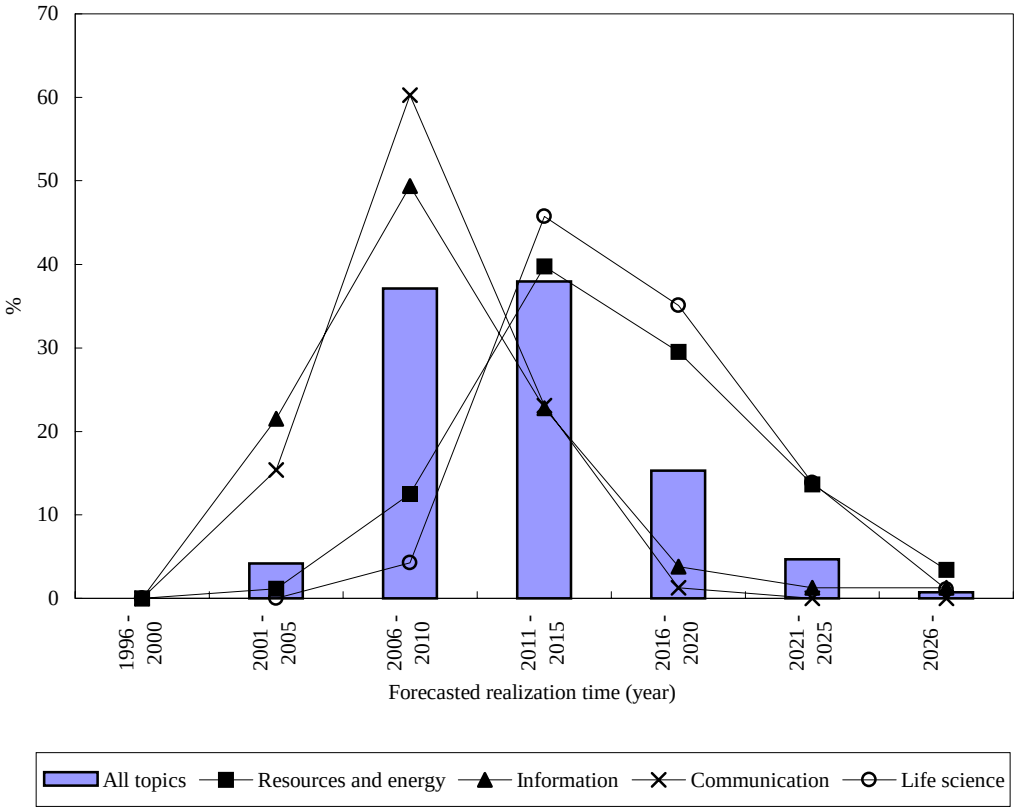


Figure 3.1-1 Trends in forecasted realization time

Table 3.1-1 Forecasted realization time and range of forecasted times

999 topics

Field	Forecasted realization time (year)	Range of forecasted times (years)
Materials	2012.3	8.5
Electronics	2013.7	8.7
Information	2009.1	7.4
Life science	2015.3	9.8
Space	2011.8	7.2
Marine science	2011.5	8.9
Resources	2014.6	9.0
Environment	2012.0	8.4
Agriculture etc.	2011.0	7.9
Production	2012.4	7.5
Urbanization	2010.7	7.6
Communication	2009.0	6.6
Transportation	2010.2	7.1
Health	2012.2	9.3
Average all topics	2011.9	8.2

3.2 Comparison of first and second round questionnaires

Here we shall look at the extent to which a consensus was reached among the respondents and how the forecasted realization times changed from the first round questionnaire (R1) to the second round questionnaire (R2). We use “the range of forecasted times” as an indicator of the degree of consensus.

3.2.1 Comparison of the convergence ratio

We calculated a convergence ratio for each topic using the following equation as an indicator to determine the extent to which a consensus had been formed through repetition of the questionnaire.

$$[\text{Conversion ratio }] = \frac{\text{R2 range of forecasted times}}{\text{R1 range of forecasted times}}$$

For example, in the case of “01001: Development of artificial muscle-like material that responds to stimuli reversibly,” the very first topic in the materials and processing field, the forecasted time range of 12.7 years in R1 was narrowed down to 4.7 years in R2, representing a convergence ratio of 4.7/12.7 = 0.37. This comparison excludes topics in which the 75th percentile of the R1 or R2 forecasted realization time is after 2026.

The average convergence ratio for the 967 topics covered is 0.75 — roughly the same ratio as that in the 5th Technology Forecast Survey. Table 3.2-1 shows that there is little difference among fields in the average convergence ratio.

Table 3.2-1 Convergence ratio by field

967 topics

Field	Average convergence ratio
Materials	0.76
Electronics	0.76
Information	0.78
Life science	0.71
Space	0.75
Marine science	0.79
Resources	0.76
Environment	0.77
Agriculture etc.	0.75
Production	0.74
Urbanization	0.70
Communication	0.76
Transportation	0.79
Health	0.75
Average all topics	0.75

Table 3.2-2 shows examples of topics with a small convergence ratio.

Table 3.2-2 Examples of topics with a small convergence ratio

Field	Topic	Convergence ratio	Forecasted realization time
Production	16 Widespread use of mega-space structures that make all-weather, 24-hour-a-day life-styles possible, including leisure activities.	0.44	2008
Space	50 Practical use in Japan of isotope batteries for probing deep space.	0.55	2011
Health	60 Practical use of batteries of artificial organs implanted in the living body.	0.55	2014
Resources	23 Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	0.57	2014
Health	14 Practical use of prevention methods for stress-induced mental disorders.	0.58	2011

3.2.2 Changes in forecasted realization time

Table 3.2-3 shows the difference and absolute difference between R1 and R2 forecasted realization times for the 1,063 topics with a forecasted realization time of before 2025 in both R1 and R2. The forecasted realization times in R2 are, over all fields, later than in R1, with an average difference of all covered topics of 0.72 years, and an absolute difference of 0.80 years. The fact that the average difference at 0.72 is smaller than the absolute difference at 0.80 shows that while in many topics the forecasted realization time is later in R2 than in R1, there are also some topics whose forecasted realization time is earlier.

Table 3.2-3 Average difference and absolute difference in forecasted realization time

1,063 topics

Field	Average difference (years)	Average absolute difference (years)
Materials	0.79	0.84
Electronics	0.91	0.94
Information	0.40	0.57
Life science	0.72	0.85
Space	0.60	0.61
Marine science	0.99	1.00
Resources	0.68	0.75
Environment	0.47	0.51
Agriculture etc.	0.57	0.65
Production	0.79	0.87
Urbanization	0.76	0.83
Communication	0.46	0.55
Transportation	0.55	0.66
Health	1.16	1.22
Average all topics	0.72	0.80

3.3 Forecasted realization times by respondents with a high degree of expertise

To determine the response trends among respondents with a high degree of expertise, we compared differences in their responses with overall responses in the second round questionnaire. This is shown in Table 3.3-1. As can be seen in the table, in all fields realization time forecasts by respondents with a high degree of expertise are from 0.5 (information) to 2.4 years (life science) earlier than those by all respondents as a whole. The average difference across all fields is 1.5 years.

Table 3.3-1 Differences in forecasted realization times between respondents with a high degree of expertise and all respondents (years)

1027 topics

Field	High expertise (A)	Overall (B)	A-B
Materials	2010.3	2012.3	-2.0
Electronics	2012.0	2014.1	-2.1
Information	2008.7	2009.2	-0.5
Life science	2013.8	2016.2	-2.4
Space	2011.6	2013.3	-1.7
Marine science	2010.4	2012.1	-1.7
Resources	2014.3	2015.7	-1.4
Environment	2010.3	2012.0	-1.7
Agriculture etc.	2009.8	2011.3	-1.5
Production	2010.7	2012.0	-1.3
Urbanization	2009.9	2011.6	-1.7
Communication	2008.0	2009.0	-1.0
Transportation	2008.9	2010.4	-1.5
Health	2011.2	2012.4	-1.2
Average all topics	2010.8	2012.3	-1.5

3.4 Topics with a high “will not be realized” response rate

Table 3.4-1 shows topics with a high “will not be realized” response rate. The fact many experts judge that the topics “will not be realized” is a good indication of just how difficult realizing that technology will be, and with the exception of the paperless office topic in the production and machinery field, the forecasted realization times for all topics are 2020 or later.

Although as many as 40% of experts do not believe the paperless office will be realized, the overall forecasted realization time is a relatively early 2009. Considering a similar topic in the information field “603065: Widespread use of paperless processing for the majority of office work” (forecasted realization time of 2007) received a “will not be realized” response from only 11% of experts, the divergence in judgement probably arose on the basis of how strictly respondents applied the “100% paperless” qualification.

Table 3.4-1 Topics with a high “will not be realized” response rate

Field	Topic	Will not be realized (%)	Forecasted realization time
Life science	43 Development of technology capable of synthesizing living cells by using only artificially produced chemical compounds.	48	2027 or later
Urbanization	67 Realization of deep underground cities where people can reside.	47	2023
Resources	86 Development of antimatter production and storage technology and energy sources based on it.	47	2026 or later
Production	30 Widespread use of 100% paperless operation in offices.	40	2009
Electronics	07 Widespread use of wafers one meter in diameter.	39	2020

3.5. Chronological table of technology forecast

This table lists 104 of the entire 1072 survey topics, selected as being highly important, deserving special attention, etc., in chronological order.

Year	Field		Topic
2002	Transportation	10	Practical use of driving simulators that enable a learner driver to have a realistic experience of driving under extreme conditions and being involved in a traffic accident (realistically simulates impact or inertia).
2003	Communication	01	Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.
	Information	05	Practical use of systems which facilitate multimedia communication from anywhere in the world using pocket-size computers.
2004	Electronics	32	Practical use of ultraviolet, blue, and green, semiconductor lasers.
	Agriculture etc.	02	Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.
2005	Information	64	Establishment of social rules regarding multimedia copyrights, and expanded production and distribution of multimedia information.
	Agriculture etc.	20	Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials.
2006	Communication	67	Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.
	Transportation	07	Development of a system that detects the initial mild tremors of an earthquake at appropriate locations, and safely stops trains as necessary to avoid places that have a high risk of collapse (because of the earthquake).
	Environment	23	Introduction of environment tax aiming at global environmental conservation.
	Environment	31	Widespread use of power generation using refuse derived fuel (RDF).
	Health	20	Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise).
2007	Materials	34	Establishment and Practical use of plastic recycling technology.
	Information	22	Widespread use of highly reliable network systems capable of protecting the privacy and secrecy of individuals and groups from the intrusion of ill-intentioned hackers.
	Environment	04	Practical use of materials that replace fluorocarbons and halons, that do not damage the ozone layer and cause global warning problem.
	Transportation	14	Widespread use of traffic control systems on road, for optimal control of the flow of traffic in cities based on identification of vehicles on road, speed, and level of congestion.
	Space	05	Development of technology for measuring, in real time, the distribution and movement of air pollution via observation from space.
	Health	13	Development of an HIV vaccine.
2008	Communication	66	Widespread use of on-line seal-less document preparation services for various official documents such as contract documents which are provided via a network based on security technology capable of achieving both privacy protection and verification.
	Space	02	Widespread use of a global-scale environmental surveillance network in which environmental changes for the earth as a whole are monitored around the clock in real time, and this information is integrated, systematically analyzed, and distributed around the world.
	Marine science	69	Inauguration in Japan of global science and technology educational organizations in the broad sense, in order to foster international scientists and technologists contributing to conservation of the global environment, development and maintenance of global resources, etc.
	Agriculture etc.	09	Widespread use of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).
2009	Transportation	55	Practical use of floating off-shore airports.
	Health	36	Practical use of anti-AIDS therapy.
	Production	70	Widespread use of earthquake damage alleviation systems for industrial complexes, nuclear facilities, etc. based on the early operation of safety devices in response to initial mild tremors.
	Space	09	Realization of precision down to less than a centimeter in measurement of crustal movement using VLBI (very long baseline inter-ferometers), satellite lasers, inverse laser ranging, and synthetic aperture radar to improve accuracy in such as earthquake forecasting.
	Urbanization	13	Practical use in Japan of a safe and rational demolition technology for decommission of

Year	Field		Topic
			commercial nuclear power plants.
	Electronics	49	Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.
	Urbanization	29	Spread of community-based efforts to utilize unused energy sources and recycle household wastes etc. in Japan.
	Resources	19	Practical use of economical methods for separating and recycling valuable substances in urban garbage.
	Transportation	31	Achievement of a 90% recyclability for motor vehicle parts and material (scrapped vehicles).
2010	Space	16	Full-scale operation of a space station as a laboratory on the low earth orbit, and realization of next-generation facilities using the space environment for research, development, and trial production of semiconductors, pharmaceuticals, etc.
	Production	17	Impact of engineering techniques that control silicon microscopic structures (to choose desired atomic and molecular arrangements at will) felt in all aspects of the production and machinery area.
	Electronics	18	Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.
	Marine science	13	Development of technologies based on large-scale numerical models for forecasting changes in the global oceans.
	Marine science	58	Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan.
	Environment	27	Widespread use, including use at home, of compact waste-water treatment systems based on biotechnology for the highly efficient treatment of persistent substances and hazardous materials.
	Transportation	30	Practical use of heavy-duty freight truck exhaust clean-up technologies - such as diesel exhaust catalysts, particulate traps, lean-burn NO_x catalysts and high precision combustion technology - to reduce the harmful components of exhaust to 1/10 of present levels.
2011	Life science	04	Development of methods for surmising new functions of proteins from human genome information.
	Environment	29	Development of low-noise engines and tires, and sound-absorbing construction materials, leading to the reduction of automobile noise within the environmental standard for the area specified to be for resident.
	Environment	05	Elucidation of the accurate mechanism of carbon dioxide generation and absorption.
	Resources	17	Practical use of technologies capable of separating useful metals, such as iron, copper and aluminum, from metal-containing wastes, such as scrap cars, discarded electric appliances, to a purity level of more than 99%.
	Health	09	Elucidation of the arteriosclerosis contraction mechanisms.
	Urbanization	04	Development of a nationwide network for detecting earthquakes, and widespread use in Japan of a disaster prevention system that gives advance warning of earthquakes at a distance of at least 50km.
2012	Environment	34	Establishment of assessing socio-economic damage/loss because of the destruction of natural environment by soil contamination and land subsidence (e.g., loss of natural beaches, forests, or fields) and incorporation of its countermeasures in regulatory system.
	Production	50	Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.
	Health	06	Elucidation of cancer metastasis mechanisms.
	Communication	38	Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality.
	Electronics	30	Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.
2013	Health	05	Elucidation of carcinogenic mutation mechanisms.
	Life science	35	Widespread production of bioplastics using microorganisms and plants, accounting for 10% of the total volume of worldwide plastic production.
	Resources	81	Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars.
	Electronics	05	Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.
	Marine science	14	Development of a numerical model of the correlation between climatic changes and changes in marine living resources.
	Health	44	Improvement in the average five-year survival rate for all types of cancer to more than 70% (currently about 40% for stomach cancer).

Year	Field		Topic
	Health	48	Practical use of effective methods against cancer metastasis.
	Life science	49	Practical use of effective means to prevent metastasis of cancer.
	Health	53	Development of effective methods of preventing Alzheimer's disease.
2014	Life science	01	Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.
	Marine science	43	Establishment of scientific methods for long-range weather forecasting (1-6 months in advance).
	Resources	06	Development of a steelmaking technology that requires fossil fuel consumption less than half of the present level.
	Materials	49	Widespread use of industrial electric machines which employ superconductive materials having a critical temperature of liquid nitrogen (77 K) or more.
	Space	25	The cost of rocket thrusted space transportation will be reduced to less than 1/10 current levels.
	Electronics	06	Practical use of VLSI with as much as 256 Gbits of memory per chip.
2015	Information	49	Practical use of robots capable of recognizing, finding, and rescuing humans involved in a disaster.
	Life science	51	Practical use of artificial organs (pancreases, kidneys, livers, etc.) incorporating human cells and tissues.
	Electronics	09	Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.
	Life science	36	Widespread production of alcohol and other fuel oils utilizing microorganisms, seaweed, etc., accounting for 10% of total worldwide fuel oil production.
	Communication	74	Practical use of biochip devices that have a memory density (10^{12} bit/ cm^2) 1,000 times that of current semiconductor devices (10^9 bits/ cm^2).
2016	Materials	84	Practical use of multi-layer solar cells with a conversion efficiency of more than 50%.
	Urbanization	20	Widespread use in Japan of active environmental clean-up facilities that absorb and fix air pollutants such as CO_2, NO_x and freons in urban areas, where the majority of emissions occur.
	Agriculture etc.	55	Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.
	Production	44	Practical use of technologies that enable the direct storage of electricity (superconducting magnets, flywheels and capacitors).
	Materials	109	Widespread use of desert afforestation technology through the advancement of water retention technology and biotechnology.
	Production	08	Practical use of room temperature superconductors in industrial products.
2017	Life science	91	Development of technologies which dramatically improve photosynthetic ability in order to increase food production.
	Electronics	08	Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.
	Materials	107	Practical use of processes for water decomposition by the sunlight.
	Production	49	Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on local ecosystems throughout product life cycles, from manufacture to disposal.
	Urbanization	05	Practical use in Japan of a mid-term (5 - 10 years in advance) prediction technique for large-scale (Magnitude 8 or stronger) earthquakes based on analyses of the distribution of strains in the earth's crust and past earthquake records.
2018	Production	51	Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.
	Agriculture etc.	84	Practical use of a system of removing almost the entire pollution load on lakes, bays and other closed water bodies that are suffering from water quality degradation by developing environmental restoration technology that utilizes ecosystems and biological functions.
	Production	42	Widespread use of non-fossil energy sources (wind, geothermal, solar (photovoltaic/solar thermal) and waste heat) in all areas of life including household, industry and transportation.
	Health	95	Elucidation of individual aging mechanisms.
2019	Resources	63	Practical use of technology for the safe disposal of highly radioactives solid waste.
2020	Life science	28	Control of signal transduction in the carcinogenesis of cells, and widespread use of treatment methods for dysdifferentiating carcinogenic cells.

Year	Field		Topic
	Space	36	Capability for transmission of electrical power to earth by microwave from solar power generation plants with huge solar cell panels, constructed in space.
	Materials	44	Development of superconductive materials with a transition temperature around room temperature.
	Marine science	56	Development of technology to alleviate dangerously heavy rainfall through the application of nephology.
2021	Resources	56	Practical use of hot dry rock power-generating technologies.
	Production	55	Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.
	Space	38	Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.
2022	Environment	09	Reduction of global carbon dioxide emissions to 20% below the 1990 level.
	Electronics	66	Development of a strage system in which one atom or molecule corresponds to 1 bit.
2023	Life science	65	Elucidation of brain mechanisms for logical reasoning.
	Marine science	60	Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.
	Information	35	Elucidation of human creative mechanism to such an extent that allows to apply to computer science.
2024	Electronics	21	Development of an "artificial intelligence chip" capable of understanding and sharing human emotions.
	Resources	75	Practical use of superconductive energy storage systems with a capacity (1000 MWh) as large as that of pumped hydro storage.
2025	Life science	58	Development of interfaces enabling direct linkage between the computer and the brain.
	Resources	77	Practical use of power networks utilizing superconducting cables.
	Resources	58	Practical use of fast breeder reactor systems including nuclear fuel cycle.
2026 or later	Information	38	Become possible for computers, using electromagnetic data, to read the information recorded inside the human brain.
	Resources	59	Development of fusion reactors.

4. Leading countries etc.

4.1 Trends in each field

Here we have converted the average topic response rate in each field for each of the five country/region options (USA, EU, Former Soviet Union and Eastern Europe, Japan, Others, Do not know) into graph format.

The USA is regarded to be the leading country in 11 of the 14 fields, and especially so in the “space,” “life science,” “information,” “communication” and “health, medical care and welfare” fields. In the remaining three fields (“resources and energy,” “urbanization and construction” and “transportation”), Japan is placed above the USA. The EU is rated quite highly in “environment” and “transportation.” However, in this survey the respondents were able to give multiple responses for the “leading country etc.,” so the final figures show the rate at which each of the countries or regions attracted “votes,” and not a relative evaluation of their technological level. For example, even though there may be only a very slight difference between a country in the first group and a country in the second, the second group country may attract hardly any votes. There is also a difference in the volume of information each of the countries or regions publish, so it is anticipated that in cases where only limited information reaches Japan, those countries or regions will be at a disadvantage. Moreover, many of the topics themselves are considered necessary and are being tackled in Japan, and most of the technologies are at the applied stage (i.e. practical use or widespread use), so we should keep in mind that these factors will tend to push up Japan’s relative percentage.

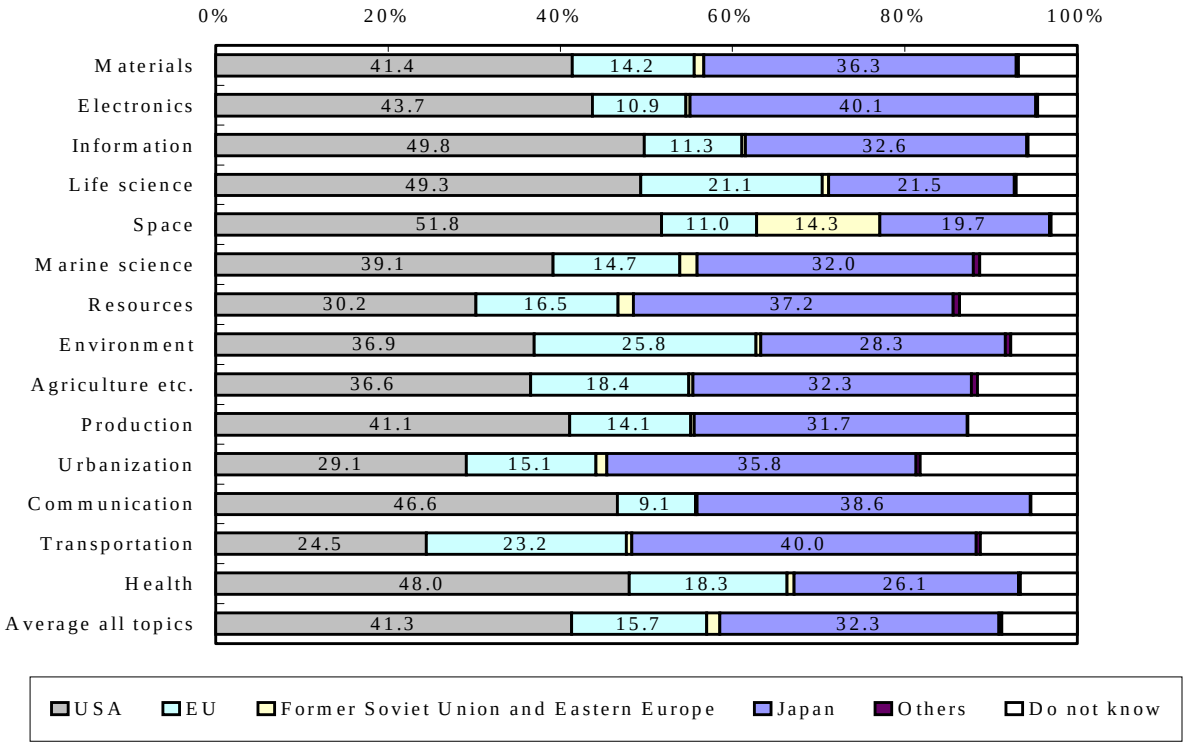


Figure 4.1-1 Leading countries etc. by field

4.2 Topics with a high "USA" response rate

Of the top 20 topics with a high "USA" response rate, the "space" field is most represented with eight, followed by "health, medical care and welfare" with four, and "urbanization and construction" with two space-related topics.

Table 4.2-1 Top 20 topics with a high "USA" response rate

Ranking	Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan
1	Life science	01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	**98**	42	0	39
2	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	**98**	6	0	19
3	Urbanization	72 Realization of facilities in the outer space where people in general can live in long period.(at least one year)	**98**	4	43	5
4	Space	15 Realization of a high-accuracy satellite positioning system operated by an international organization.	**97**	16	22	29
5	Urbanization	73 Realization of manned laboratories on Mars.	**97**	0	32	3
6	Space	48 Exploration of Saturn and other planets beyond it.	**97**	4	28	5
7	Health	75 Practical use of heterogeneous organ transplantation as means of treatment.	**97**	20	0	19
8	Space	16 Full-scale operation of a space station as a laboratory on the low earth orbit, and realization of next-generation facilities using the space environment for research, development, and trial production of semiconductors, pharmaceuticals, etc.	**97**	44	64	46
9	Health	05 Elucidation of carcinogenic mutation mechanisms.	**96**	46	1	59
10	Space	21 Development of a space plane capable of transporting between the earth and space stations in the similar manner as conventional airplanes.	**96**	19	26	29
11	Space	46 Realization of landing of manned spacecraft on Mars and the return to the Earth.	**96**	3	46	3
12	Space	02 Widespread use of a global-scale environmental surveillance network in which environmental changes for the earth as a whole are monitored around the clock in real time, and this information is integrated, systematically analyzed, and distributed around the world.	**96**	47	4	56
13	Information	52 Widespread use of in-home shopping via networks, by means of virtual shopping systems.	**96**	24	1	49
14	Space	38 Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.	**96**	7	46	8
15	Life science	27 Elucidation of the immune mechanisms which distinguish between "self" and "not self".	**96**	55	0	46
16	Health	73 Practical use of gene therapy for genetic disorders.	**96**	37	0	32
17	Space	04 Development of technology to construct of artificial satellites with large-scale antenna (several tens of meters in diameter) at permanent manned space stations in low earth orbit.	**96**	16	25	50
18	Information	21 Widespread use of computer networks in which a virtual space can be shared in real time by a large number of unspecified, geographically dispersed persons.	**96**	13	0	53
19	Information	03 Practical use of parallel computers with one million or more processors.	**96**	7	0	55
20	Health	09 Elucidation of the arteriosclerosis contraction mechanisms.	**96**	43	0	49

4.3 Topics with a high "EU" response rate

Not one topic recorded over 90% for the EU. Overall the top 20 topics lean toward an environmental theme; the "environment" field has four topics, "production and machinery" has three environment-related topics, and "materials and processing" and "transportation" have one environment-related topic each. "Resources and energy" also has three topics in the top 20, but all of these are connected with nuclear power.

Table 4.3-1 Top 20 topics with a high "EU" response rate

Ranking	Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan
1	Production	50 Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials through legally establishing manufacturers' responsibilities for collection and disposal of disused products.	20	**84**	0	33
2	Environment	32 Wide acceptance of LCA-style product design concepts that encourage recycling and reuse.	39	**83**	1	42
3	Environment	13 Elucidation of the mechanism of the impact caused by acid rain to animals and plants.	45	**82**	4	42
4	Environment	23 Introduction of environment tax aiming at global environmental conservation.	22	**81**	0	22
5	Transportation	31 Achievement of a 90% recyclability for motor vehicle parts and material (scrapped vehicles).	18	**75**	0	48
6	Transportation	08 Utilization of new materials in rails and wheels and improvements in the technology of vehicle structures, leading to the continuous operation of Shinkansen bullet trains at a speed of 350 Km/h while satisfying environmental quality standards.	0	**75**	0	85
7	Materials	34 Establishment and practical use of plastic recycling technology.	50	**74**	0	63
8	Resources	63 Practical use of technology for the safe disposal of highly radioactives solid waste.	62	**71**	3	63
9	Resources	58 Practical use of fast breeder reactor systems including nuclear fuel cycle.	24	**71**	12	80
10	Environment	12 Elucidation of the worldwide long-distance migration mechanisms of acid-rain-causing substances, such as SO_x and NO_x, considering regional characteristics.	58	**70**	2	51
11	Production	51 Advancements in technological development such as carbon dioxide recovery and detoxification of harmful wastes, leading to the widespread use of global environmental conservation measures throughout the world.	47	**69**	0	47
12	Materials	33 Biodegradable plastics will account for 10% of all plastics.	66	**68**	1	67
13	Production	49 Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on local ecosystems throughout product life cycles, from manufacture to disposal.	26	**68**	0	42
14	Agriculture etc.	33 Widespread use of fully automated feed formulation, feeding, milking and animal waste treatment systems.	58	**66**	0	41
15	Information	66 Widespread use of electronic money to settle monetary matters.	90	**65**	1	35
16	Agriculture etc.	31 Widespread use of advanced sustainable grazing techniques that improve pasture productivity and make labor-saving livestock management possible by taking advantage of the functions of organisms forming part of pasture ecosystems.	54	**64**	1	16
17	Resources	59 Development of fusion reactors.	79	**64**	17	75
18	Urbanization	29 Spread of community-based efforts to utilize unused energy sources and recycle household wastes etc. in Japan.	14	**63**	0	36
19	Agriculture etc.	35 Widespread use of animal waste utilization techniques via decomposition into constituents.	23	**62**	1	46
20	Urbanization	25 Widespread use in Japan of development techniques aimed at coexisting with nature (e.g. conservation of ecosystems and creation of wildlife habitats) through the elucidation of the mechanisms whereby development impacts on ecosystems.	25	**62**	0	28

4.4 Topics with a high "Former Soviet Union and Eastern Europe" response rate

Nineteen of the top 20 topics are connected with space (17 in the "space" field, and two of the remaining three are space-related).

Table 4.4-1 Top 20 topics with a high "Former Soviet Union and Eastern Europe" response rate

Ranking	Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan
1	Space	31 Development of high-pressure (1 atmosphere), flexible space suit for use outside of a spaceship.	95	5	**66**	3
2	Space	50 Practical use in Japan of isotope batteries for probing deep space.	90	3	**66**	3
3	Space	16 Full-scale operation of a space station as a laboratory on the low earth orbit, and realization of next-generation facilities using the space environment for research, development, and trial production of semiconductors, pharmaceuticals, etc.	97	44	**64**	46
4	Space	51 Practical use of space nuclear propulsion systems.	86	3	**63**	5
5	Marine science	49 Practical use of boring technology capable of reaching the depth of 15 Km.	77	34	**55**	21
6	Space	44 Long-term observation of the atmosphere of Venus by means of balloons.	91	5	**53**	22
7	Space	45 Analysis of the surface substances of Mars, its with weather observation and earthquake observation, etc., via an unmanned Mars exploration unit.	95	6	**51**	15
8	Space	23 Realization of bases for transporting to the moon and planets in middle or low-level orbiting transport	94	11	**50**	11
9	Space	27 Establishment of a remote medical diagnosis/treatment system for astronauts.	89	19	**49**	17
10	Space	42 Practical use of nuclear power generating system at lunar bases.	83	8	**48**	13
11	Space	26 Development of technologies for removing micro-organisms that lead to uncomfortable factors in space life such as mildew and offensive smells in space stations.	86	14	**46**	19
12	Space	46 Realization of landing of manned spacecraft on Mars and the return to the Earth.	96	3	**46**	3
13	Space	38 Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.	96	7	**46**	8
14	Space	30 Development of life support technology applied to a closed ecosystem, able to self-supply vegetable, grain, animal protein, and other food.	95	13	**44**	34
15	Space	43 Return of samples from other planets.	95	10	**43**	38
16	Urbanization	72 Realization of facilities in the outer space where people in general can live in long period.(at least one year)	98	4	**43**	5
17	Space	17 Realization of a micro gravity research facility capable of an environment of 10^{-6} G or less for several days.	91	39	**42**	46
18	Space	40 Creation of a permanent, manned station on the surface of the moon, executing geological surveys of the moon, scientific observations from the moon, and development of technology to utilize the moon's resources.	95	9	**41**	19
19	Health	96 Elucidation of the mechanism whereby living organisms undergo changes in the space environment.	86	14	**39**	8
20	Space	37 Development of high-performance orbital transfer vehicle to transfer large structures between lower and geostationary orbits.	92	18	**37**	26

4.5 Topics with a high "Japan" response rate

The "electronics" field accounts for the largest number of topics in the top 20 with nine, followed by "communication" with five.

Table 4.5-1 Top 20 topics with a high "Japan" response rate

Ranking	Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan
1	Communication	28 Practical use of 90 in. large wall-mountable high-definition flat color displays.	23	1	0	**96**
2	Communication	27 Development of a 4,000 x 4,000 pixel high-definition display, image sensor, and signal processing technique.	38	3	0	**96**
3	Electronics	06 Practical use of VLSI with as much as 256 Gbits of memory per chip.	61	2	0	**96**
4	Communication	51 Widespread use of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more.	12	2	0	**95**
5	Electronics	32 Practical use of ultraviolet, blue, and green, semiconductor lasers.	55	12	2	**95**
6	Transportation	04 Practical use of superconducting magnetically levitated railways with a maximum speed on the order of 500 Km per hour.	3	50	0	**94**
7	Information	07 Development of 5,000 dpi high-quality color printers.	52	2	0	**94**
8	Urbanization	16 Practical use in Japan of a technology to effectively control and absorb vibrations in massive structures caused by winds and earthquakes.	39	3	0	**94**
9	Electronics	36 Widespread use of opto-electronic integrated circuits (OEIC) in which multiple optical elements and their wave guide connections are integrated on a semiconductor substrate.	82	29	1	**93**
10	Electronics	05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	75	10	0	**92**
11	Information	27 Widespread use of voice word processors in which Japanese text can be input by voice (continuous speaking by unspecified speakers).	47	9	0	**92**
12	Electronics	18 Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence.	68	16	0	**91**
13	Urbanization	14 Practical use in Japan of techniques to assess the soundness of foundations of existing structures and to seismically strengthen existing foundations.	32	4	0	**91**
14	Electronics	30 Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt.	65	11	1	**90**
15	Electronics	42 Practical use, in the field of optical communications and optical switching, of technology to convert the wavelength of a signal into another wavelength.	87	27	1	**90**
16	Environment	24 Widespread use of control technologies in virtually all types of automobiles, capable of meeting the emission control standard for nitric oxide at the order of 0.1 to 0.2 g/Km. (The current level for heavy diesel motorcars is on the order of 4 to 5 g/Km, and the standard control value for gasoline passenger cars in 1978 is 0.25 g/Km.)	46	40	0	**89**
17	Communication	73 Development of light-reflecting liquid crystal color displays (no backlighting) with the advantage of low power consumption.	27	1	0	**89**
18	Electronics	08 Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	72	3	0	**89**
19	Communication	03 Practical use of modes of transmission ever extremely long distance without repeaters based on realization of optical fiber with ultra low rate of transmission loss (less than 0.01 dB/Km), enabling installation of Japan-Hawaii optical trunk ine without repeateers.	58	4	1	**88**
20	Electronics	49 Production of household-use optical fiber signal tranceiver units at a cost of around 5,000 yen.	72	17	0	**88**

4.6 Topics with a high “Other countries” response rate

In this survey, as well as the four specific countries or regions (USA, EU, Former Soviet Union and Eastern Europe, and Japan), respondents who believed a country or region other than those four is a world leader had “other countries” as an option, and were asked to indicate the specific country or region. Over all fields, there were few “other countries” responses, and Table 4.6-1 shows three topics with a reasonably high response rate. The “Did not indicate” in the table shows the cases where the “other countries” was selected, but a specific country or region was not written down.

Table 4.6-1 Topics with a high “Other countries” response rate

Field	Topic	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries				Do not know
Marine science	61 Elucidation of the existence of a correlation between animal behavior and earthquakes for use as earthquake prediction data	9	2	2	48	China	Greece		Did not indicate	26
						21	1		1	
Electronics	06 Practical use of VLSI with as much as 256 Gbits of memory per chip	61	2	0	96	ROK	Taiwan	NIES	Did not indicate	0
						12	2	0	1	
Resources	67 Widespread use of methanol fuel	54	26	0	41	Brazil	South America		Did not indicate	19
						7	1		7	

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5. Effective measures the government should adopt in Japan

We asked respondents to indicate whether they believe the government should adopt any measures to promote the technological topic, and if so, to choose up to three measures from among the following.

i) Foster researchers, engineers and research assistants

ii) Enhance systems to promote personnel exchanges among the industrial, academic and government sectors and cooperation among different fields of science and technology

iii) Upgrade advanced R&D facilities and equipment and make them available for more widespread use

iv) Develop a research base comprising data bases, standard reference material, genetic resources and the like

v) Increase the government's funding for research

vi) Adjust relevant regulations (relax/toughen/establish/abolish)

vii) Others

5.1 Overall trends

Figure 5.1-1 shows the average percentage value for all topics in each field. The average of all topics is quite high in "increase government research funding" (52.5) and "foster human resources" (52.1), followed by "promote personnel exchanges among the industrial, academic and government sectors and different fields" (42.4). This shows that over many topics, respondents want the government to provide greater R&D support in both personnel and funding aspects, and play a coordinating role in personnel exchanges and cooperation.

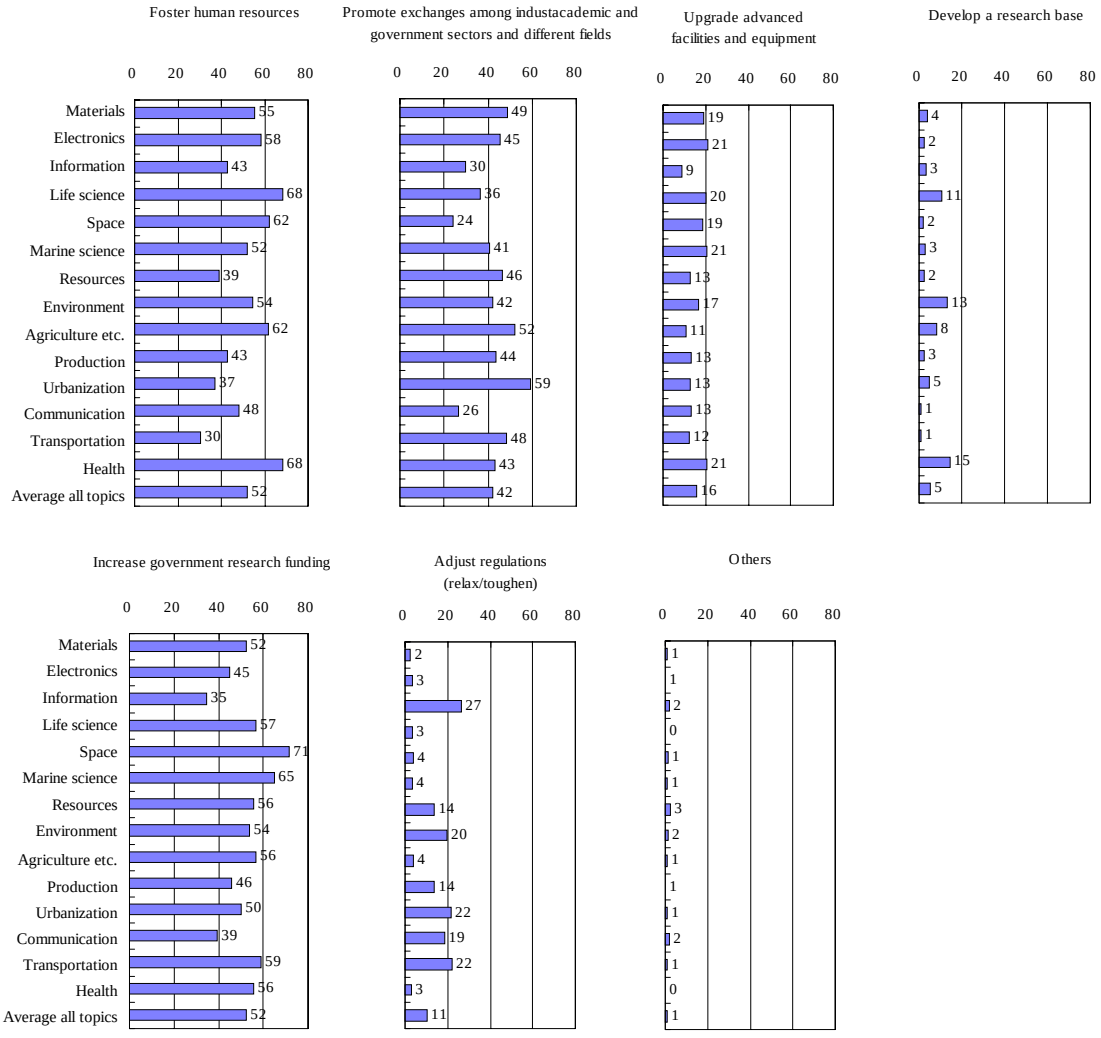

Figure 5.1-1 Measures the government should adopt by field

On the other hand, it is quite low in "develop a research base" (5.3) and "adjust regulations (relax/toughen)" (10.5), indicating there were relatively few topics for which respondents believed developing a research base and adjusting (relaxing or toughening) regulations would be effective.

The figures show that in some fields expectation of government participation is indeed strong, while in others it is less so. To quantify these expectations, we totaled the percentage values of i)–vii) for each topic, and plotted the field averages on a graph, shown at Figure 5.1-2. Since respondents could select up to three responses for each topic, the maximum value is 300. The aggregate value is smaller in "information" and "communication," fields with many topics with a relatively early forecasted realization time, and larger in the "health," "environment," "life science" and "agriculture etc." fields. As shown in Table 5.1-1, four of the top five topics are connected with gene technology.

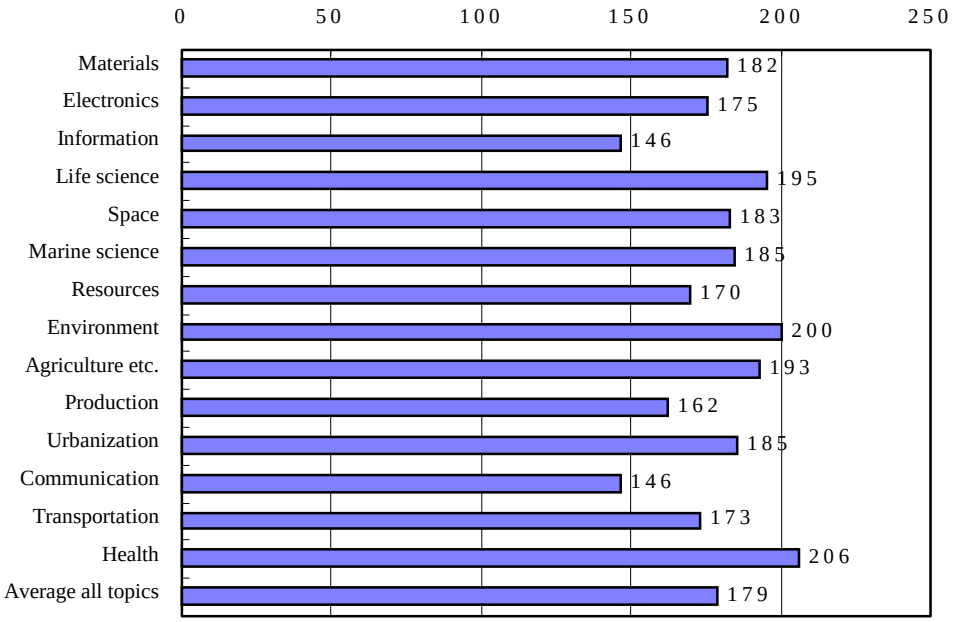

Figure 5.1-2 Response aggregates for measures the government should adopt

Table 5.1-1 Topics with a high response in "Measures the government should adopt"

Ranking	Field	Topic	Number of responded times	Forecasted realization time
1	Agriculture etc.	01 Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	2.44	2009
2	Health	51 Widespread use of gene therapy against malignant tumors.	2.39	2014
3	Agriculture etc.	02 Practical use of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	2.37	2004
4	Health	05 Elucidation of carcinogenic mutation mechanisms.	2.36	2013
5	Life science	01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	2.36	2014

5.2 Foster researchers, engineers and research assistants (Foster human resources)

With an average of all topics of 52.1, the "Foster human resources" measure is the second highest. Overall, the measure is comparatively high in the life-related fields of "health, medical care and welfare" (68.3), "life science" (68.2) and "agriculture, forestry and fisheries" (61.5), and in the eye-catching and extremely expensive science field of "space" (62.1); and low in "transportation" (30.4), "urbanization and construction" (36.9), "resources and energy" (38.9) and "production and machinery" (42.9). The highest ranking topic list is dominated by life-related topics: eight topics in the "life science" field, seven in "health, medical care and welfare" and five in "agriculture, forestry and fisheries".

Table 5.2-1 Top 20 topics in "Foster human resources"

Ranking	Field	Topic	Foster human resources	Forecasted realization time
1	Agriculture etc.	69 Elucidation of the mechanisms of totipotency of plant cells.	86	2021
2	Health	19 Widespread use of preventive measure for cerebral palsy.	86	2012
3	Agriculture etc.	24 Practical use of a livestock production technology that utilizes embryonic stem (ES) cells.	84	2011
4	Life science	83 Elucidation of the neural mechanisms of sleep and dreams.	84	2017
5	Marine science	51 Elucidation of the series of processes including the generation, rise, storage, and extrusion of magma.	82	2016
6	Life science	41 Elucidation of relationships between higher-order structures and functions of the nuclei in eukaryotic cells.	82	2015
7	Marine science	54 Practical use of analytical methods capable of tracing gradual changes (atomic fluctuations) involved in fossilization which cause material in organisms corpses to be replaced by silica.	82	2016
8	Life science	84 Complete elucidation of the molecular mechanisms of development and differentiation.	82	2022
9	Life science	82 Elucidation of the entire molecular mechanisms which generate the internal rhythms in organisms.	82	2015
10	Health	82 Development of methods for recombining disconnected central nerves.	82	2018
11	Agriculture etc.	82 Development of an ecosystem management system that enables rare species of organisms dependent on forests to propagate according to their ecological conditions.	81	2016
12	Life science	23 Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest.	81	2023
13	Life science	68 Elucidation of the cause of manic-depressive psychosis at the molecular level.	81	2016
14	Agriculture etc.	03 Development of C_3 plants with modified photosynthesis systems through the techniques of biological/biochemical control or gene manipulation, etc.	81	2012
15	Agriculture etc.	43 Elucidation of the mechanism whereby organisms belonging to forest ecosystems turn into pests, and development of a prediction technique for the outbreak of major pests and an integrated pest control technique that takes advantage of the self-maintanance functions of forests.	81	2014
16	Health	51 Widespread use of gene therapy against malignant tumors.	81	2014
17	Health	40 Possible to cure autoimmune diseases.	80	2020
18	Health	60 Practical use of batteries of artificial organs implanted in the living body.	80	2014
19	Life science	86 Elucidation of the neurobiological basis for emotion.	80	2021
20	Life science	20 Complete elucidation of the molecular mechanism explaining the cell cycle in higher order mammals (humans, mice).	80	2015
20	Health	21 Elucidation of gout-causing genes.	80	2008
20	Marine science	70 Inauguration in Japan of international research centers for comparative planetology, including the science of the earth, based on the development of planetology through specimens obtained from meteorites and planets.	80	2011
20	Health	14 Practical use of prevention methods for stress-induced mental disorders.	80	2011
20	Marine science	64 Elucidation of the entire aspect of the movement and storage of carbon dioxide extending over the air, land, oceans, and sea bottoms.	80	2016

5.3 Enhance systems to promote personnel exchanges among the industrial, academic and government sectors and cooperation among different fields of science and technology (Promote exchanges among industrial, academic and government sectors and different fields)

The average of all topics for this measure is reasonably high at 42.4. It is highest in the "urbanization" (59.1) and "agriculture etc." (51.9) fields, and lowest in the government-run field of "space" (24.3) and the multi-media-related fields of "communication" (26.3) and "information" (30.0). By topic, 12 of the top 20 topics are in "agriculture etc.," and most of these are connected with food. There are also some robot-related topics among the top 20.

Table 5.3-1 Top 20 topics in "Promote exchanges among industrial, academic and government sectors and different fields"

Ranking	Field	Topic	Promote exchanges among industrial, academic and government sectors and different fields	Forecasted realization time
1	Agriculture etc.	75 Practical use of general-purpose taste measuring equipment provided with a taste sensor capable of sensing taste ingredients and a texture sensor capable of sensing physical properties.	80	2010
2	Agriculture etc.	20 Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials.	80	2005
3	Agriculture etc.	14 Development of remote-controlled, multi-purpose agricultural robots with artificial intelligence, that can make even aged people self-reliant in cultivation and harvesting of crops.	80	2011
4	Agriculture etc.	18 Widespread use of a technology that keeps starch-based foods with high water content from deteriorating for a prolonged period, making it possible to eat such foods at any time without reheating, through combination with aseptic packaging.	79	2007
5	Agriculture etc.	77 Practical use of containers and packaging with in-built temperature control technology that obviates the need for refrigeration for processed foods aimed at the outdoor lifestyle.	78	2008
6	Agriculture etc.	12 Practical use of agricultural robots capable of harvesting and simultaneous sorting of fruits according to quality.	78	2007
7	Agriculture etc.	76 Development of household food testers capable of instantaneously determining freshness and microorganic contamination levels of foods.	78	2008
8	Agriculture etc.	68 Practical use of artificial sugar substitutes with the same cooking characteristics as sucrose which are ideal for diet food preparation.	78	2007
9	Agriculture etc.	32 Practical use of fully automated agricultural work execution techniques based on autonomous-travel tractors for the cultivation and harvesting of forage crops.	77	2009
10	Marine science	30 Widespread use of marine ranches with optimal environmental management through incorporation of biological system technology and a wide range of engineering technology.	77	2015
11	Transportation	38 Practical use of computer-integrated manufacturing systems (CIM) for shipbuilding, which incorporate design/production databases and intelligent CAD/CAM systems, leading to a reduction in shipbuilding labor costs to about half the present level.	76	2006
12	Agriculture etc.	33 Widespread use of fully automated feed formulation, feeding, milking and animal waste treatment systems.	76	2008
13	Urbanization	37 Practical use in Japan of distributed energy supply systems for houses utilizing fuel cells, cogeneration, etc..	75	2011
14	Urbanization	08 Introduction of robots to fire-fighting activities and their widespread use in search and rescue operations in fire events in Japan.	75	2010
15	Life science	62 Development of diagnostic and medical treatment micromachines capable of traveling on their own inside organisms (body cavity organs).	75	2015

Ranking	Field	Topic	Promote exchanges among industrial, academic and government sectors and different fields	Forecasted realization time
16	Urbanization	11 Widespread use in Japan of remote monitoring and control systems for enhancing the safety of essential services of utilities. (e.g. water, electricity and gas)	75	2007
17	Agriculture etc.	67 Practical use of functional foods which help prevent diseases according to individual body characteristics.	74	2011
18	Urbanization	38 Practical use in Japan of technology that facilitates the recycling of almost all construction by products such as concrete debris, asphalt waste and surplus soil.	73	2009
19	Agriculture etc.	41 Practical use of technologies for manufacturing paper and pulp by using the enzyme of wood decaying fungi.	73	2010
20	Life science	35 Widespread production of bioplastics using microorganisms and plants, accounting for 10% of the total volume of worldwide plastic production.	73	2013

5.4 Upgrade advanced R&D facilities and equipment and make them available for more widespread use (Upgrade advanced facilities and equipment)

The average of all topics for this measure is quite low at 15.9. It is relatively high in the basic technology fields of “electronics” (21.1), “marine science” (20.9), “health” (20.7) and “life science” (19.9). Lowest is the “information” field with 8.6.

Among the top 20 topics, only three are above 50%. By field, “electronics” has the highest share with nine topics, followed by “marine science” with four and “production” with three. Many of the topics are connected with electronics-related facilities and equipment, indicating that the respondents are looking to the government to upgrade and throw open electronics-related advanced R&D facilities and equipment across various fields.

Table 5.4-1 Top 20 topics in “Upgrade advanced facilities and equipment”

Ranking	Field	Topic	Upgrade advanced facilities and equipment	Forecasted realization time
1	Marine science	66 Practical use of high-luminosity radiation via electron or positron storage rings with emittance of 0.1 nano radians or less, for use in analysis of the atomic structure of materials deep inside the earth.	63	2023
2	Marine science	65 Development of a positron microscope.	59	2019
3	Electronics	05 Practical use of technology which allows mass processing of patterns with minimum line width as low as 10 nanometers.	58	2013
4	Electronics	06 Practical use of VLSI with as much as 256 Gbits of memory per chip.	48	2014
5	Electronics	01 Development of technology capable of manipulating single atoms and single molecules.	47	2007
6	Electronics	03 Practical use of LSIs using single-electron transistors.	44	2015
7	Marine science	67 Practical use of neutron spectrographs via megawatt-class spallation neutron sources, for use in analysis of the atomic structure of materials deep inside the earth.	43	2024
8	Production	18 Practical use of superprecision processing technologies (machining, analysis and testing) through the availability of length, displacement and surface roughness measurement to the angstrom order and time measurement to the femtosecond order, as a result of advancements in beam technology, involving ions, electrons and lasers, and equipment control technology.	42	2009
9	Electronics	02 Practical use of quantum-phase devices that control the phases of, for example, electron waves.	41	2012
10	Production	10 Establishment of atomic and molecular structure control techniques, leading to widespread use of high functionality materials and super materials, designed to operate under extreme conditions.	41	2019
11	Materials	23 Practical use of devices that enable X-ray structural analysis of supramolecular-biopolymer crystals in real time.	40	2011
12	Marine science	68 Practical use of 0.1-1.0 nm wavelength lasers, facilitating the observation of material structures via hard X-ray holography.	39	2014
13	Production	11 Realization of new material plants utilizing high-vacuum and weightless conditions in space.	39	2017
14	Electronics	07 Widespread use of wafers one meter in diameter.	38	2020
15	Materials	83 Practical use of technology for constructing material through the employment of ions and particle beams with controlled characteristics.	38	2011
16	Health	28 Practical use of diagnosing methods for determining the level and spread of arteriosclerosis focused by a non-invasive process.	38	2008
17	Electronics	43 Practical use of soft X-ray lasers oscillating at wavelengths in the order of 10/Å.	37	2016
18	Electronics	09 Practical use of semiconductor LSIs that operate at a switching speed of 1 ps or less.	37	2015
19	Life science	87 Elucidation of physiological effects of gravity-free state and development of measures for preventing deterioration in biological functions caused by the weightless state.	37	2016
20	Electronics	08 Practical use of non-volatile, erasable with more than 100 Gbits capacity random access semiconductor memories.	36	2017

5.5 Develop a research base comprising data bases, standard reference material, genetic resources and the like (Develop a research base)

The average of all topics here is lowest among the six measures at 5.3. It is highest in the life-related fields of “health” (14.8), “environment” (13.0), “life science” (10.6) and “agriculture etc.” (8.4). Of the top 20 topics, nine are in “health” and eight are in “life science.” Many are gene-related, with 16 containing the term “genome” in the topic text.

Table 5.5-1 Top 20 topics in “Develop a research base”

Ranking	Field	Topic	Develop a research base	Forecasted realization time
1	Life science	03 Utilization of information about the gene structure of each individual patient in diagnosis and treatment.	77	2015
2	Life science	21 Application of human genome analysis methods to other animals and plants, and practical use of technology to analyse whole genome sequence in livestock breeding, and fisheries, agriculture and forestry.	73	2017
3	Agriculture etc.	01 Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	67	2009
4	Life science	04 Development of methods for surmising new functions of proteins from human genome information.	66	2011
5	Life science	01 Identification of multiple genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis.	62	2014
6	Health	23 Widespread use of a cancer risk assessment technique based on genetic analysis.	56	2010
7	Life science	22 Establishment of technology enabling to decipher human DNA modification (methylization) information for all genomes.	55	2014
8	Health	18 Practical use of the prevention against congenital anomaly originating in the embryonic or fetal period.	50	2013
9	Health	73 Practical use of gene therapy for genetic disorders.	48	2012
10	Agriculture etc.	02 Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	47	2004
11	Health	42 Practical use of gene therapy for diabetes.	46	2014
12	Health	56 Widespread use of gene therapy for muscular dystrophy.	45	2016
13	Life science	94 Advancement of the analysis of the human genome diversity regarding individual races, and the elucidation of the origin and phylogeny of human being.	45	2018
14	Health	21 Elucidation of gout-causing genes.	45	2008
15	Health	51 Widespread use of gene therapy against malignant tumors.	43	2014
16	Life science	25 Establishment of technologies enabling prediction of the functions of proteins from their higher-order structures.	43	2014
17	Health	05 Elucidation of carcinogenic mutation mechanisms.	42	2013
18	Urbanization	06 Practical use in Japan of online data base on natural disasters in Japan necessary for risk management.	40	2009
19	Life science	23 Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest.	40	2023
20	Health	43 Widespread use of gene therapy for familial hypercholesterolemia.	39	2014

5.6 Increase the government's funding for research (Increase government research funding)

With an average of all topics of 52.5, "Increase government research funding" is the highest of all measures. It is especially high in the eye-catching and extremely expensive science field of "space" (71.4), and in "marine science and earth science" (65.1). Conversely, it is lowest in the media-related fields of "information" (34.8) and "communication" (39.1). Of the top 20 topics, ten are in "space," indicating that respondents expect the government to inject the massive amounts of funds needed for success in this field.

Table 5.6-1 Top 20 topics in "Increase government research funding"

Ranking	Field	Topic	Increase government research funding	Forecasted realization time
1	Transportation	37 Development of autonomous, unmanned, underwater investigation vessels employing artificial intelligence which are capable of investigating sea-bottom resources and undertaking other activities without receiving any energy supply or external communication.	85	2009
2	Space	20 Development of two-stage-to-orbit, completely re-usable, space transport system.	85	2011
3	Space	21 Development of a space plane capable of transporting between the earth and space stations in the similar manner as conventional airplanes.	84	2016
4	Space	39 Set of optical or radio telescopes on the surface of the moon.	83	2017
5	Space	37 Development of high-performance orbital transfer vehicle to transfer large structures between lower and geostationary orbits.	83	2015
6	Space	04 Development of technology to construct of artificial satellites with large-scale antenna (several tens of meters in diameter) at permanent manned space stations in low earth orbit.	82	2008
7	Space	40 Creation of a permanent, manned station on the surface of the moon, executing geological surveys of the moon, scientific observations from the moon, and development of technology to utilize the moon's resources.	82	2025
8	Agriculture etc.	44 Practical use of the forecasting of landslide and avalanche as the result of development in remote sensing techniques using suitable sensors and computer systems.	82	2011
9	Marine science	50 Development of technologies for digging into the crust at the ocean floor to gather mantle materials.	82	2016
10	Space	43 Return of samples from other planets.	80	2010
11	Space	11 Practical use of global-scale marine and land mapping using satellite-mounted multi-frequency/multi-polarization synthetic aperture radar.	80	2008
12	Transportation	57 Practical use of robots to guide blind people in particular districts such as stations and shopping centers.	80	2006
13	Space	45 Analysis of the surface substances of Mars, its with weather observation and earthquake observation, etc., via an unmanned Mars exploration unit.	80	2008
14	Space	38 Development of manned orbital transfer vehicle for trips to and from geostationary orbits and the moon.	79	2021
15	Marine science	52 Positioning in several locations, under an international agreement, of neutrino detectors for the purpose of surveying the earth's internal structure.	79	2012
16	Marine science	67 Practical use of neutron spectrographs via megawatt-class spallation neutron sources, for use in analysis of the atomic structure of materials deep inside the earth.	79	2024
17	Materials	109 Widespread use of desert afforestation technology through the advancement of water retention technology and biotechnology.	78	2016
18	Agriculture etc.	80 Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.	78	2016
19	Communication	63 Practical use of integrated building management systems and home security systems which are linked to an earthquake detection system and take the necessary safety measures to protect human lives in the event of a non-direct-hit earthquake, taking advantage of the time lag to the arrival of seismic waves.	78	2011
20	Transportation	55 Practical use of floating off-shore airports.	78	2009

5.7 Adjust relevant regulations (relax/toughen/establish/abolish)

The average of all topics for this measure is a low 10.5. It is relatively high in “information” (26.7), “transportation” (22.0), and “urbanization” (21.6), and low in “materials” (2.2), “health” (3.1) and “electronics” (3.3). Of the top 20 topics, 17 are media-related fields: 12 in “information” and five in “communication”. And most of these are connected to the use of networks. Many respondents expressed their hope that the government would review relevant regulations as our society enters an era of advanced information technology, as typified by the remarkable growth of the internet over recent years.

Table 5.7-1 Top 20 topics in “Adjust regulations”

Ranking	Field	Topic	Adjust regulations (relax/toughen)	Forecasted realization time
1	Information	66 Widespread use of electronic money to settle monetary matters.	84	2006
2	Information	61 Realization of in-home electronic voting (elections).	84	2009
3	Information	58 Realization of applications, registrations, and other official public procedures and services over networks.	83	2004
4	Information	57 Full computerization of the foreign exchange, stock and other financial markets, and widespread use of fully automated rapid trading systems that do not require dealers or traders.	83	2005
5	Information	64 Establishment of social rules regarding multimedia copyrights, and expanded production and distribution of multimedia information.	83	2005
6	Information	62 The holding of electronic parliamentary sessions (electronic prefectural council meetings) in conjunction with television broadcasts of parliament, and the passage of bills (acts) through electronic voting by the citizenry.	79	2013
7	Information	67 Become possible to verify the counterparty to a contract concluded over a network with the use of database systems.	77	2004
8	Communication	67 Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	77	2006
9	Environment	23 Introduction of environment tax aiming at global environmental conservation.	77	2006
10	Information	73 Establishment of electronic primary and middle schools, making it possible for students who cannot travel to and from schools to take courses and obtain graduation diplomas.	75	2008
11	Urbanization	59 Widespread use in Japan of "three-dimensional" cities where the space above railway lines etc. is utilized through the establishment of artificial ground foundations and the like.	75	2013
12	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	75	2003
13	Communication	66 Widespread use of on-line seal-less document preparation services for various official documents such as contract documents which are provided via a network based on security technology capable of achieving both privacy protection and verification.	74	2008
14	Information	18 Realization of an environment in which the unlimited utilization of high-capacity networks (150 Mbps) for around 2,000 yen/month is possible.	73	2008
15	Information	19 Completion of networks enabling interconnection from anywhere in Japan through pocketbook-size telephones.	72	2005
16	Information	52 Widespread use of in-home shopping via networks, by means of virtual shopping systems.	72	2005
17	Communication	70 Realization of high-security communication, and widespread use of electronic secret ballots.	71	2012
18	Production	33 Strengthening of the relationship between consumption and production and advancements in networking between stores and factories, leading to widespread mergers between manufacturers and retailers/wholesalers and between manufacturers and distributors.	71	2007
19	Information	59 Formation and widespread use of a dynamic information market (including auctions) based on information provided by individuals.	70	2005
20	Communication	09 Widespread use of integrated information wiring and plug socket that incorporate services such as the telephone, Internet, VOD and high-definition TV in homes and offices.	70	2007

6. Potential problems in Japan

In this section, we asked respondents to indicate whether they believe there are any potential problems that should be considered beforehand in relation to the realization of each of the topics, and if so, to choose up to two items from among the following.

i) Adverse effect on the natural environment

ii) Adverse effect on safety

iii) Adverse effect on morals, culture or society

iv) Other adverse effects

6.1 Overall trends

Figure 6.1-1 shows the average percentage value for all topics in each field. The average of all topics is quite low in “adverse effect on the natural environment,” “adverse effect on safety” and “adverse effect on morals, culture or society,” indicating that overall the respondents have no major concerns that topic realization could produce an adverse effect.

Fields where concern about an “adverse effect on the natural environment” is relatively high are those closely linked to the natural environment, such as “environment” (47.4), “resources” (38.1) and “agriculture etc.” (27.5). In contrast, concern was lowest in “information” (1.0), “health” (1.1) and “electronics” (1.6).

As for “adverse effect on safety,” concern is highest in the urban-base fields of “transportation” (30.4), “urbanization” (24.7) and “information” (22.9), and lowest in the basic technology fields of “materials” (4.6) and “electronics” (5.5).

As for “adverse effect on morals, culture or society,” concern is by far the highest in the “health” field (37.7), followed by “information” (27.5) and “life science” (21.9), and lowest in “transportation” (2.0), “resources” (2.7) and “marine science” (2.9).

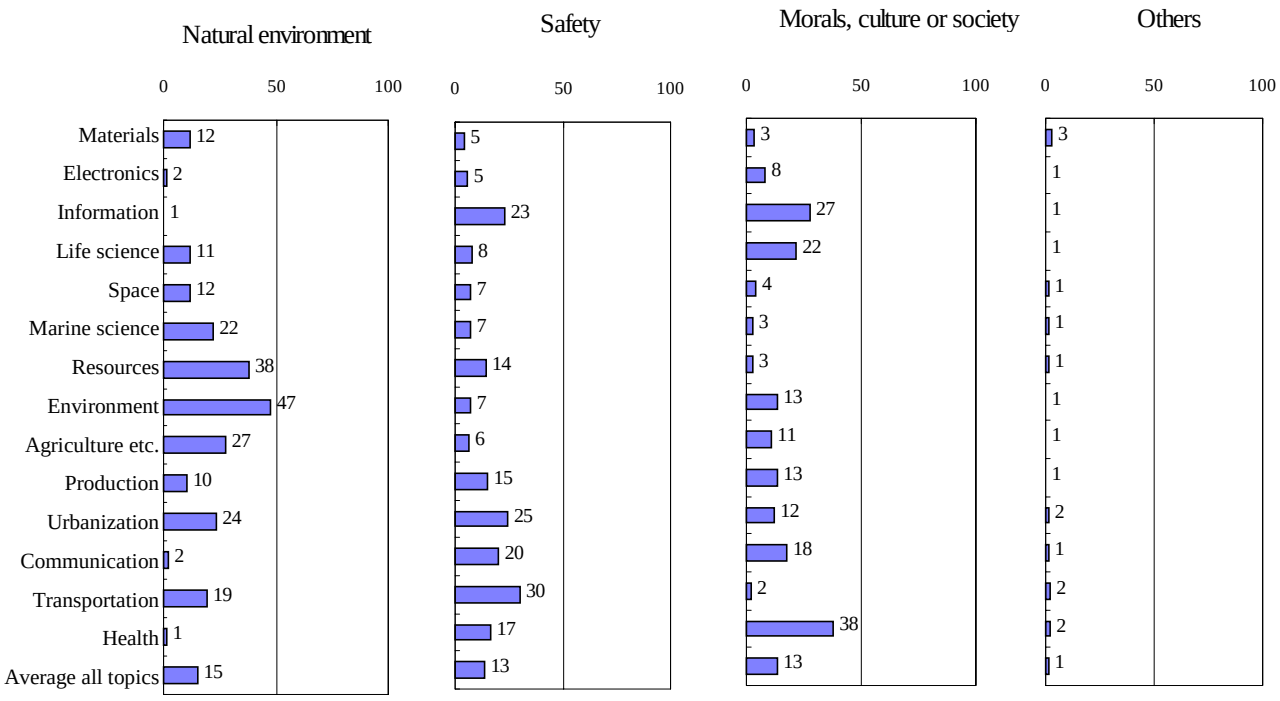

Figure 6.1-1 Potential problems in Japan

6.2 Adverse effect on the natural environment

Among the top 20 topics, six are in the “resources” field, and four are in “urbanization.” Most of the topics are connected to the deep underground, deep sea, artificial islands and gene manipulation.

Table 6.2-1 Top 20 topics in “Adverse effect on the natural environment”

Ranking	Field	Topic	Natural environment	Forecasted realization time
1	Resources	01 Practical use of solution mining, a technology to recover minerals from deep underground deposits by rendering ores such as chalcopyrite and sulfides of lead and zinc into solutions and pumping them up.	84	2020
2	Environment	10 Development of storage methods of carbon dioxide at deep sea levels of more than 3,000 m below surface.	75	2014
3	Resources	20 Practical use of inducing artificial rainmarking in event of drought.	74	2014
4	Life science	40 Widespread use of worldwide environmental remediation using genetically-engineered microorganisms released into the environment.	72	2016
5	Agriculture etc.	45 Realization of the creation of varieties of fisheries-resource aquatic organisms with traits advantageous for cultivation, such as high resistance to changes in water temperature and diseases, through cell fusion, gene manipulation, etc.	72	2010
6	Urbanization	32 Widespread use in Japan of "snow dam" technology to store snow and use it as cold heat source.	71	2014
7	Resources	41 Practical use of large-scale underground coal gasification.	71	2021
8	Urbanization	61 Development in Japan of design and construction technology for floating airports along coastal areas.	70	2005
9	Urbanization	13 Practical use in Japan of a safe and rational demolition technology for decommission of commercial nuclear power plants.	70	2009
10	Urbanization	69 Practical use of technology system needed to systematically build cities in remote areas such as deserts and polar regions.	70	2022
11	Resources	56 Practical use of hot dry rock power-generating technologies.	69	2021
12	Transportation	48 Development of a passenger transport that cruises at Mach 3 - 4 (1.5 - 2 times as fast as the Concorde) with a maximum of 300 passengers on board (3 times as many as the Concorde), and is capable of crossing the Pacific Ocean in 3 - 4 hours.	69	2016
13	Agriculture etc.	09 Widespread use of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).	68	2008
14	Agriculture etc.	48 Practical use of technologies for using a large volume of deep sea water for new fishing grounds in the open sea.	66	2013
15	Environment	21 Development of plants that are resistant to dry and saline conditions via biotechnology with the aim of greening deserts.	66	2013
16	Resources	23 Advancement in artificial groundwater recharging technology and widespread practice of the conservation and the rationalized use of groundwater.	66	2014
17	Resources	40 Practical use of methane hydrate mining.	65	2019
18	Marine science	18 Practical use of man-made off-shore islands processing of living disposal. (total dissassembly and decomposition of waste materials in order to dump harmful matter and recycle useful matter)	65	2012
19	Marine science	28 Practical use of marine cities (bases for transportation, communication, research, production and recreational activities) mainly of the legged or floating structures.	65	2013
20	Environment	11 Practical use of carbon dioxide fixing technologies using marine organisms such as microscopic algae.	65	2015

6.3 Adverse effect on safety (disaster prevention, health, security, privacy etc.)

Of the top 20 topics, eight are in "communication" and seven are in "information," for a total of 15 in fields dealing with networks and other sophisticated information technologies that have been advancing rapidly over the past few years, indicating there is a fair amount of concern about the growing levels of computer crime in these areas and the improper use of personal information.

Table 6.3-1 Top 20 topics in "Adverse effect on safety"

Ranking	Field	Topic	Safety	Forecasted realization time
1	Information	66 Widespread use of electronic money to settle monetary matters.	67	2006
2	Communication	67 Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	67	2006
3	Communication	66 Widespread use of on-line seal-less document preparation services for various official documents such as contract documents which are provided via a network based on security technology capable of achieving both privacy protection and verification.	66	2008
4	Information	67 Become possible to verify the counterparty to a contract concluded over a network with the use of database systems.	66	2004
5	Information	57 Full computerization of the foreign exchange, stock and other financial markets, and widespread use of fully automated rapid trading systems that do not require dealers or traders.	64	2005
6	Communication	69 Widespread use of security systems capable of identifying individuals based on the recognition of distinguished features of a person such as finger prints, hand writing, voice and face.	64	2009
7	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	63	2003
8	Information	58 Realization of applications, registrations, and other official public procedures and services over networks.	62	2004
9	Urbanization	70 Practical use in Japan of a technology to construct super high-rise buildings (around 1,000 m tall) with living spaces.	62	2020
10	Information	56 Widespread use of automobiles which drive automatically.	62	2017
11	Transportation	60 Practical use of vertical transportation systems for super high-rise buildings capable of providing a transporting capacity per occupant volume which is at least five times that of current elevators. (e.g., systems equipped multiple car-gondolas, turn-back function, and passing function)	61	2011
12	Communication	68 Widespread use of a security technology that automatically monitors illicit activities involving network ethics, such as copyright infringement concerning multimedia software use over a network and the violation of privacy.	59	2009
13	Communication	19 Practical use of a personal mobile communication system that enables communication with anyone anywhere in the world through advances in distributed databases and personal ID technology.	59	2008
14	Communication	02 Widespread use of indoor broadband optical wireless communication via indirect or scattered light that enables PCs and graphics terminals to make wireless connection to a network.	59	2005
15	Transportation	53 Achievement of radical automation of air traffic control through advances in computer technology, leading to a labor saving of about 50% compared to the present level.	58	2009
16	Information	59 Formation and widespread use of a dynamic information market (including auctions) based on information provided by individuals.	58	2005
17	Communication	70 Realization of high-security communication, and widespread use of electronic secret ballots.	57	2012
18	Life science	03 Utilization of information about the gene structure of each individual patient in diagnosis and treatment.	57	2015
19	Information	08 Widespread use of multipurpose ID card system with wireless communication capability.	55	2005
20	Resources	58 Practical use of fast breeder reactor systems including nuclear fuel cycle.	55	2025

6.4 Adverse effect on morals, culture or society

Of the top 20 topics, “health, medical care and welfare” has the highest share with eight, and most are connected with genes and other aspects of personal information, organ transplant, brain, and networks.

Table 6.4-1 Top 20 topics in “Adverse effect on morals, culture or society”

Ranking	Field	Topic	Morals, culture or society	Forecasted realization time
1	Life science	03 Utilization of information about the gene structure of each individual patient in diagnosis and treatment.	75	2015
2	Communication	01 Practical use of a highly secure next-generation internet that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	73	2003
3	Health	02 Practical use of a method to quantitatively assess the level of aging (biological age) in relation to chronological age.	68	2008
4	Health	76 Widespread use of a worldwide organ supply system.	68	2010
5	Information	38 Become possible for computers, using electromagnetic data, to read the information recorded inside the human brain.	67	2026
6	Materials	02 Practical use of hybrid artificial organs in which cells are immobilized on materials such as high polymer plastics.	67	2014
7	Health	18 Practical use of the prevention against congenital anomaly originating in the embryonic or fetal period.	66	2013
8	Urbanization	40 Widespread use in Japan of devices in ordinary households that enable people to enjoy imaginary experiences of trips, sporting events, etc. utilizing virtual reality technology.	65	2010
9	Information	62 The holding of electronic parliamentary sessions (electronic prefectural council meetings) in conjunction with television broadcasts of parliament, and the passage of bills (acts) through electronic voting by the citizenry.	64	2013
10	Communication	37 Realization of electronic courts based on a teleconferencing system and electronic filing system.	64	2013
11	Life science	15 Development of technology to regenerate organs or individuals from separated animal cells.	63	2023
12	Health	01 Realization of the quantification of stress levels.	63	2007
13	Life science	50 Widespread use of technologies for long-term (semi-permanent) culturing and preservation of organs.	62	2017
14	Agriculture etc.	64 Widespread use of cross-species organ transplantation based on transgenic animals created through the introduction of genes that alleviate or prevent organ rejection as part of organ transplant treatment.	62	2015
15	Health	75 Practical use of heterogeneous organ transplantation as means of treatment.	61	2016
16	Health	14 Practical use of prevention methods for stress-induced mental disorders.	60	2011
17	Health	19 Widespread use of preventive measure for cerebral palsy.	59	2012
18	Health	27 Practical use of classification and stage determination of schizophrenia based on diagnostic imaging.	58	2013
19	Information	60 Formation of virtual communities, and realization of cultural interchange over wide areas.	58	2005
20	Environment	23 Introduction of environment tax aiming at global environmental conservation.	57	2006

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7. Intersecting technological fields

7.1 Setting the intersecting axes

We set the following axes that intersected all fields in view of current social, economic and technological conditions, selected and arranged topics related to these axes from each field, then analyzed each of their characteristics etc.

Aging countermeasures	:	(no age barriers, quality of life, support for independence)
Safety	:	(tackles natural disasters, tackles computer crime, etc.)
Environmental preservation and recycling	:	(new energy development, energy saving measures, recycling technology, etc.)
Common base technologies	:	(design technology, processing technology, handling, measuring and observation technology, etc.)

Table 7.1-1 shows the number of topics for each field intersecting axis.

Table 7.1-1 Number of topics in the four field intersecting axes

Field	Aging countermeasures	Safety	Environmental preservation and recycling	Common base technologies
Materials	2	3	11	41
Electronics	6	1	4	18
Information	12	10	4	6
Life science	13	0	10	22
Space	0	1	4	1
Marine science	2	12	20	1
Resources	0	5	48	2
Environment	0	0	39	0
Agriculture etc.	7	4	18	3
Production	10	5	15	16
Urbanization	7	24	20	1
Communication	7	12	2	9
Transportation	7	15	16	1
Health	30	1	0	4
Total	103	93	211	125

7.2 Aging countermeasures

We analyzed the 103 aging-related topics after classifying them into the following five domains.

i) Medical care technology : 13 topics (micro medical devices, dementia and aging, diagnostic and treatment technology for adult diseases)

ii) Technology to aid or substitute physical functions : 26 topics (artificial organs, supporting devices, etc.)

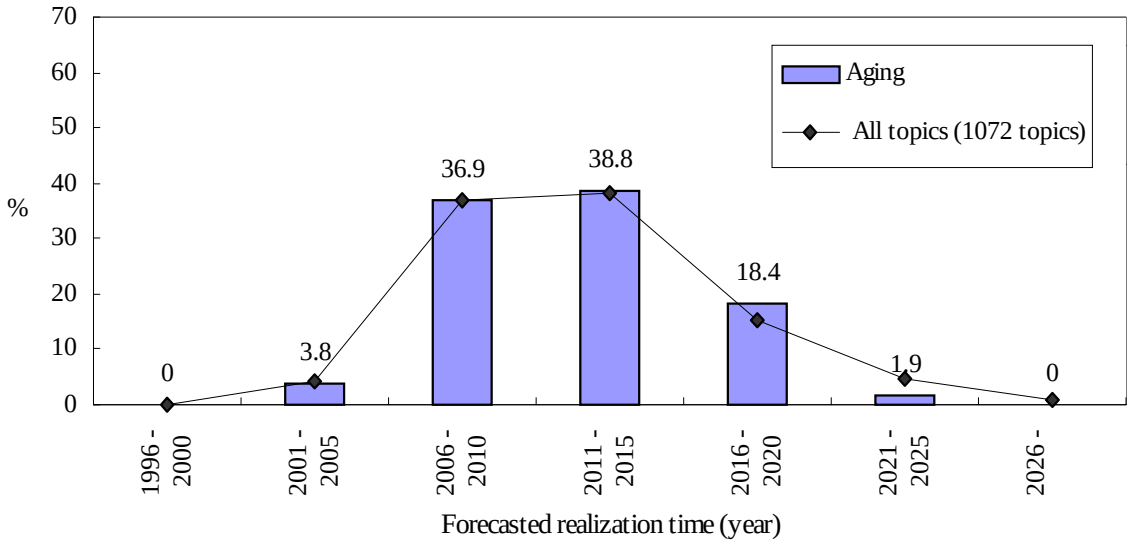
iii) Health management technology : 8 topics (disease prevention methods, health examinations)

iv) Daily life support systems technology : 26 topics (use of virtual reality technology, nursing care and housekeeping robots, etc.)

v) Social systems technology : 30 topics (use of internet, medical information systems, systems that support visually impaired people, etc.)

7.2.1 Forecasted realization time

Figure 7.2-1 shows the distribution of forecasted realization times for the 103 topics dealing with aging countermeasures. The average realization time of these topics is 2012.3 — roughly the same as the average over all 1,072 topics of 2012.6. The distribution of percentages is also virtually the same.



(Figures in the graph shows percentages for aging countermeasures)

Figure 7.2-1 Distribution of forecasted realization times (aging countermeasures)

Figure 7.2-2 shows the relationship between forecasted realization time and degree of importance index for each of the five domains. As for the medical care technology topics, the forecasted realization time is later and the degree of importance index is higher than the average of all topics, indicating that while elucidation of the causes of disease and R&D for methods of diagnosing and treating disease is important in Japan, their realization is likely to take considerable time.

On the other hand, social systems technology is earliest in the forecasted realization time and lowest in degree of importance among the five domains. This is thought to be largely because although the rapid advancement of the internet etc. over recent years means that realization will not take as long as the other domains, there are various methods of achieving the objectives and non-technical issues that have to be addressed. However, among these topics, systems that aid the employment of elderly people, such as the widespread use of production systems that support elderly people suffering from functional degeneration, are considered to have a comparatively high degree of importance.

The overall degree of importance is quite low for daily life support systems technology, although it is reasonably high, as are expectations, for the practical use of robots which provide medical care support in homes, hospitals, etc.

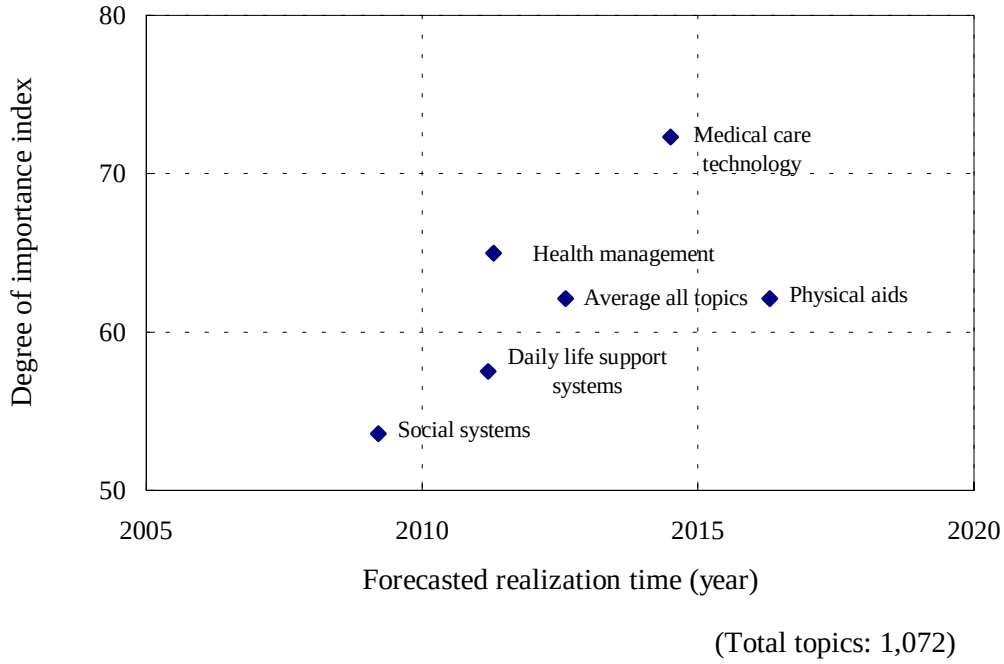


Figure 7.2-2 Cross-comparison between forecasted realization time and degree of importance (aging countermeasures)

7.2.2 Technological development outlook

Tables 7.2-1 – 7.2-3 show the forecasted realization times of topics connected with aging countermeasures with a comparatively high degree of importance. In medical care technology, treatment of dementia and elucidation of the aging mechanism will steadily be realized in the 2010s, while basic research into adult diseases will be realized between the late 2000s and early 2010s. However, new developments in the treatment of myocardial infarction is thought to be at least 20 years away.

As for technology to aid or substitute physical functions, steady developments in artificial organ technology are expected in the 2010s, and the 2020s will see the clinical application of technology enabling organs to regenerate through the multiplication of their own cells.

As for health management technology, methods of preventing of adult diseases and presbyopia, and basic research into health management will be realized between the late 2000s and late 2010s. Moreover, home health examination and diagnosis systems will be realized between the late 2000s and early 2010s, greatly improving the convenience for elderly people and others with limited mobility.

Regarding daily life support systems technology, the widespread use of virtual reality technology that enables in-home shopping and provides vicarious experiences of vacations etc. for elderly people and others with limited mobility will be realized from the late 2000s to the early 2010s. Furthermore, robots that care for elderly or disabled people and perform household chores will be steadily realized in the 2010s.

As for social systems technology, the first decade of the new century is forecasted to be a period in which systems that facilitate social communication by elderly or disabled people at home through the internet etc. will be realized and medical care information systems will be developed. It is also forecasted that systems that help elderly or disabled people to engage in work will be realized between the late 2000s and early 2010s.

Table 7.2-1 Forecasted realization times of topics connected with aging countermeasures (1)

Realization time (Year)	Medical care technology			Aid or substitute physical functions
	Micro medical devices	Dementia and aging	Adult-diseases-related	Artificial organs, supporting devices, etc
2000				
2005				
	(Health) Development of a capsule-type total gastro-intestinal tract monitoring system			
2010				(Health) Practical use of implanted bladder control devices
			(Health) Elucidation of the arteriosclerosis contraction mechanisms	
		(Health) Elucidation of the emergence mechanism of Alzheimer's disease	(Life science) Identification of the genes related to diabetes, hypertension, and arteriosclerosis	(Health) Widespread use of artificial hemoglobin as a red blood cell substitute
	(Electronics) Development of non-invasive, CT-type devices capable of recognizing, in real time, excited cerebro-neural states with a resolution on the order of 1 mm	(Health) Development of effective methods of treating Alzheimer's disease		(Life science) Development of an entirely implantable artificial kidney
	(Electronics) Practical use of micro medical devices for performing blood diagnosis and thrombus treatment			(Health) Development of fully implanted artificial hearts
2015				(Health) Practical use of fully implanted artificial pancreas
	(Life science) Development of diagnostic and medical treatment micromachines capable of traveling on their own inside organisms			(Life science) Practical use of artificial organs incorporating human cells and tissues
		(Life science) Realization of cure for Alzheimer's disease		(Health) Development of artificial liver (external devices supporting liver functions) usable on a long-term, continuous basis
				(Life science) Widespread use of technologies for long-term (semi-permanent) culturing and preservation of organs
		(Health) Elucidation of individual aging mechanisms		
			(Health) Application of a technique to induce the differentiation of fibroblasts into cardiac muscle to the treatment of myocardial infarction	(Life science) Development of an artificial cornea, allowing the visually impaired to regain their sight
				(Health) Practical use of fully implanted artificial lungs
2020				
				(Life science) Clinical application of technology enabling organs to regenerate through the multiplication of their own cells
2025				

Table 7.2-2 Forecasted realization times of topics connected with aging countermeasures (2)

Realization time (Year)	Health management technology	Daily life support systems technology	
	Disease prevention methods, health examinations	Use of virtual reality technology	Nursing care and housekeeping robots, etc.
2000			
2005	(Health) Widespread use of scientific guidelines for adult-disease-preventing life-styles (nutrition, rest and exercise)	(Information) Widespread use of in-home shopping by means of virtual shopping systems	
	(Health) Widespread use of prevention and treatment methods to ensure the retention of 20 or more teeth at 80 years of age (Health) Practical use of systems for an appropriate diagnosis at home in event of accident or diseases	(Life science) Widespread use of vicarious experience devices which allow bed-ridden patients to take vacations, etc.	
2010	(Production) Widespread use of operatorless systems enabling at-home health examination and diagnosis	(Information) Realization of the operation of information equipment through conversation between virtual operators and humans (Production) Widespread use of virtual reality life-style service communication systems for people with limited mobility	(Information) Practical use of robots which provide medical care support in homes, hospitals, etc.
	(Health) Widespread use of presbyopia prevention methods		(Health) Widespread use of robots that care for people with severe physical and mental disabilities
			(Urbanization) Widespread use in Japan of houses equipped with robots and other devices that assist senior citizens and disabled people (Production) Development of housekeeping robots that carry out household chores by learning their owners' habits
2015	(Life science) Elucidation of the mutual regulatory mechanisms of the immune system, nervous system, and endocrine system		
			(Electronics) Widespread use (one in every household) of housekeeping robots that carry out cleaning, laundry, etc.
2020			
2025			

Table 7.2-3 Forecasted realization times of topics connected with aging countermeasures (3)

Realization time (Year)	Social systems technology		
	Use of internet	Medical information systems	Workplace support systems
2000			
	(Information) Realization of applications, registrations, and other official public procedures and services over networks		
2005	(Information) Formation of virtual communities, and realization of cultural interchange over wide areas		
		(Health) Practical use of an ID card system that covers an individual's health conditions and medical data (Communication) Widespread use of systems for transmitting images etc. between ambulance and hospital for emergency medical care (Transportation) Practical use of systems for guiding visually impaired people at stations etc.	
2005			(Agriculture etc.) Practical use of labor-saving grazing techniques using computers etc. (Transportation) Widespread use of systems that facilitate the automation and mechanization of the inspection/construction of railway vehicles, railroad tracks, etc. (Production) Widespread use of telecommuting via multimedia information exchange tools based on the internet
	(Information) Realization of in-home electronic voting in elections	(Urbanization) Widespread use in Japan of systems for guiding visually impaired people on footpaths using magnetic sensors etc.	(Production) Practical use of keyboardless input devices in computerized office/distribution systems
2010			(Urbanization) Widespread use at Japanese urban public facilities of information systems which can be used by senior citizens and disabled people;
	(Communication) Widespread use of electronic secret ballots through the realization of high-security communication		
			(Production) Widespread use of production systems that provide comprehensive support for senior citizens and people with disabilities (Agriculture etc.) Widespread use of super labor-saving fishing boats designed to automate searching for shoals of fish, dragging and lifting nets, etc.
2015			(Transportation) Widespread use of guidance and control systems that enable the automatic operation of motor vehicles on expressways etc.;
			(Information) Widespread use of automobiles which drive automatically
2020			
2025			

7.2.3 Current leading countries etc.

Figure 7.2-3 is a breakdown of Japanese expert's selections of the leading countries in the various fields. As can be seen in the figure, overall the USA is ranked highest, followed by Japan and the EU. The USA is ranked especially high in topics connected with medical care with a considerable gap between it and Japan and the EU in topics concerning arteriosclerosis and other adult diseases and Alzheimer's disease.

Japan is placed relatively high in technology connected with systems that help people in their daily lives. For example, experts in the communication or information field have a high regard for Japan in the conversion of text into voice and vice versa. Japanese experts also give Japan a fairly high mark in household robots and medical or nursing care robots.

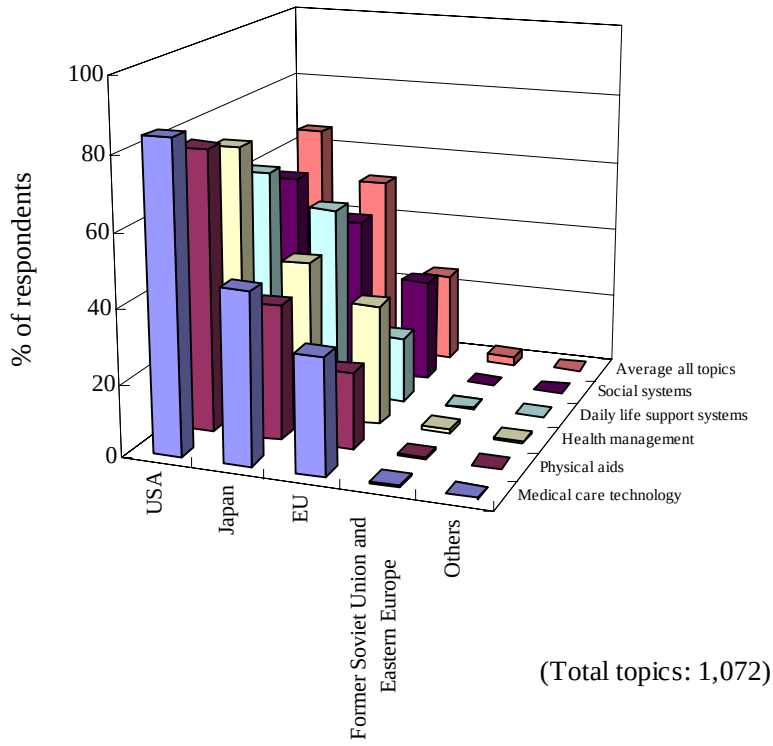


Figure 7.2-3 Leading countries etc. (aging countermeasures)

7.2.4 Effective measures the government should adopt

Figure 7.2-4 shows overall trends for government measures, with the highest being "foster human resources," followed by "increase government research funding" and "promote exchanges among industrial, academic and government sectors and different fields." Highest expectations of the government in "foster human resources" are in medical care technology and technology to aid or substitute physical functions, and especially Alzheimer's disease and arteriosclerosis topics and topics connected with artificial organs and supporting devices, such as implanted bladder control devices. Although "adjust regulations (relax/toughen)" is, overall, quite low, it is relatively high in social systems technology, and in particular, respondents want the government to review regulations on electronic voting and official public procedures and services over networks.

As for "increase government research funding," most focus is on topics connected with support in the daily and social lives of elderly people and others with limited mobility, such as systems for guiding visually impaired people, intelligent wheelchairs, and health or nursing care robots. As for "promote exchanges among industrial, academic and government sectors and different fields," topics connected with farming support for elderly people, such as multi-purpose agricultural robots, feed formulation systems and other fully automated systems are considered to be effective.

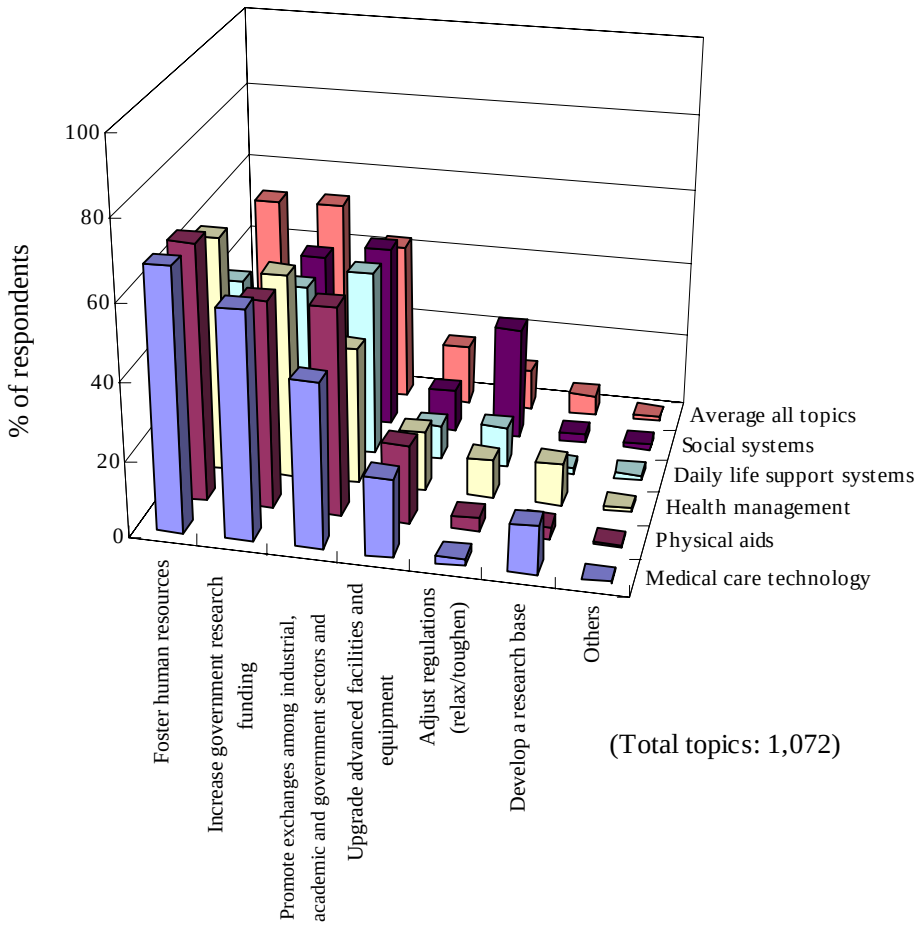


Figure 7.2-4 Measures the government should adopt (aging countermeasures)

(Reference) The following table shows a breakdown by field of the 103 aging-related topics

Table 7.2-4 Number of topics by field (aging countermeasures)

Field	Aging countermeasures					
	i) Medical care technology	ii) Physical aids	iii) Health management	iv) Daily life support systems	v) Social systems	Total
Materials	0	2	0	0	0	2
Electronics	4	1	0	1	0	6
Information	0	0	0	8	4	12
Life science	3	7	2	1	0	13
Space	0	0	0	0	0	0
Marine science	0	0	0	0	2	2
Resources	0	0	0	0	0	0
Environment	0	0	0	0	0	0
Agriculture etc.	0	0	0	4	3	7
Production	0	0	0	2	5	7
Urbanization	0	0	1	4	5	10
Communication	0	0	0	4	3	7
Transportation	0	0	0	1	6	7
Health	6	16	5	1	2	30
Total	13	26	8	26	30	103

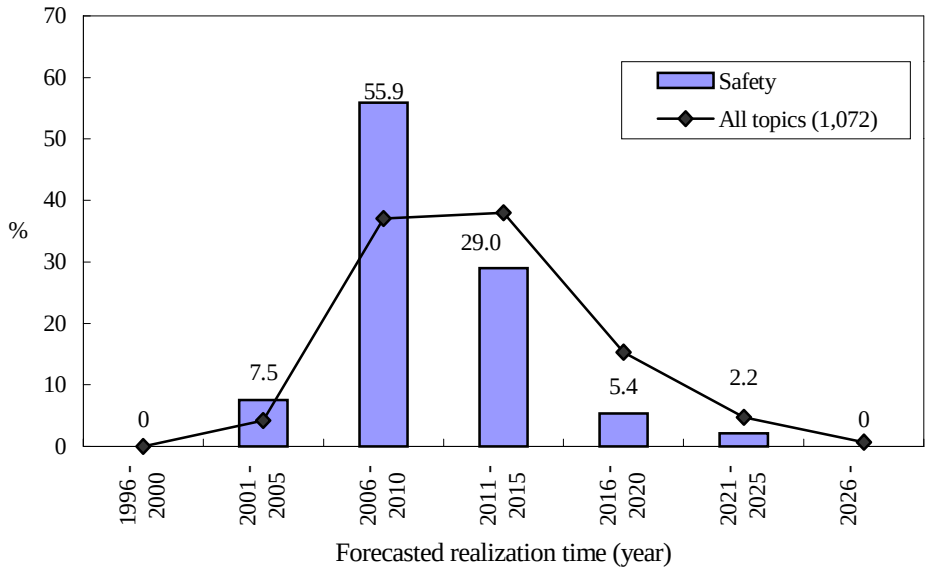
7.3 Safety

We analyzed 93 safety-related topics classified into the following five domains.

i)	Natural disaster research	:	20 topics (research into earthquake prediction, research into volcanic eruptions, etc.)
ii)	Natural disaster countermeasures	:	30 topics (improving the earthquake resistance of buildings and material, disaster prevention systems, search and rescue robots, etc.)
iii)	Information and communication security	:	16 topics (network technology, etc.)
iv)	Labor and transportation safety	:	21 topics (traffic accident prevention measures, workplace automation, etc.)
v)	General life safety	:	6 topics (safety at medical facilities, food safety, etc.)

7.3.1 Forecasted realization time

Figure 7.3-1 shows the distribution of forecasted realization times for the 93 topics dealing with safety. The average realization time of these topics is 2010.4, or about two years earlier than the average over all 1,072 topics of 2012.6. More than half of the topics are expected to be realized in the five years between 2006 and 2010.



(Figures in the graph shows percentages for safety)

Figure 7.3-1 Distribution of forecasted realization times (safety)

Figure 7.3-2 shows the relationship between forecasted realization time and degree of importance index for each of the five domains. As for natural disaster research, the forecasted realization time is relatively late, and about three years later than that for natural disaster countermeasures. The degree of importance is relatively high, indicating that while research into earthquake prediction is considered very important to Japan, its realization is going to be quite difficult indeed.

On the other hand, realization times for safety in our general life and information and communication security are about four years earlier than the average for all topics. We can probably put this down to the reasonably promising outlook in these domains due to the advancement of information networks technology, and especially the internet, over recent years.

Looking at degree of importance by topic, we can see that over half of the top 20 topics are earthquake-related, while many of the others are connected with countermeasures aimed at ensuring the security of information networks.

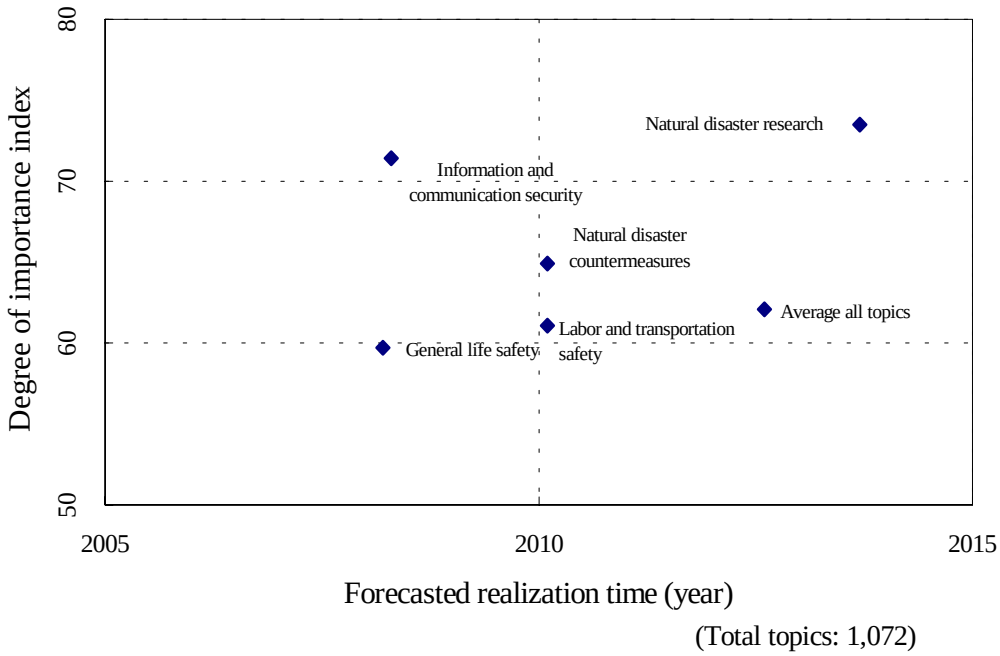


Figure 7.3-2 Cross-comparison between forecasted realization time and degree of importance (safety)

7.3.2 Technological development outlook

Table 7.3-1 and 7.3-2 show the forecasted realization times of topics connected with safety with a comparatively high degree of importance. In natural disaster research, progress is expected in the development of nationwide information transmission systems facilitating tsunami forecasting using satellites, greater accuracy in earthquake observation technology, and earthquake prediction between the late 2000s and early 2010s. On the other hand, technology for forecasting earthquakes of magnitude 7 or larger in the medium to short-term is unlikely to be realized until the late 2010s to early 2020s, while progress is expected to be seen in research into volcanic eruption during the 2010s.

As for natural disaster countermeasures, improving the earthquake resistance of building structures is expected to be realized in the 2000s, while advances are expected in technology for measuring the life of building material late in the first decade of the new century. On the other hand, realization of material that is able to repair itself is not expected until much later in the 2010s and 2020s. Various disaster prevention systems will be realized between the late 2000s and early 2010s, while the period from the late 2000s to the 2010s will see the realization of robots that can rescue victims of disasters.

Regarding information and communication security, topics dealing with the internet and other advanced information networks, for example, the development of technology for drawing up contracts over a network or producing vaccines automatically, are expected to be realized in the 2000s, whereas, electronic voting is not expected to appear until the 2010s, largely because this will require a far-reaching review of social systems.

In labor and transportation safety, the prevention of traffic accidents is likely to be enhanced with the steady realization of driving simulators in the early 2000s and automobiles that drive automatically in the late 2010s. And between the late 2000s and early 2010s we will see the automation of the workplace so that workers are not placed at risk doing dangerous work.

As for safety in our general lives, in the 2000s large numbers of people will carry around ID cards that contain personal medical information. Furthermore, technology to improve food safety will be realized from the late 2000s to the early 2010s.

Table 7.3-1 Forecasted realization times of topics connected with safety (1)

Realization time (Year)	Natural disaster research		Natural disaster countermeasures	
	Earthquake prediction research	Research into volcanic eruptions, etc.	Buildings and material	Disaster prevention systems, search and rescue robots
2000			(Urbanization) Practical use in Japan of techniques to rationally enhance earthquake resistance (Urbanization) Practical use in Japan of a technology to control and absorb vibrations in massive structures	
2005	(Marine science) Practical use of tsunami forecasting systems through satellites			(Information) Widespread use of security systems that provide emergency information at the time of a disaster (Urbanization) Widespread use in Japan of monitoring and control systems for enhancing the safety of essential services in a disaster (Urbanization) Widespread use in Japan of warning systems etc. based on localized weather forecasts
	(Space) Realization of precision down to less than a centimeter in measurement of crust movement using VLBI, satellites, etc.	(Marine science) Widespread use in Japan of observation systems for predicting downbursts at airports immediately before their occurrence	(Transportation) Practical use of a technology to automatically monitor bridges for fatigue	(Urbanization) Development of disaster forecasting and information transmission systems to prevent panic during an earthquake (Production) Widespread use of earthquake damage alleviation systems for industrial complexes etc. based on the early operation of safety devices in response to initial mild tremors
2010		(Marine science) Practical use of technology for predicting and forecasting landslides and rockslides caused by intense rainfall in certain locations in Japan	(Materials) Development of technologies for estimating remaining life of metallic materials structures and components depending on service conditions by non-destructive means	(Urbanization) Widespread use in Japan of robots in search and rescue operations at fires
	(Marine science) Nationwide installation of bore-hole-type observation equipment for use in earthquake forecasting			(Communication) Practical use of integrated building management systems linked to an earthquake detection system
2015		(Marine science) Realization of technology for forecasting the outbreak and scale of pyroclastic flows accompanying volcanic eruption (Marine science) Realization of time-series observation of the condition	(Urbanization) Development of intelligent construction materials with self-diagnostic functions etc.	(Information) Practical use of robots capable of recognizing, finding, and rescuing humans involved in a disaster

Realization time (Year)	Natural disaster research		Natural disaster countermeasures	
	Earthquake prediction research	Research into volcanic eruptions, etc.	Buildings and material	Disaster prevention systems, search and rescue robots
		of magma inside volcanoes		
		(Marine science) Elucidation of the series of processes involved in the generation, rise, etc. of magma		
	(Urbanization) Practical use in Japan of mid-term prediction techniques for large-scale (magnitude 8 or above) earthquakes			
2020		(Marine science) Development of technology to alleviate dangerously heavy rainfall through the application of nephology		
			(Transportation) Widespread use of road structures using smart materials with self-repairing functions etc.	
	(Marine science) Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance			
2025				

Table 7.3-2 Forecasted realization times of topics connected with safety (2)

Realization time (Year)	Information and communication security	Labor and transportation safety	General life safety
	Network technology etc.	Transport countermeasures, workplace automation, etc.	Safety at medical facilities, food safety, etc.
2000		(Transportation) Practical use of driving simulators that give a realistic experience of driving under extreme conditions and being involved in a traffic accident	
	(Communication) Practical use of a highly secure next-generation internet that allows the transmission of real-time information (Information) Verification of a counterpart to a contract concluded over a network with the use of database systems		
2005	(Information) Practical use of face, voice, and other personal recognition technology in the area of security management	(Transportation) Practical use of systems that can detect obstacles on railway tracks and brake the train automatically	
		(Transportation) Practical use of systems for guiding visually impaired people at stations etc.	(Health) Practical use of an ID card system that covers an individual's health conditions and medical data (Communication) Widespread use of systems for transmitting images etc. between ambulance and hospital for emergency medical care
	(Information) Widespread use of highly reliable network systems capable of protecting privacy and secrecy		(Agriculture etc.) Widespread use of a technology for full food sterilization at 3,000 atmospheres in a continuous process
	(Communication) Practical use of a technology that ensures a crash-proof communication network	(Transportation) Widespread use of systems that facilitate the automation and mechanization of the inspection/construction of railway vehicles, railroad tracks, etc.	(Agriculture etc.) Development of household food testing devices capable of instantaneously determining food freshness and micro-organic contamination levels
	(Communication) Widespread use of security technology that monitors illicit activities involving information and communication ethics (Information) Development of technology capable of automatically detecting harmful viruses and automatically producing vaccines	(Urbanization) Widespread use in Japan of systems for guiding visually impaired people on footpaths using magnetic sensors	(Information) Practical use of automatic security surveillance systems using robots
	(Information) Realization of in-home electronic voting in elections	(Transportation) Practical use of a fully automatic aircraft takeoff, landing and taxiing system	
2010		(Production) Widespread use of safety measures at industrial complexes etc. that are in line with their size and functionality based on potential danger assessment	
		(Production) Widespread use of robots for work in hazardous or extreme conditions to ensure worker safety	(Agriculture etc.) Widespread use of allergy-free livestock product manufacturing techniques
	(Communication) Widespread use of electronic secret ballots through the realization of high-security communication		
2015		(Transportation) Widespread use of guidance and control systems that enable the automatic operation of motor vehicles on expressways etc.; (Information) Widespread use of automobiles which drive automatically	
2020			
2025			

7.3.3 Current leading countries etc.

Figure 7.3-3 is a breakdown of Japanese expert's selections of the leading countries in the various fields, and as shown in the figure, in both natural disaster domains and labor and transportation safety, the experts place Japan at the top, followed by USA and EU, while in information and communication security and general life safety, USA is ranked first followed by Japan and EU.

As for individual topics, many experts rank Japan top in earthquake prediction research and strengthening the earthquake resistance of buildings and structures, while many put the USA on top in the internet-related topics, especially the practical use of the next-generation internet and measures to combat hackers and viruses. Among the topics in which the EU is ranked high are those connected with systems for guiding visually impaired people at stations and other public facilities.

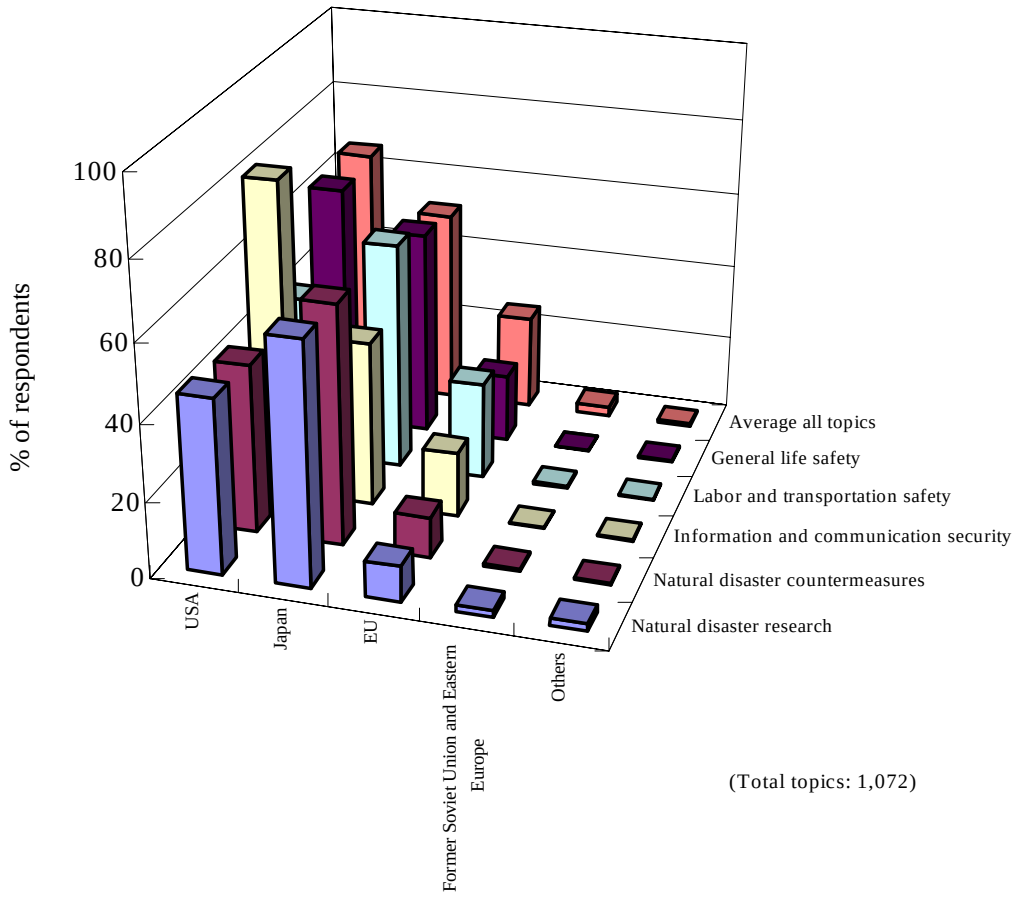


Figure 7.3-3 Leading countries etc. (safety)

7.3.4 Effective measures the government should adopt

Figure 7.3-4 shows overall trends for government measures, with the highest being "increase government research funding," followed by "promote exchanges among industrial, academic and government sectors and different fields" and "foster human resources."

Respondents expect more funding from the government in topics connected with earthquake prediction research and earthquake disaster countermeasures, while more effort by the government at promoting exchanges is wanted in topics dealing with food safety and fire-fighting robots and intelligent robots for construction sites. A relatively high percentage of respondents believe more government effort is required for fostering human resources in research on earthquake prediction and volcanic eruption and magma observation.

In information and communication security, "adjust regulations (relax/toughen)" is ranked relatively high, indicating that respondents expect the government to give greater regulatory consideration to improving the security of information networks.

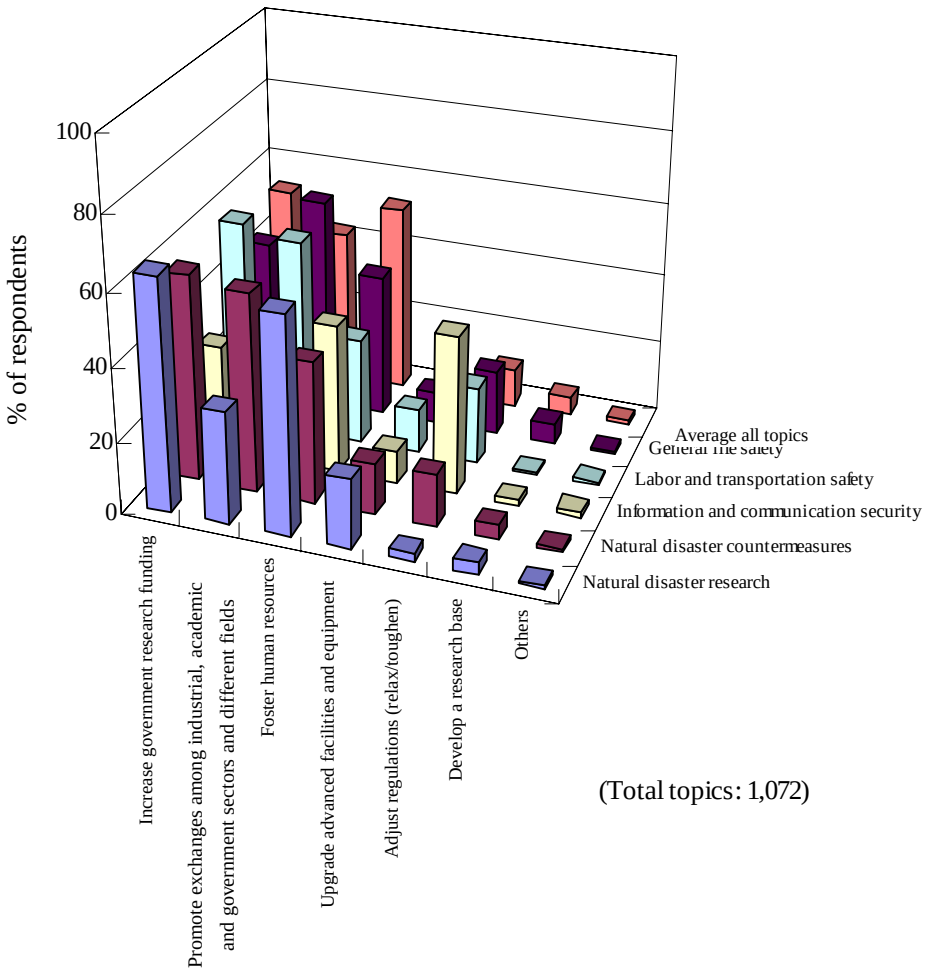


Figure 7.3-4 Measures the government should adopt (safety)

(Reference) The following table shows a breakdown by field of safety-related topics

Table 7.3-3 Number of topics by field (safety)

Field	Safety					
	i) Natural disaster research	ii) Natural disaster countermeasures	iii) Information and communication security	iv) Labor and transportation safety	v) General life safety	Total
Materials	0	3	0	0	0	3
Electronics	0	0	1	0	0	1
Information	1	2	5	1	1	10
Life science	0	0	0	0	0	0
Space	1	0	0	0	0	1
Marine science	12	0	0	0	0	12
Resources	1	3	0	1	0	5
Environment	0	0	0	0	0	0
Agriculture etc.	1	0	0	0	3	4
Production	0	1	0	4	0	5
Urbanization	3	16	1	4	0	24
Communication	0	2	9	0	1	12
Transportation	1	3	0	11	0	15
Health	0	0	0	0	1	1
Total	20	30	16	21	6	93

7.4 Environmental preservation etc.

We analyzed 211 topics dealing with environmental preservation and recycling, classified into the following three domains.

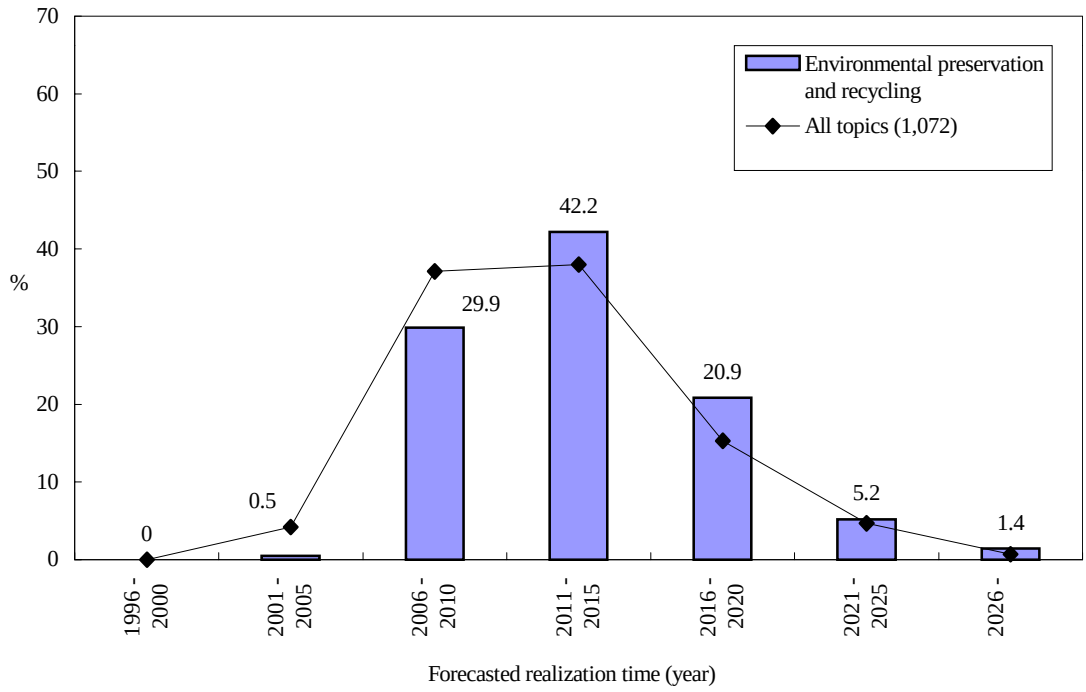
i) Global environment : 57 topics (protection of the ozone layer, controlling CO_2 emissions, agriculture, forestry and fisheries countermeasures, etc.)

ii) Regional environment : 81 topics (recycling technology, vehicle-related environmental countermeasures, biodegradable plastics, etc.)

iii) New energy and energy saving : 73 topics (solar cells, alternative energy, energy saving measures, etc.)

7.4.1 Forecasted realization time

Figure 7.4-1 shows the distribution of forecasted realization times for the 211 topics dealing with environmental preservation and recycling. The average realization time of these topics is 2013.6, or one year later than the average over all 1,072 topics of 2012.6.



(Figures in the graph shows percentages for environmental preservation and recycling

Figure 7.4-1 Distribution of forecasted realization times (environmental preservation and recycling)

Figure 7.4-2 shows the relationship between forecasted realization time and degree of importance index for each of the three domains. The overall degree of importance is higher than the average of all 1,072 topics, reflecting the considerable importance with which environmental preservation and recycling is generally regarded.

Regional environment has the highest importance index of the three domains, and on average, its realization will be earlier than the other two domains. Conversely, new energy and energy saving is considered to be not as important, and requires much more time for realization.

By topic, those connected with the widespread use of non-fossil energy and practical use of solar cells are ranked highly important, and while plastic recycling and acceptance of LCA-style product design concepts are expected to be realized relatively early, topics connected with the widespread use of non-fossil energy for various purposes, use of superconductors in energy, and also nuclear power are not expected to be realized until much later.

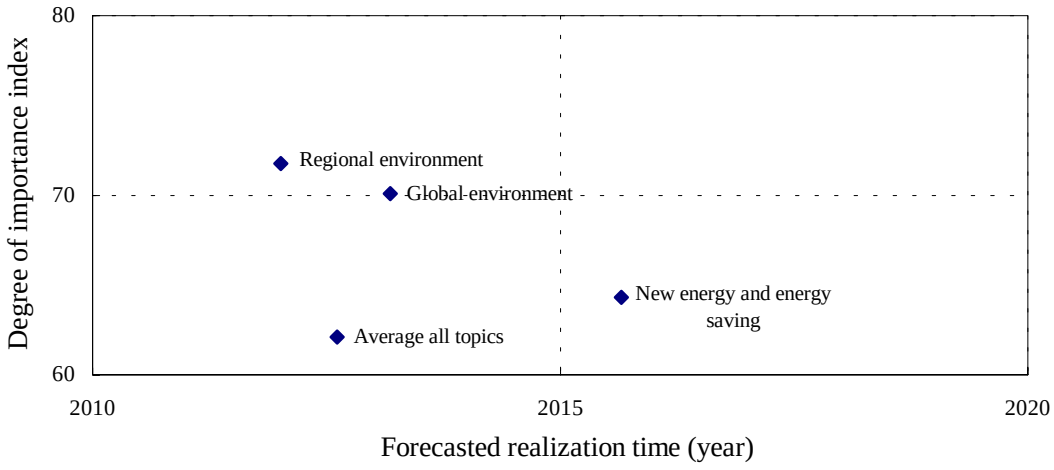


Figure 7.4-2 Cross-comparison between forecasted realization time and degree of importance (environmental preservation and recycling)

7.4.2 Technological development outlook

Tables 7.4-1–7.4-3 show the forecasted realization times of environmental preservation and recycling topics with a comparatively high degree of importance. In the global environment, progress is expected in R&D into ozone layer protection, such as the practical use of fluorocarbon substitutes, between 2006 and 2010. As for control of CO_2 emissions, 2000–2010 is expected to see the introduction of an environment tax, the 2010s will see progress in the development of plants with a high CO_2 fixing capability, while the early half of the 2020s should witness a reduction of global CO_2 emissions to 20% below the 1990 level according to the experts. Desert afforestation technology is expected to be well on the road to realization in the 2010s, while in the agriculture, forestry and fisheries area, industries that are closely linked to the environment, elucidation of the acid rain mechanism, development of numerical models for analyzing climatic change, and advanced forest management technology are also expected to be realized successively in the 2010s.

In the regional environment, progress is expected in recycling technology from the late 2000s to late 2010s. Advances will be made in the recycling of plastics, and auto parts and materials between 2006 and 2010, and the widespread use of recycling systems for almost all materials used will take place in the early 2010s. Regarding vehicle-related environmental countermeasures, reductions in heavy-duty freight truck exhaust gases will be achieved in the period 2006–2010, and in the early 2010s we will see the first practical electric cars on our streets. A few years later in the late 2010s, we will begin to see the widespread use of hydrogen cars. As for plastics, in the late 2000s, biodegradable plastics are expected to account for 10% of all plastics used.

In new energy and energy saving, the scope of solar cell use will extend to portable computers and road and tunnel lighting in the late 2000s, and in the first half of the 2010s we will be using solar cells that provide power at less than 100 yen/watt. Therefore these and other technologies that will facilitate our shift in energy dependence from fossil fuels to alternative sources of energy will steadily be realized from the late 2000s to the early 2020s. Meanwhile, the tangible application of superconductors in the energy area is expected after the 2010s. As for energy saving technology, significant improvements in automobile fuel efficiency, energy-efficient houses and the like are expected to be realized from the late 2000s to the early 2010s.

Table 7.4-1 Forecasted realization times of topics connected with environmental preservation and recycling (1)

Realization time (Year)	Global environment			
	Ozone layer protection	CO_2 reduction	Desert afforestation	Agriculture, forestry and fisheries countermeasures
2000				
2005	(Environment) Practical use of fluorocarbon and halon substitutes that do not damage the ozone layer and cause global warming (Environment) Quantitative elucidation of effect of fluorocarbon and the like on change in the ozone layer (Marine science) Elucidation of the mechanisms of ozone layer formation, variation and extinction	(Environment) Introduction of an environment tax aiming at global environmental conservation		(Environment) Elucidation of the mechanism of the impact caused by acid rain to animals and plants
2010	(Environment) Elucidation of the impact on humans, plants and animals of increased UV radiation due to depletion of the ozone layer	(Environment) Elucidation of the precise mechanism of carbon dioxide generation and absorption (Life science) Production of genetically engineered plants with high CO_2 fixing ability	(Environment) Elucidation of the effect of desertification on climate and weather (Environment) Development of plants that are resistant to arid and saline conditions through biotechnology with the aim of desert afforestation	(Environment) Elucidation of the worldwide long-distance migration mechanisms of acid-rain-causing substances (Environment) General understanding of the impact of global warming on world agricultural production (Marine science) Development of a numerical model of the correlation between climatic changes and changes in marine living resources (Marine science) Elucidation of the impact on the ecosystem from ocean development through the establishment of a numerical model
2015		(Environment) Practical use of carbon dioxide fixing technologies using marine organisms such as microscopic algae	(Agriculture etc.) Development of new plants and cultivation systems which enable those plants to grow in regions with very limited rainfall	

Realization time (Year)	Global environment			
	Ozone layer protection	CO_2 reduction	Desert afforestation	Agriculture, forestry and fisheries countermeasures
		(Marine science) Elucidation of the entire aspect of the movement and storage of carbon dioxide	(Materials) Widespread use of desert afforestation technology through the advancement of water retention technology and biotechnology	Agriculture etc.) Development of a forest management method that realizes the advanced use of forests, while maintaining sustainable forest operation, on a global scale
		(Materials) Practical use of carbon dioxide fixation technology necessary for protecting the global environment (Life science) Practical use of technology for the biological fixation of highly concentrated carbon dioxide at thermal power plants		(Agriculture etc.) Development of fishery production systems based on predictions of long term (10 to 20 years) changes major fishery resources;
2020		(Production) Widespread use of global environmental conservation measures throughout the world based on carbon dioxide recovery technology (Environment) Reduction of global carbon dioxide emissions to 20% below the 1990 level		(Agriculture etc.) Practical use of a management technique for fishery resources that migrate over great distances
2025				

Table 7.4-2 Forecasted realization times of topics connected with environmental preservation and recycling (2)

Realization time (Year)	Regional environment			
	Recycling technology etc.	Vehicle-related environmental countermeasures	Biodegradable plastics	Environmental preservation in bays etc.
2000				
2005			(Agriculture etc.) Widespread use of biodegradable containers and wrapping materials that use bio-oriented materials	
	(Materials) Practical use of plastic recycling technology	(Environment) Widespread use of NOx emission control technologies in virtually all types of automobiles		
	(Environment) Wide acceptance of LCA-style product design concepts that facilitate recycling and reuse			
	(Resources) Practical use of economical methods for separating and recycling valuable substances in urban garbage		(Environment) Widespread use of biodegradable plastics that can be fully decomposed by anaerobic microorganisms	(Marine science) Development of a model for predicting the occurrence of Red Tides
	(Transportation) Realization of a 90% recyclability for motor vehicle parts and material		(Materials) Biodegradable plastics will account for 10% of all plastics	
2010		(Transportation) Practical use of technologies to reduce the harmful components of truck exhausts to 1/10 of present levels		(Environment) Widespread use of formulation methods for water environment plans based on a quantitative understanding of natural purification functions
				(Environment) Realization of technology to predict and forecast the impact of water pollution on ecosystems in closed water bodies
	(Resources) Practical use of technologies capable of separating useful metals from scrap cars etc. to a purity level of more than 99%	(Transportation) Widespread use of electric vehicles that can run for more than 200 Km after rapid battery recharging		
	(Production) Widespread use of designing, producing, collecting and recycling systems which make it possible to recycle most used materials			
		(Resources) Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars	(Life science) Widespread use of bioplastic production so it accounts for 10% of total worldwide plastic production	(Marine science) Widespread use of technologies for the comprehensive use and conservation of entire bays that are subject to intensive use
		(Environment) Widespread use of nonpolluting automobiles (e.g., electric vehicles) so they account for at least 10% of all		

Realization time (Year)	Regional environment			
	Recycling technology etc.	Vehicle-related environmental countermeasures	Biodegradable plastics	Environmental preservation in bays etc.
		vehicles in the world		
2015	(Agriculture etc.) Halving new tree requirements by extending the service life of wood resources and improving their recycling rate	(Transportation) Widespread use of electric vehicles carrying fuel cells which have high energy conversion efficiencies.		
2020	(Production) Widespread use of low entropy-generating eco-factories, which give due consideration to the impact on ecosystem	(Materials) Production of automobiles powered by hydrogen fuel stored in hydrogen-occlusive alloys exceeds 10% of the total automobile production (Resources) Widespread use of hydrogen cars		(Resources) Improvement in the water quality of closed water areas such as Tokyo Bay so that people can safely swim there (Agriculture etc.) Practical use of a system of removing almost the entire pollution load caused by environmental degradation on closed water bodies
2025				

Table 7.4-3 Forecasted realization times of topics connected with environmental preservation and recycling (3)

Realization time (Year)	New energy and energy saving			
	Ozone layer protection	Alternative energy	Superconductor use and nuclear energy	Energy saving technology
2000				
2005	(Information) Practical use of portable computers powered primarily by solar cells	(Environment) Widespread use of power generation using refuse derived fuel (RDF)		
				(Transportation) Widespread use of motor vehicles with fuel efficiencies 30% greater than current vehicles
	(Urbanization) Widespread use in Japan of photovoltaic power generation systems designed for road and tunnel lighting	(Marine science) Practical use of breakwaters capable of utilizing wave energy to generate electricity		(Urbanization) Practical use in Japan of a highly efficient heating and cooling system through a combination of solar energy and super heat pumps
2010	(Electronics) Development of solar cells capable of maintaining 15% efficiency for at least 10 years without light convergence (Materials) Practical use of large-area amorphous silicon solar cells with a conversion efficiency of more than 20%			(Agriculture etc.) Practical use of technologies for manufacturing paper and pulp by using the enzyme of wood decaying fungi
	(Electronics) Practical use of solar cells which make the cost of power generation facilities less than 100 yen/watt			(Information) Widespread use of low-energy personal computers capable of running for one year on a single button-type battery (Resources) Widespread use of energy-efficient houses that consume less than half the power for air conditioning that present houses consume
		(Resources) Development of technology that requires fossil fuel consumption less than half of the present level		
2015		(Life science) Widespread use of fuel oil production technology using microorganisms etc. so it accounts for 10% of total worldwide fuel oil production		(Resources) Practical use of aluminum reduction methods that do not use electrolysis
	(Materials) Practical use of multi-layer solar cells with a conversion efficiency of more than 50% (Resources) Practical use of 100 MW photovoltaic power generation system in desert areas		(Production) Practical use of room temperature superconductors in industrial products (Production) Practical use of technologies that enable the direct storage of electricity	
		(Materials) Practical use of processes for water decomposition by the sunlight		

Realization time (Year)	New energy and energy saving			
	Ozone layer protection	Alternative energy	Superconductor use and nuclear energy	Energy saving technology
2020		(Production) Widespread use of non-fossil energy in all areas of life including household, industry and transportation		
		(Production) Practical use of technologies for mass-producing hydrogen from organic substances through application of solar energy and biological systems		
2025			(Resources) Widespread use in industry of generators and other power equipment that use high-temperature superconductivity (Resources) Development of high-safety small to medium-scale nuclear reactors designed for cogeneration of heat and power (Resources) Practical use of fast breeder reactor systems including nuclear fuel cycle	

7.4.3 Current leading countries etc.

Figure 7.4-3 is a breakdown of Japanese expert's selections of the leading countries in the various fields, and as shown in the figure, in the global environment, USA is placed highest followed by Japan and the EU, while in the regional environment and new energy and energy saving, Japan is placed highest, followed by USA and EU.

The USA is ranked quite high in topics connected with environmental monitoring at the global level, while in the regional environment and new energy and energy saving, many experts consider Japan to be a world leader in topics connected with vehicle-related environmental controls and solar cells.

Overall, the USA average for environmental preservation and recycling topics is about 15 points below its all-topics average (1,072 topics), Japan's average is about the same as its all-topics average, while the EU is about 10 points above.

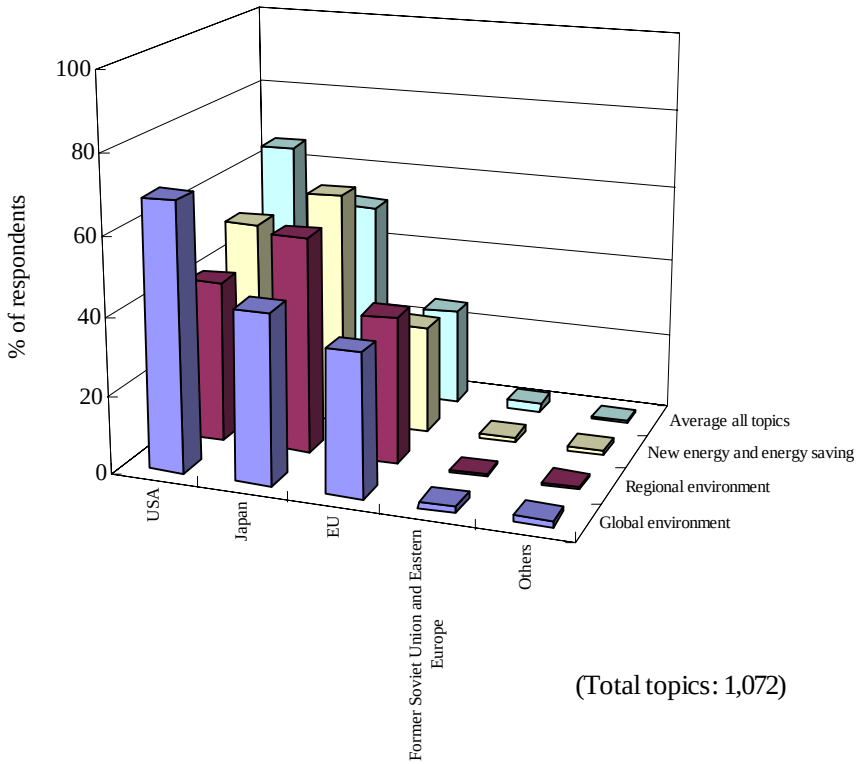


Figure 7.4-3 Leading countries etc. (environmental preservation and recycling)

7.4.4 Effective measures the government should adopt

Figure 7.4-4 shows overall trends for government measures, and like the average for all topics, "increase government research funding" is at the top, followed by "foster human resources" and "promote exchanges among industrial, academic and government sectors and different fields" with roughly the same percentages.

"Adjust regulations (relax/toughen)" is relatively high in regional environment topics such as those connected with preserving resources through controls on vehicle exhaust gas emissions and noise and the paperless office, and also the realization of a recycling society.

Many of the topics with a pressing need for the government to foster human resources are connected with forests, including technologies for the management of forest ecosystems and the organisms living there, the relationship between the destruction of tropical forests and the weather and climate, and the development of forest management techniques.

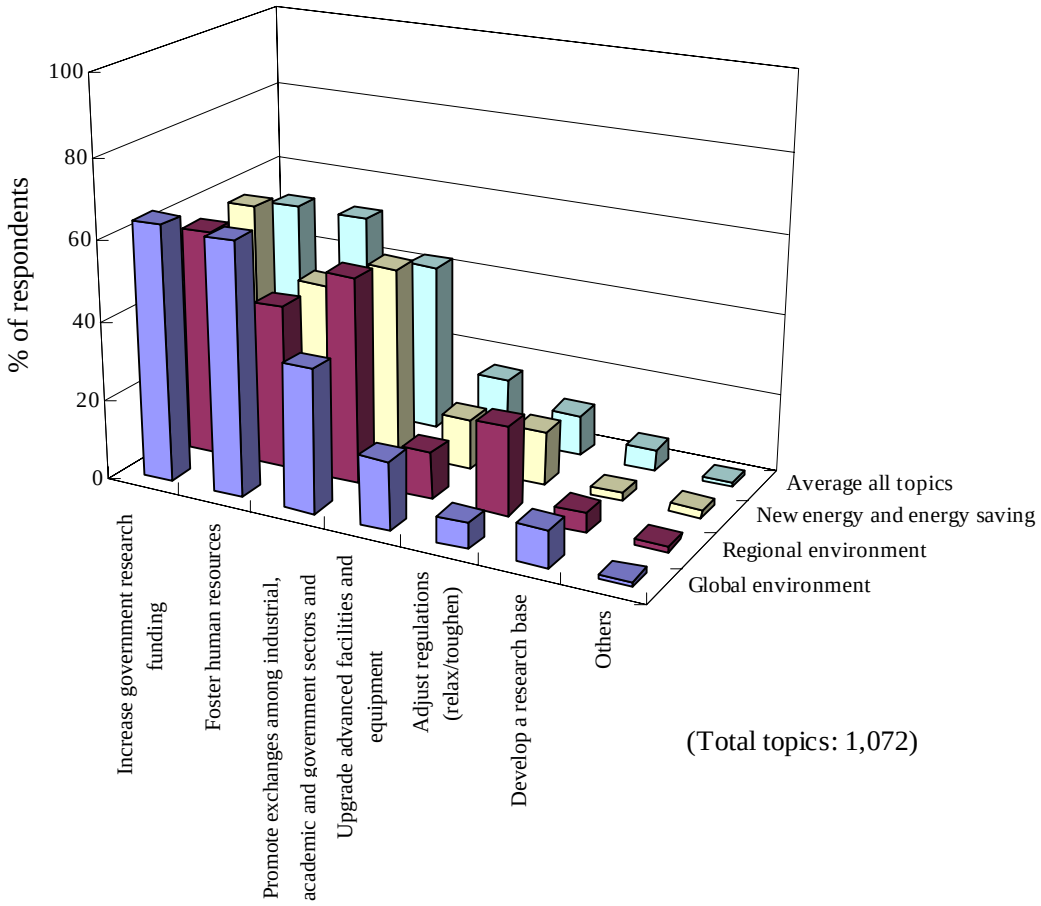


Figure 7.4-4 Measures the government should adopt (environmental preservation and recycling)

(Reference) The following table shows a breakdown by field of topics related to environmental preservation and recycling

Table 7.4-4 Number of topics by field (environmental preservation and recycling)

Field	Environmental preservation and recycling			
	i) Global environment	ii) Regional environment	iii) New energy and energy saving	Total
Materials	2	4	5	11
Electronics	0	0	4	4
Information	1	1	2	4
Life science	6	1	3	10
Space	4	0	0	4
Marine science	11	7	2	20
Resources	0	11	37	48
Environment	23	15	1	39
Agriculture etc.	6	11	1	18
Production	2	5	8	15
Urbanization	1	13	6	20
Communication	1	1	0	2
Transportation	0	12	4	16
Health	0	0	0	0
Total	57	81	73	211

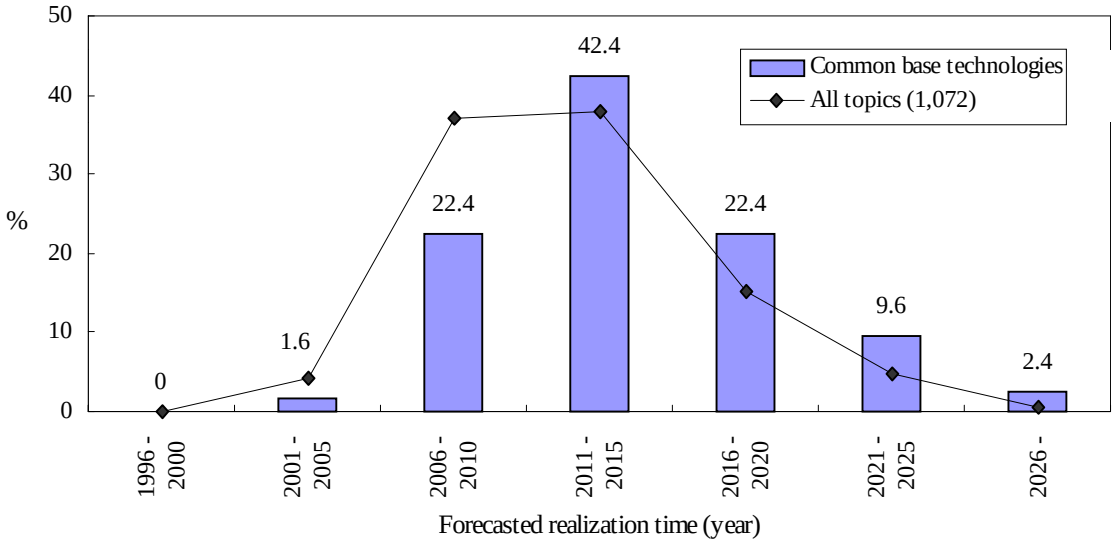
7.5 Common base technologies

We analyzed 125 topics dealing with common basic technologies, classified into the following five domains.

i)	Materials base	:	30 topics (superconductors, microscopic structures, simulation technology, new processes, etc.)
ii)	Medical care and biotechnology base	:	28 topics (medical engineering, gene-related, cancer-related, brain functions and nerve systems, etc.)
iii)	Energy base	:	11 topics (secondary batteries, superconductor use in energy, use of biological functions, etc.)
iv)	Measuring and processing base	:	26 topics (high-precision measuring, superprecision processing, etc.)
v)	Computer/electronics base	:	30 topics (Network communication, system software, etc.)

7.5.1 Forecasted realization time

Figure 7.5-1 shows the distribution of forecasted realization times for the 125 topics dealing with common base technologies. The average realization time of these topics is 2014.7, or about two years later than the average over all 1,072 topics of 2012.6, indicating a belief among respondents that technologies which can form a base for various scientific and technological developments will, for the most part, take quite some time to be realized.



(Figures in the graph shows percentages for common base technologies)

Figure 7.5-1 Distribution of forecasted realization times (common base technologies)

Figure 7.5-2 shows the relationship between forecasted realization time and degree of importance index for each of the five domains. The overall forecasted realization time is later than average, and although the degree of importance of the energy base is high, its forecasted realization time is also later than the average, in this case by at least four years.

In both the medical care and biological base and the computer/electronics base, many topics have a high degree of importance and also will require considerable time before they can be realized.

Topics with a high degree of importance are those connected with superprecision processing technology, the development of superconducting material and its use in energy, cancers, genes, and enhancing computer performance.

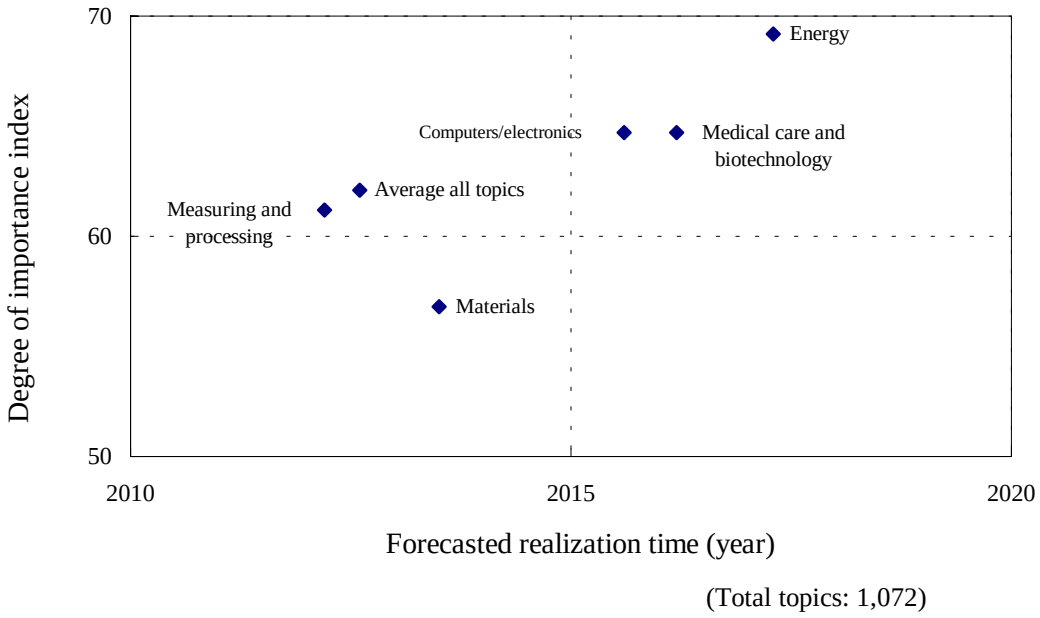


Figure 7.5-2 Cross-comparison between forecasted realization time and degree of importance (common base technologies)

7.5.2 Technological development outlook

Tables 7.5-1 – 7.5-4 show the forecasted realization times of common base technology topics with a comparatively high degree of importance. In the materials base, development of intelligent material with self-diagnostic functions and high-temperature organic superconductors is expected in the latter half of the 2010s, while steady progress in the practical use of materials with specific microscopic structures is expected in the 2010s. The development etc. of new polymer reaction processes is expected to be realized in the early 2010s.

As for the medical care and biotechnology base, advancements in medical engineering will be seen from the late 2000s, and in the 2020s we will probably see the realization of interface technology that improves the performance of artificial limbs dramatically. In the genetics area, elucidation of the whole DNA sequences of crops is expected in the late 2000s, while elucidation of the mechanism by which differentiation and functions are manifest in higher order animals will not take place until the early 2020s. Elucidation of the carcinogenesis mechanism is expected in the early 2010s, while research into brain functions and the nervous system is expected to bear fruit in the late 2010s and early 2020s.

In energy, advancements in secondary battery technology are expected around 2010, while the use of superconductors in the energy area is unlikely to be realized until the late 2010s at the earliest. In measuring and processing, X-ray microscopes with high resolution and positron microscopes will appear in the 2010s, and in processing technology, we can expect changes in the design of artificial objects through microtechniques also in the 2010s.

As for the computer and electronics base, topics concerned with network communication will be realized in the 2000s, and in electronics (hardware), progress is expected to be seen in the development of various new devices between the late 2000s and early 2010s. Around 2020 we will probably see the development of switching devices that are operated by the movement of a single atom. Biocomputers are viewed as a relatively long-term prospect, and their realization is not expected until the mid 2010s at the earliest.

Table 7.5-1 Forecasted realization times of topics connected with common base technologies (1)

Realization time (Year)	Materials base			
	Superconductors etc.	Microscopic structures	Simulation technology	New process technologies
2000				
2005	(Materials) Development of heat-resistant polymer capable of continuous use at temperatures of up to 450°C			
2010	(Materials) Development of a ceramic-metal bonding technology that can withstand heat fatigue from repeated temperature changes of over 500°C;		(Materials) Development of first-principle computer simulation technology of 10,000 atom scale	(Materials) Elucidation of the crystallization growth mechanism using femtosecond technology (Materials) Development of a heteroepitaxial technology for growing semiconductor material on silicon substrate (Materials) Development of precision supplementary polymerization processes for polymer controlled at the molecular level
	(Materials) Development of alloys which can tolerate loads of 15Kgf/mm^2 at ambient temperatures of 1,050°C for more than 1,000 hours	(Materials) Practical use of organic and inorganic composite materials with constituent parts in the order of tens to hundreds of Å.		(Materials) Development of technology that can freely control molecular weight and its distribution in condensation polymer
		(Materials) Development of inorganic materials which exhibit self-organization phenomenon with specific nano-scale structure/characteristics	(Materials) Practical use of computer-aided material design methods for solid catalysts	
	(Transportation) Development of composite materials that adapt to external stimuli by changing rigidity in response to load	(Materials) Practical use of organic hybrid composite materials of a controlled structure at the monomolecular level		
2015	(Urbanization) Development of intelligent construction materials with self-diagnostic functions etc. (Materials) Widespread use of intelligent materials with self-diagnostic and self-repair functions (Materials) Development of organic superconductor with a transition temperature higher than 77 K			
		(Production) Widespread use of highly functional materials and super materials that control structures at the atomic and molecular level		
2020	(Materials) Development of room temperature superconductors			
2025				

Table 7.5-2 Forecasted realization times of topics connected with common base technologies (2)

Realization time (Year)	Medical care and biotechnology base			
	Medical engineering	Gene-related	Cancer-related	Brain functions and nerve systems
2000				
2005	(Electronics) Practical use of biosensors utilizing antibodies	(Agriculture etc.) Elucidation of the whole DNA sequences of crops		
2010	(Electronics) Practical use of ultra-small medical biosensors that utilize biochemical reactions	(Life science) Practical use of technology to alter the functions of biological molecules and cells by means of molecular evolutional engineering techniques (Life science) Development of technology that artificially alters organelle genes and causes the altered organelle genes to function within cells	(Agriculture etc.) Development of biomicromachining technology which uses a cancer drug delivery system that is biodegradable after drug discharge (Health) Elucidation of cancer metastasis mechanisms	
2015	(Materials) Practical use of artificial materials that promote development of biological tissues and organogenesis (Electronics) Development of medical micromachine devices powered by the ATP etc. contained in blood (Electronics) Practical use of biosensors capable of identifying single molecules	(Life science) Practical use of technology to analyse whole genome sequence in livestock breeding, and fisheries, agriculture and forestry	(Health) Elucidation of carcinogenic mutation mechanisms (Life science) Identification of most genes related to cancer, and elucidation of the relationships between those genes and carcinogenesis	(Materials) Elucidation of the information transmission structure of sensory nerves (Life science) Elucidation of the molecular mechanisms for formation of neuronal networks at the molecular level (Health) Elucidation of molecular mechanism of memory
2020	(Life science) Establishment of interface technology between neural information and artificial organism structures	(Life science) Elucidation of the transcription cascade for all genes, from fertilized egg to individual, in a single higher animal species, e.g. mice, and the mechanism by which differentiation and functions are manifest		(Life science) Elucidation of brain mechanisms for logical reasoning
2025				

Table 7.5-3 Forecasted realization times of topics connected with common base technologies (3)

Realization time (Year)	Energy base		Measuring and processing base	
	Secondary batteries and superconductors	Use of biological functions	High-precision measuring	Superprecision processing
2000				
2005				(Electronics) Development of technology capable of manipulating single atoms and single molecules
			(Materials) Development of technology to analyze the chemical species of solid surface atoms	
	(Communication) Development of high performance batteries with an energy density of about 500 Wh/Kg		(Space) Realization of a micro gravity research facility capable of an environment of 10^{-6}G or less for several days	(Production) Practical use of superprecision processing technologies that enable measurement to the angstrom order and time measurement to the femtosecond order
2010				(Production) Initial impact of engineering techniques that control silicon microscopic structures in the production and machinery area
	(Materials) Practical use of plastic secondary batteries with a capacity of 400Wh/liter		(Materials) Development of technology for inducing and measuring ultra-high vacuums in the order of 10^{-14} torr	(Production) Realization of radical changes in the theories of designing artificial objects based on microtechniques
			(Materials) Practical use of equipment capable of ultra-micro-analysis up to the ppt level	
				(Electronics) Practical use of technology which allows mass processing of 10nm patterns
		(Life science) Development of artificial membranes with functions similar to biological membranes	(Materials) Establishment of technology to measure minute levels of force (10^{-19} newtons or less)	
2015			(Electronics) Development of X-ray microscopes capable of 10-100nm resolution	
	(Production) Practical use of technologies that enable the direct storage of electricity	(Life science) Development of engineering technologies that apply biological energy conversion mechanisms		(Production) Discovery of new laws etc. based on the functions of living organisms, leading to a radical change in the theories of designing artificial objects
	(Production) Practical use of room temperature superconductors in industrial products			
		(Life science) Development of light energy elements patterned after photosynthetic response		
			(Marine science) Development of a positron microscope	
2020				
		(Life science) Development of technology for synthesizing artificial cells that replace such functions as cell membrane transport and substance conversion		
	(Resources) Practical use of superconductive energy storage systems with a capacity as large as that at pumped hydroelectric power plants			
2025				

Table 7.5-4 Forecasted realization times of topics connected with common base technologies (4)

Realization time (Year)	Computer/electronics base			
	Network communication	Electronics	System software	Biocomputers etc.
2000	(Communication) Development of a super high-speed computer communication protocol with a throughput of hundreds of Mbps			
2005	(Production) Realization of radical changes to the production and machinery area through multimedia technology (Communication) Development of an encoding technique that can compress image information to about 1/250 of the original size (Communication) Practical use of narrow-band high-quality image encoding technology with a bit rate of around 10 Kbps	(Communications) Development of a 4,000 x 4,000 pixel high-definition display, image sensor, etc. (Electronics) Development of digital optical logic circuits which carry out binary operations		
2010	(Communication) Development of an optical fiber communication method using the quantum state of photons	(Material) Development of elements which utilize colossal magnetic resistance effect (Materials) Development of PHB memory devices	(Information) Development of software capable of using sensory and learning functions to rewrite itself into an even more advanced program (Information) Realization of software inspection and verification technology that enables quick development of error-free, large-scale software	
2015		(Electronics) Development of high-speed, highly-integrated devices that switch by the movement of a single atom	(Electronics) Practical use of multi-processor systems with advanced self-restoration capabilities	(Communication) Practical use of biochip devices that have a memory density 1,000 times that of current semiconductor devices (Information) Practical use of biocomputers based on a new algorithm (Life science) Development of neural-computers with new logic structures modeled on brain functions

Realization time (Year)	Computer/electronics base			
	Network communication	Electronics	System software	Biocomputers etc.
2020		(Electronics) Development of a storage system in which one atom or molecule corresponds to 1 bit		(Electronics) Development of artificially functioning bio-nerve circuits with about 10,000 cells (Information) Elucidation of human creative mechanism to such an extent that it can be applied to computer science (Electronics) Development of an “artificial intelligence chip” capable of understanding and sharing human emotions
2025				(Life science) Development of interfaces that enable a direct linkage between computer and brain

7.5.3 Current leading countries etc.

Figure 7.5-3 is a breakdown of the leading countries in the various fields, and as can be seen in the figure, overall the USA is ranked highest, followed by Japan and the EU. The USA is placed above its all-topics average in all five domains, and is ranked especially high in the medical care and biotechnology base, which includes cancer- and gene-related technologies, and in the computer/electronics base, which includes computer software and computer communication.

Japan is generally at about the same level as its all-topics average, and is ranked relatively high in the materials base and the measuring and processing base. As for the EU, its score for the medical care and biotechnology base is higher than its all-topics average.

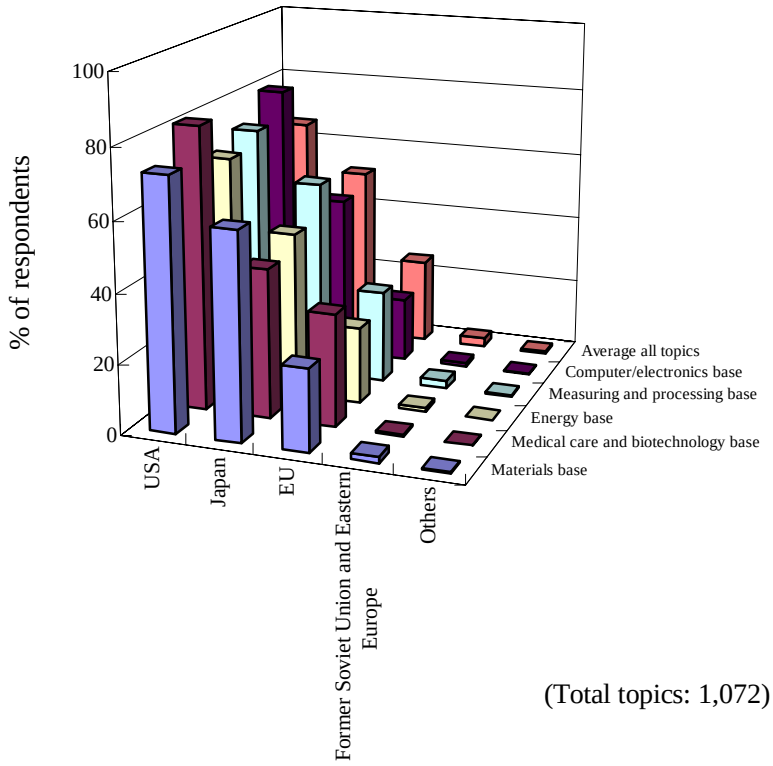


Figure 7.5-3 Leading countries etc. (common base technology)

7.5.4 Effective measures the government should adopt

Figure 7.5-4 shows overall trends. “Foster human resources” ranks highest, followed by “increase government research funding” and “promote exchanges among industrial, academic and government sectors and different fields.” The percentage for “foster human resources” is higher than the average percentage for all 1,072 topics.

“Foster human resources” is particularly high in the medical care and biotechnology domain, and topics in which this was highlighted by large numbers of respondents include those connected with genes, such as the elucidation of the mechanism by which differentiation and functions are manifest in mice etc., those connected with the nervous system, including the elucidation of the information transmission structure of sensory nerves, and those connected with cancer, such as the elucidation of carcinogenic mutation mechanisms.

In the energy base, a high percentage of respondents want the government to increase its research funding, and also foster human resources to a much greater degree. The use of superconductors in the storage of energy is one example of the topics in which most respondents believe the government should inject more research money.

And in medical care and biotechnology, “develop a research base” is ranked relatively high.

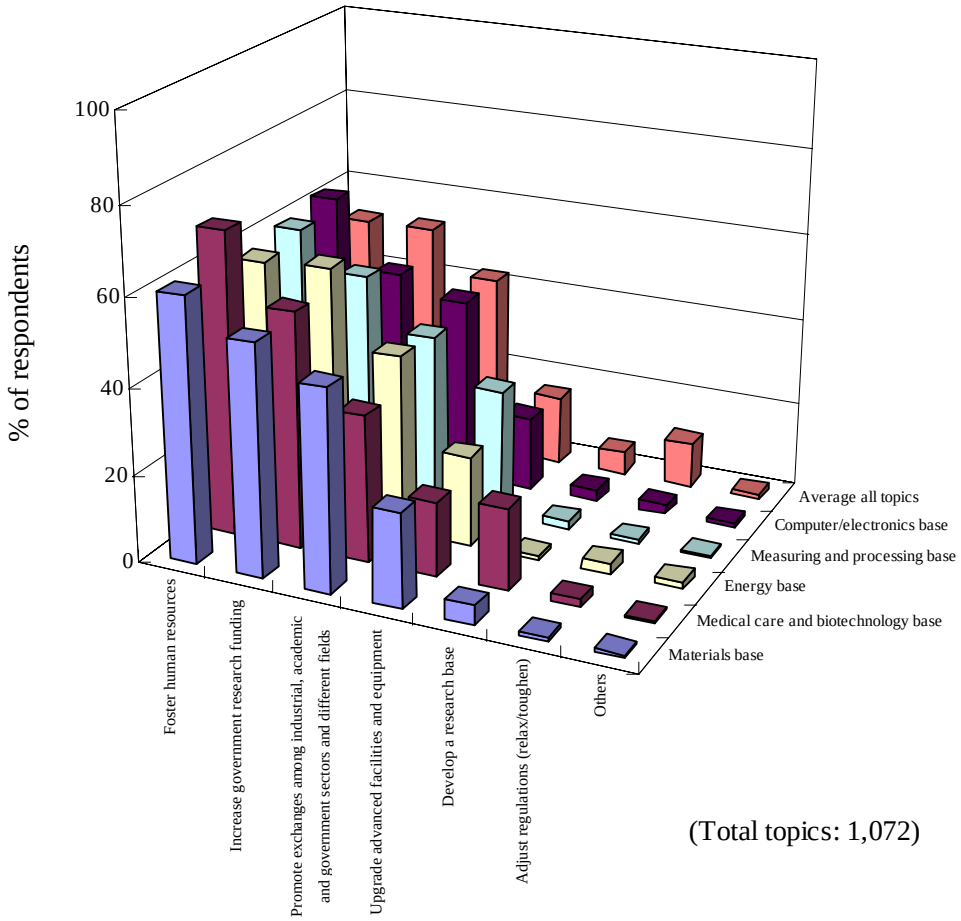


Figure 7.5-4 Measures the government should adopt (common base technology)

(Reference) The following table shows a breakdown by field of topics related to common base technology

Table 7.5-5 Number of topics by field (common base technology)

Field	Common base technology					
	i) Materials	ii) Medical care and biotechnology	iii) Energy	iv) Measuring and processing	v) Computers/electronic	Total
Materials	26	4	1	8	2	41
Electronics	0	5	0	6	7	18
Information	0	0	0	1	5	6
Life science	0	12	4	0	6	22
Space	0	0	0	1	0	1
Marine science	0	0	0	1	0	1
Resources	0	0	2	0	0	2
Environment	0	0	0	0	0	0
Agriculture etc.	0	3	0	0	0	3
Production	2	1	2	9	2	16
Urbanization	1	0	0	0	0	1
Communication	0	0	2	0	7	9
Transportation	1	0	0	0	0	1
Health	0	3	0	0	1	4
Total	30	28	11	26	30	125

8. Identical and similar topics among fields

We compared and examined forecasts by the experts in different fields based on the results of identical and similar topics set over several fields. Of the 1,072 topics of this survey, two groups (five topics) were identical, and 69 groups (162 topics) were similar. In most cases, the forecasted realization times are practically the same. Table 8.1-1 gives four groups as examples of similar results for similar topics, while Tables 8.2-1–3 and 8.3-1–2 shows examples of different results for similar topics.

8.1 Examples of topics with similar results

(1) Cancer (identical topics)

This is an identical topic common to both “life science” and “health.” In the degree of importance, the topic in the “health” field is, at 91, slightly higher than the identical topic in the “life science” field with 76. In the other questionnaire items the trends are quite similar.

(2) ID card (similar topics)

In both the “information” and “communication” fields, the realization time for these topics is forecasted to be 2004–2005, and the degree of importance is also virtually the same. The same is also true for the other questionnaire items.

(3) Electric car (similar topics)

Six similar topics in three fields deal with electric cars. Experts in all three fields indicate realization times for these topics of between 2011 and 2014. In degree of importance, the highest rating was given by experts in the “environment” field, while the lowest was given by experts in “resources.” As for measures the government should adopt in Japan, environmental experts believe “adjust regulations (relax/toughen)” is the most important, but experts in the other fields rate “increase government research funding” the highest, and attach less importance to any adjustment of regulations.

(4) Portable automatic interpreting devices (similar topics)

Four topics in four fields are similar regarding portable automatic interpreting devices. In all four fields the forecasted realization time is roughly the same at between 2010 and 2013. However, considering the topic in the “health” field deals with the widespread use of such devices whereas topics in the other fields talk about their practical use, the forecasted realization times indicated by the health experts are perhaps somewhat optimistic. Among the experts in the four fields, this topic area was given the lowest degree of importance rating by those in the “health” field.

Table 8.1-1 Examples of topics with similar results (identical and similar topics among fields)

Key word	Field	Topic	Degree of importance index	Expected effect (%)				Forecasted realization time	Leading countries (%)			Measures the government should adopt (%)						Potential problems (%)		
				Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources		USA	EU	Japan	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Natural environment	Safety	Morals, culture or society
Cancer	Life science	49 Practical use of effective means to prevent metastasis of cancer.	76	32	1	93	18	2013	84	34	54	76	46	24	19	59	0	1	13	26
	Health	48 Practical use of effective methods against cancer metastasis.	91	22	0	97	11	2013	91	48	49	70	51	19	9	67	2	1	10	19
ID card	Information	08 Widespread use of multipurpose ID card system with wireless communication capability.	66	84	6	83	4	2005	84	30	78	35	26	3	1	18	62	2	55	29
	Communication	16 Widespread use of battery-free wireless cards in automatic train ticket inspection and physical distribution systems.	70	81	4	75	1	2004	70	31	76	31	39	8	0	22	45	2	52	16
Electric vehicles	Resources	81 Widespread use of electric vehicles with driving performance equal to that of gasoline motorcars.	79	57	89	32	2	2013	74	40	83	28	57	11	0	58	37	23	12	4
	Environment	38 Widespread use (e.g., more than 10% in the world) of automobiles as urban transportation system (e.g., electric vehicles) which do not cause air or noise pollution.	86	68	80	51	1	2013	72	45	67	24	55	12	1	45	63	40	13	16
	Transportation	26 Widespread use of electric vehicles that carry a battery capable of powering a vehicle for 200 km after about 15 minutes of rapid charging and are capable of driving patterns necessary to follow actual urban traffic flows.	77	40	96	17	3	2011	78	48	70	33	62	13	0	73	24	35	17	2
	Transportation	27 Widespread use of electric vehicles carrying fuel cells which have high energy conversion efficiencies.	71	32	93	16	3	2014	76	33	58	40	55	13	2	76	16	38	14	1
	Resources	82 Practical use of electric vehicles powered by solar cells and secondary batteries.	65	49	88	22	2	2013	73	35	82	33	53	10	0	57	30	24	12	2
	Resources	83 Practical use of electric vehicles powered by fuel cells and secondary batteries.	66	51	91	20	0	2013	73	36	71	37	53	8	0	59	30	23	18	2

Key word	Field	Topic	Degree of importance index	Expected effect (%)				Forecasted realization time	Leading countries (%)			Measures the government should adopt (%)						Potential problems (%)		
				Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources		USA	EU	Japan	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Natural environment	Safety	Morals, culture or society
Interpreting machines	Information	28 Practical use of portable translation devices (translates simple, common phrases in both directions) using voice input.	63	57	4	86	14	2012	64	18	82	65	41	7	6	39	1	0	3	18
	Electronics	23 Practical use of portable automatic translation systems with a single-chip LSI.	77	84	4	79	5	2013	68	15	82	55	61	16	2	46	1	1	5	15
	Production	27 Practical use of pocket-size voice actuated interpreting machines that enable people to communicate even if they do not speak each other's language.	64	63	5	81	9	2012	48	9	72	57	46	8	2	43	5	0	5	27
	Communication	38 Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality.	81	73	8	86	10	2012	39	13	84	63	34	10	3	57	2	0	6	34
	Health	89 Widespread use of portable conversational speech interpretation systems.	58	66	2	78	17	2010	64	14	72	50	67	24	0	43	2	0	14	36

8.2 Examples of topics with a recognized difference in forecasted realization time

(1) Power generation using high-temperature rock base (similar topics)

Experts in “marine science” are more optimistic about this technology than are the experts in “resources.” The difference in forecasted realization time is ten years, but if we consider that the topic in “marine science” talks about the widespread use of the technology whereas the topic in “resources” deals with its practical use, the real difference between the two would be considerably more. The degree of importance is assessed to be lower in the “resources” field, where energy experts outnumber resources experts, than in the “marine science” field.

Table 8.2-1 Topics with different results (high-temperature rock base power generation)

Field	Topic	Importance index	Forecasted realization time
Marine science	55 Widespread use of systems for forcing water into high-temperature subterranean locations in order to extract thermal energy in the form of steam.	65	2011
Resources	56 Practical use of hot dry rock power-generating technologies.	50	2021

(2) Artificial muscles (similar topics)

The terms used in the topics are slightly different in artificial muscle material and artificial muscle devices, and forecasts by experts in the “materials” field are earlier than those by experts in “life science” and “health.” The topic in the “production” field deals with robots, not humans, and experts here forecast that actuators resembling human muscles will be developed in 2013. The degree of importance is generally the same across all four fields.

Table 8.2-2 Topics with different results (artificial muscles)

Field	Topic	Importance index	Forecasted realization time
Materials	01 Development of artificial muscle-like material that responds to stimuli reversibly.	51	2012
Life science	55 Development of artificial muscle elements.	57	2019
Health	58 Practical use of artificial muscles for limbs.	47	2020
Production	56 Development of flexible actuators resembling human muscles, which can be applied to small, lightweight robots.	53	2013

(3) Energy conversion (similar topics)

Most experts here are in the biotechnology area, and experts in “life science,” who provide the necessary technology forecast a realization time five years earlier than experts in “production,” who set up and use this technology. The degree of importance is virtually the same.

Table 8.2-3 Topics with different results (energy conversion)

Field	Topic	Importance index	Forecasted realization time
Life science	31 Development of technologies, such as biomotors, using the biological energy conversion mechanisms.	59	2016
Production	58 Development of high energy converting efficiency machines which apply the biological energy converting mechanism.	60	2021

8.3 Examples of topics with a recognized difference in degree of importance

(1) Hydrogen production (similar topics)

This technology is afforded the lowest degree of importance in “resources,” where energy experts form the majority, and is as much as 26 points lower than the corresponding figure in “materials.” The forecasted realization time is quite similar across the three fields at between 2017 and 2021.

Table 8.3-1 Topics with different results (hydrogen production)

Field	Topic	Importance index	Forecasted realization time
Resources	64 Practical use of thermochemical decomposition processes for hydrogen production.	59	2019
Production	55 Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.	78	2021
Materials	107 Practical use of processes for water decomposition by the sunlight.	85	2017

(2) Nursing care robots (similar topics)

In “information,” considered to be the field that provides this technology, the degree of importance is quite high at 81, but in “urbanization” and “health,” fields that cover homes and hospitals where the robots will be used, it is only around 60. The forecasted realization times are generally similar at between 2010 and 2014. It is earliest in “information” at 2010, but we believe this can be put down to the fact that the topic in this field deals with the practical use of the technology, whereas in the other two fields the topics talk about its widespread use.

Table 8.3-2 Topics with different results (nursing care robots)

Field	Topic	Importance index	Forecasted realization time
Urbanization	46 Widespread use in Japan of houses equipped with robots and other devices that assist senior citizens and disabled people with everyday tasks, including eating meals, bathing, going to the toilet, and having entertainment, to carry these out without human assistance.	56	2014
Health	90 Widespread use of robots that care for people with severe physical and mental disabilities.	60	2012
Information	54 Practical use of robots which provide medical care support in homes, hospitals, etc.	81	2010

9. Comparison with forecasted realization time and degree of importance results in the 5th survey

Arranging the 1,072 topics in this survey relative to the topics of the previous survey reveals the following.

i) Topics that have remained unchanged from the previous survey because of their continuing high importance — 380 topics (identical topics)

ii) Topics for which a higher target value has been set or the technological stage has become more advanced (elucidation - development - practical use - widespread use) — 233 topics (revised topics)

iii) New topics — 459 topics (new topics)

Here we shall compare the forecasted realization time and degree of importance for identical and revised topics between the last and the current survey.

9.1 Trends by field

We divided the identical topics into their fields, and calculated the average forecasted realization time and importance index. Table 9.1-1 shows the comparison between this and the previous survey. For this comparison, we excluded topics with a forecasted realization time of after 2026 (after 2021 for the previous survey). Overall, the importance index has dropped by 5.8 points, and the realization time is later by 6.3 years. Considering the five-year gap between surveys, we can say this lag in forecasted realization time is indeed considerable. By field, identical topics in the “production,” “electronics” and “marine science” fields are later by a substantial degree in realization time, and topics in the “space,” “urbanization” and “health” fields have dropped by at least ten points in the importance index.

Table 9.1-1 Comparison with the 5th Survey (identical topics)

Field	Number of topics	Degree of importance index / forecasted realization time		
		This survey	Previous survey	Difference
Materials	51	59.5 / 2012.4	63.8 / 2006.1	-4.3 / 6.3
Electronics	7	65.5 / 2014.2	62.4 / 2005.5	3.1 / 8.7
Information	15	64.9 / 2010.7	66.9 / 2006.8	-2.0 / 3.9
Life science	24	65.8 / 2017.2	72.4 / 2011.6	-6.6 / 5.6
Space	20	52.8 / 2015.2	67.6 / 2009.9	-14.8 / 5.3
Marine science	39	67.5 / 2012.0	69.0 / 2003.9	-1.5 / 8.1
Resources	49	60.7 / 2015.8	67.0 / 2008.4	-6.3 / 7.4
Environment	23	70.8 / 2012.8	77.1 / 2005.3	-6.3 / 7.5
Agriculture etc.	27	63.2 / 2011.5	69.3 / 2007.5	-6.1 / 4.0
Production	20	65.0 / 2014.7	67.3 / 2005.9	-2.3 / 8.8
Urbanization	32	54.9 / 2013.4	67.2 / 2005.9	-12.3 / 7.5
Communication	19	59.3 / 2009.2	60.2 / 2004.6	-0.9 / 4.6
Transportation	21	59.1 / 2010.3	60.3 / 2005.2	-1.2 / 5.1
Health	35	62.5 / 2012.4	73.2 / 2007.5	-10.7 / 4.9
Total identical topics	382	61.9 / 2013.1	67.7 / 2006.8	-5.8 / 6.3

Note: The reason there are 382 topics in the table is that six of the 380 identical topics were surveyed in two fields in the previous survey and here we have compared them separately, and we excluded four topics with a realization time later than 2026.

9.2 Topics with earlier/later forecasted realization times

Of the 382 topics, 38 have roughly the same (within three years) forecasted realization time, 342 topics are least three years later, and two are at least three years earlier. Table 9.2-1 shows the five topics that are later by the largest margin. Of these, three are in the "production and machinery" field, and all three deal with technology aimed at the industrial application of biological functions. The degree of importance of these topics is roughly the same or higher.

Table 9.2-1 Topics later by the largest margin in forecasted realization time

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Production and machinery) 53 Development of technology to synthesize protein from carbon dioxide and ammonia, via a bioreactor.	66/2018	73/2003	(Production) 14 Development of technology to synthesize protein from carbon dioxide and ammonia, via a bioreactor.
(Production and machinery) 55 Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.	78/2021	74/2006	(Production) 16 Practical use of technologies for mass-producing hydrogen by decomposing organic substances through application of solar energy and biological systems.
(Production and machinery) 54 Practical use of technologies for producing glucide by artificial photosynthesis applying the mechanism of natural photosynthesis.	70/2019	59/2005	(Production) 15 Practical use of technologies for producing glucide by artificial photosynthesis applying the mechanism of natural photosynthesis.
(Urbanization and construction) 71 Elucidation of the impact of living in a super high-rise building (around 1,000 m tall) on human physiology and psychology.	32/2018	44/2005	(Lifestyles and culture) 33 Elucidation of feasibility of living in hyper high-rise buildings (500m to 1,000m) with respect to the physiological and psychological aspects of human being.
(Marine science and earth science) 60 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.	92/2023	94/2010	(Marine science and earth science) 73 Development of technology capable of forecasting the occurrence of major earthquakes (magnitude 7 or above) several days in advance.

The following table shows topics whose forecasted realization time is earlier in this survey, and of these, three are in "agriculture etc." and two are in "resources and energy."

Table 9.2-2 Topics earlier in forecasted realization time

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Agriculture, forestry and fisheries) 10 Development of prevention systems against crop damage by cold-weather, such as localized climate control, that respond to weather forecasts.	66/2018	75/2009	(Agriculture, forestry and fisheries)15 Development of cold damage prevention systems based on highly accurate medium and log term weather forecasts.
(Health, medical care and welfare) 73 Practical use of gene therapy for genetic disorders.	58/2012	74/2016	(Health, medical care) 84 Practical use of gene therapy for a number of gene disorders.
(Resources and energy) 14 Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.	61/2017	56/2020	(Mineral and water resources) 13 Development of exploration technology capable of estimating the economic feasibility of mineral deposits with virtually no drilling.
(Materials and processing) 01 Development of artificial muscle-like material that responds to stimuli reversibly.	51/2012	66/2014	(Materials and processing) 15 Development of a material having a flexible function equivalent to that of human muscles.
(Agriculture, forestry and fisheries) 55 Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	84/2016	81/2018	(Agriculture, forestry and fisheries) 61 Development of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.
(Agriculture, forestry and fisheries) 51 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	72/2013	60/2015	(Agriculture, forestry and fisheries) 56 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.
(Information) 26 Development of equipment for automatic preparation of summaries and abstracts of books and other documents (degree of condensation can be adjusted as necessary).	60/2009	60/2010	(Information and electronics) 94 Development of equipment for automatic preparation of summaries and abstracts of books and other documents (degree of condensation can be adjusted as necessary).
(Resources and energy) 20 Practical use of inducing artificial rainmaking in event of drought.	57/2014	57/2015	(Mineral and water resources) 20 Practical use of inducing artificial rainmaking in event of drought.

Among the revised topics, the following table gives some examples of those that have advanced in the technological development stage, e.g. from development to practical use, but have not shown any substantial delay in forecasted realization time.

Table 9.2-3 Topics with a more advanced technological development stage but without a significant delay in forecasted realization time

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Health, medical care and welfare) 43 Widespread use of gene therapy for familial hypercholesterolemia.	54/2014	65/2011	(Health, medical care) 54 Development of gene therapy for familial hypercholesterolemia.
(Communication) 41 Widespread use of binocular stereoscopic TV broadcasts that can be enjoyed at home.	39/2011	49/2008	(Communication) 64 Practical use of stereoscopic broadcasting based on development of displays for stereoscopic home television, witch can be viewed without glasses.
(Information) 09 Widespread use of sound field shielding technology capable of isolating a specific spatial area from the surrounding noise.	52/2009	54/2006	(Information and electronics) 79 Practical use of sound field shielding technology capable of isolating a specific spatial area from the surrounding noise.
(Information) 21 Widespread use of computer networks in which a virtual space can be shared in real time by a large number of unspecified, geographically dispersed persons.	60/2008	51/2005	(Information and electronics) 88 Practical use of computer networks in which a virtual space can be shared by a large number of unspecified, geographically dispersed persons.
(Resources and energy) 74 Widespread use of high energy density (200 Wh/kg: 5 times the energy density of a conventional lead acid battery) secondary batteries (Ni-MH, Li, etc.).	71/2010	70/2007	(Energy) 40 Practical use of high energy density (200 Wh/kg: 5 times the energy density of a conventional lead acid battery) secondary batteries (Ni-MH, Li, etc.).

9.3 Topics with a significant change in degree of importance

Of the 382 topics, 266 have generally the same importance index (difference of ± 10 points), 106 topics have a lower index by at least 10 points, and ten have a higher index by at least 10 points. Table 9.3-1 shows the five topics with the largest drop in importance index. Two are in the “space” field, and it should also be noted that the degree of importance of topics connected with the global environment, such as the prevention of desertification and management of tropical rain forests, has dropped.

Table 9.3-1 Topics with a considerably lower degree of importance index

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Materials and processing) 23 Practical use of devices that enable X-ray structural analysis of supramolecular-biopolymer crystals in real time.	49/2011	81/2006	(Particles) 39 Practical use of equipment capable of realtime X-ray structure analysis for large bio-macromolecular crystals, including the collection and analysis of diffraction data.
(Space) 50 Practical use in Japan of isotope batteries for probing deep space.	44/2011	75/2004	(Space) 26 Practical use of isotope batteries for probing deep space.
(Life science) 92 Practical application of breeding techniques for plants resistant to dry and saline conditions aimed at desertification prevention.	61/2014	92/2009	(Life science) 94 Practical use of (breeding methods to produce) plants with drought and salt tolerance at a high degree to stop the spread of desert environment.
(Space) 31 Development of high-pressure (1 atmosphere), flexible space suit for use outside of a spaceship.	46/2009	76/2006	(Space) 42 Development of high-pressure, flexible space suit for use outside of a spaceship.

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Agriculture, forestry and fisheries) 80 Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.	55/2016	83/2014	(Agriculture, forestry and fisheries) 73 Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.

The following table shows some of the topics with a higher degree of importance index in this survey.

Table 9.3-2 Topics with a considerably higher degree of importance index

Topic (this survey)	Degree of importance index / forecasted realization time		Topic (previous survey)
	This survey	Previous survey	
(Marine science and earth science) 01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.	91/2007	71/2001	(Marine science and earth science) 01 Practical use of Tsunami forecasting systems based on tide and Tsunami observation through satellites and on other data including shelf topography.
(Materials and processing) 20 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)	82/2011	63/2008	(Materials and processing) 36 Practical use of rechargeable polymer batteries having a volume-specific capacity of 400 Wh/liter. (Capacity of current Ni-Cd batteries: 180 Wh/liter)
(Transportation) 55 Practical use of floating off-shore airports.	78/2009	62/2008	(Transportation) 53 Practical use of floating off-shore airports.
(Environment) 29 Development of low-noise engines and tires, and sound-absorbing construction materials, leading to the reduction of automobile noise within the environmental standard for the area specified to be for resident.	76/2011	61/2006	(Environment) 37 Development of low-noise engines and tires, and sound-absorbing construction materials, reducing automobile noise within the environmental standard for the area specified to be for resident.
(Agriculture, forestry and fisheries) 51 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	72/2013	59/2015	(Agriculture, forestry and fisheries) 56 Practical use of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.

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10. Assessment and analysis of the results of the 1st and 2nd surveys

10.1 Purpose

The significance of technology forecasts is that, through their assessment and analysis of realization time and importance of various topics, they give an indication of the direction and objectives of research and development, and this in turn provides the foundations for the promotion and development of science and technology. To make the technology forecast survey more effective, we have to incorporate certain assessments and analyses from past surveys into the examinations of current and future surveys. All technology forecast surveys have focused on the period from the present to 30 years in the future. Already 26 and 21 years have passed since the first (1971) and second (1976) surveys were carried out, so it is now possible to assess whether the topics forecasted in those two surveys have been realized or not. An assessment of the results of the first survey was carried out when the fifth survey was done in 1992, and this is contained at Appendix 1 of NISTEP Report No. 25, *The Fifth Technology Forecast Survey, Future Technology in Japan*; but it is now five years later and we believe it is important to reassess those results in the light of developments that have taken place since then.

10.2 Assessment method

We distributed all topics from the first and second surveys to the different subcommittees according to topic content, and asked them to determine the state of realization for each. The subcommittees examined their allocated topics, and divided them into one of the following three realization classifications.

Realized	: Realized by 1996
Partially realized	: A part of the topic had been realized by 1996
Unrealized	: Neither of the above

Based on this, the subcommittees then calculated the following for analysis.

Realization rate	: Percentage of “realized” topics to the total number of topics
Realization rate including partially realized topics	: Percentage of “realized” and “partially realized” topics to the total number of topics
Unrealized rate	: Percentage of “unrealized” topics to the total number of topics

“Partially realized” is defined as follows.

- Cases where a single topic contains two or more aspects, and while one or more aspects have been realized, there remains at least one aspect that has not been realized.
- Cases where an expression (including adjectives describing performance) in the topic is not quantitatively defined, and its realization is open to interpretation.
- Cases where a part of the requirement described in the topic has been realized.

In this assessment and analysis we looked at topics whose forecasted realization time was 1996 (the year of the assessment) or earlier, and topics whose forecasted realization time was 1997 or later but which had already been realized (including partially realized topics).

Table 10.2-1 Classification of all topics and assessed topics in the first technology forecast survey by division and field

Division/Field	Set topics	Assessed topics
Social development — total	136	130
Improvement of clothing standards	22	20
Improvement of housing standards	19	18
Leisure	20	20
National land and urban development	19	17
Improvement of traffic and transportation	21	20
Prevention of pollution	20	20
Improving education	15	15
Information — total	111	105
Socioeconomic demands	41	40
Information technology	52	47
Basic technology	18	18
Health and medical care — total	103	83
Progress of medical diagnosis and treatment	50	37
Development of preventive medicine	9	9
Development of the medical care system	12	12
Elucidation of life phenomena	12	9
Humans and the environment	10	10
Medical education	6	5
Others	4	1
Food and agriculture — total	100	96
Development of food material	31	30
Systems development	33	33
Development of control methods	21	20
Machinery development	15	13
Industry and resources — total	194	174
Space development	29	23
Marine development	29	25
Energy development	31	24
Resources development	30	27
Increasing mining production	38	38
Material development	37	37
Total	644	588

Table 10.2-2 Classification of all topics and assessed topics in the second technology forecast survey by field

Field	Set topics	Assessed topics
Food resources	70	69
Forest resources	14	11
Mineral resources	24	19
Water resources	9	8
Energy	33	21
Environment	48	47
Safety	22	18
Family life	33	29
Leisure	11	10
Education	25	24
Health and medical care	58	41
Labor	10	10
Transportation	27	20
Information	60	53
Construction	29	20
Industrial production	59	54
Space development	32	18
Marine development	35	28
Life science	27	22
Software science	30	27
Total	656	549

10.3 Analysis of realization rate

10.3.1 First survey

Of the assessed topics in the first survey, 151 are “realized,” 225 “partially realized” and 212 “unrealized,” resulting in a realization rate, realization rate including partially realized topics, and unrealized rate of 26%, 64% and 36% respectively.

By division, 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.

Table 10.3-1 Realization rate of assessed topics in the first technology forecast survey

Division	Field	Assessed topics	Realized	Partially realized	Unrealized	Realization rate (%)	Realization rate including partially realized topics (%)	Unrealized rate (%)
Social development	Improvement of clothing standards	20	6	9	5	30	75	25
	Improvement of housing standards	18	3	5	10	17	44	56
	Leisure	20	5	6	9	25	55	45
	National land and urban development	17	0	11	6	0	65	35
	Improvement of traffic and transportation	20	2	3	15	10	25	75
	Prevention of pollution	20	2	10	8	10	60	40
	Improving education	15	2	6	7	13	53	47
	Subtotal	130	20	50	60	15	54	46
Information	Socioeconomic demands	40	8	20	12	20	70	30
	Information technology	47	19	10	18	40	62	38
	Basic technology	18	9	2	7	50	61	39
	Subtotal	105	36	32	37	34	65	35
Health and medical care	Progress of medical diagnosis and treatment	37	9	20	8	24	78	22
	Development of preventive medicine	9	1	4	4	11	56	44
	Development of the medical care system	12	3	9	0	25	100	0
	Elucidation of life phenomena	9	1	8	0	11	100	0
	Humans and the environment	10	1	7	2	10	80	20
	Medical education	5	0	4	1	0	80	20
	Others	1	1	0	0	100	100	0
	Subtotal	83	16	52	15	19	82	18
Food and agriculture	Development of food material	30	10	11	9	33	70	30
	Systems development	33	8	19	6	24	82	18
	Development of control methods	20	6	12	2	30	90	10
	Machinery development	13	4	4	5	31	62	38
	Subtotal	96	28	46	22	29	77	23
Industry and resources	Space development	23	8	5	10	35	57	43
	Marine development	25	6	10	9	24	64	36
	Energy development	24	3	3	18	13	25	75
	Resources development	27	3	6	18	11	33	67
	Increasing mining production	38	13	10	15	34	61	39
	Material development	37	18	11	8	49	78	22
	Subtotal	174	51	45	78	29	55	45
Total		588	151	225	212	26	64	36

10.3.2 Second survey

Of the assessed topics in the second survey, 114 are “realized,” 232 “partially realized” and 203 “unrealized,” resulting in a realization rate, realization rate including partially realized topics, and unrealized rate of 21%, 63% and 37% respectively.

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.

Table 10.3-2 Realization rate of assessed topics in the second technology forecast survey

Field	Assessed topics	Realized	Partially realized	Unrealized	Realization rate (%)	Realization rate including partially realized topics (%)	Unrealized rate (%)
Food resources	69	18	32	19	26	72	28
Forest resources	11	1	7	3	9	73	27
Mineral resources	19	3	8	8	16	58	42
Water resources	8	0	3	5	0	38	63
Energy	21	3	2	16	14	24	76
Environment	47	3	23	21	6	55	45
Safety	18	3	10	5	17	72	28
Family life	29	8	9	12	28	59	41
Leisure	10	1	3	6	10	40	60
Education	24	3	12	9	13	63	38
Health and medical care	41	7	27	7	17	83	17
Labor	10	2	5	3	20	70	30
Transportation	20	1	7	12	5	40	60
Information	53	22	12	19	42	64	36
Construction	20	3	11	6	15	70	30
Industrial production	54	16	21	17	30	69	31
Space development	18	8	9	1	44	94	6
Marine development	28	6	14	8	21	71	29
Life science	22	5	12	5	23	77	23
Software science	27	1	5	21	4	22	78
Total	549	114	232	203	21	63	37

10.4 Relationship between degree of importance and realization rate

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 (calculated according to the formula described under v) of Section 4. “Reading the survey results” of Chapter 1), 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 10.4-1 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

Note: Covers all set topics.

10.5 Forecasted realization time and realization rate

Here we classified the topics by forecasted realization time, and calculated the realization rate for each 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 10.5-1 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

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

Note: Covers all set topics.

Table 10.5-2 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

Note: Covers all set topics.

10.6 Unrealized topics

The range of reasons that topics have not been realized is indeed broad, and it is by no means a simple task to narrow this range down to a representative few, but the subcommittees have decided on the five general reasons of technological problem, social problem, insufficient need, cost problem, and emergence of alternative technologies. Technological problems is by far the main factor in why topics have not been realized, followed by cost problems, social problems, and insufficient need. This pattern is common to both surveys. In this section, we shall examine the “energy” and “traffic and transportation” fields, where the realization rate is low, the “information” field, where the private sector plays a leading role in technological development, and the “space” field, which is for all intents and purposes a national program.

10.6.1 Energy

In both the first and second surveys, the realization rate for energy was low. Many topics in this field were forecasted to be realized after 1997: seven of 31 topics in the first survey and 13 of 33 topics in the second survey.

The main reason topics in the first survey have not yet been realized is technological problem (realization of superconductive power transmission), but insufficient need (practical use of portable microcapsulated liquid fuel) is also an important factor.

In the second survey, technological problem (practical use of hydrogen systems (including fuel cells) in certain regions), cost problem (practical use of coal liquefaction technology) and social problem (practical use of nuclear cells with an output of 1kW and a service life of at least ten years, and their application in remote areas and oceans) are all at about the same level. Many of the topics for which cost problem is a key factor deal with alternative fuel technologies. The reason many of the topics contain reference to alternative fuels is thought to be that the survey was taken soon after the oil crisis, but because the skyrocketing oil prices later settled down, cost became an important factor that hindered the technology’s realization. Many of the topics in which social problem is a key factor are connected with nuclear power. The second survey was conducted in a climate in which reducing the dependence on petroleum for energy was an urgent matter, so it has many more topics dealing with the diversification of energy resources than the first survey.

10.6.2 Traffic and transportation

In the first survey, many of the topics have not been realized because of a technological problem (practical use of a fully automatic system for controlling train speed, starting and stopping, and response in an emergency through the adoption of a stopping system in trains) and a cost problem (practical use of nonpolluting community cars (small and safe personal transportation vehicles)).

In the second survey, the main reasons that topics have not been realized are technological problem (widespread use of electric cars for transportation within cities) and cost problem (practical use of high-speed passenger transportation networks, such as large hovercraft and large hydrofoil craft for long-distance coastal transportation). In both surveys, a characteristic of this field is that the cost problem is much more of a factor in the non-realization of topics than in other fields.

10.6.3 Information

In the first survey the reason for unrealized topics is overwhelmingly technological problem (development of chemical calculation devices suitable for mass information processing), followed by social problem (most judgement work, such as the granting of permits and licenses, will be standardized and computerized) and emergence of alternative technologies (practical use of highly sensitive (same or higher than film) optical memory devices that can be erased and reused freely).

In the second survey, the main reasons are technological problem (practical use of random access memory using laser holography) and social problem (practical use of systems that allow an individual to search through various public statistical data banks easily and at any time). In the second survey there are more topics that are unrealized because of social problems than in the first survey.

10.6.4 Space

The space field has a comparatively high realization rate, and programs in it are more often than not carried out as a form of national policy.

In the first survey, the main reasons for unrealized topics are technological problem (probe of the moon's surface in a manned spacecraft), cost problem (realization of manned flights into outer space), and social problem (realization of the disposal of radioactive waste in space).

In the second survey, only one topic has not been realized because of insufficient need (launch of a large-scale stationary scientific satellite to observe the earth and surrounding space); all other topics have been realized, including those partially realized.

10.7 Topics realized early

The first and second survey topics listed in the following table were realized early.

Table 10.7-1 Topics realized early (first survey)

Topics	Importance index	Forecasted realization year
102047: Development of technology that can detect smells and tastes (kind, concentration, etc.)	47	1997
104003: Realization of useful animals and plants (excluding microorganisms) through cell fusion or cell nucleus fusion	50	1997
103080: Elucidation of the mechanism by which tissue antigens can be synthesized based on genetic type	55	1997
103035: Possibility of external fertilization, ectogenesis, or artificial womb;	30	2001 or later

Table 10.7-2 Topics realized early (second survey)

Topics	Importance index	Forecasted realization year
214053: Possibility to a certain degree of working at home through the use of TV-telephones, telefaxes, etc.	31	1998
201002: Practical use of biomolecular methods for improving the shape and quality of useful plants (excluding microorganisms)	57	1998
214030: Development of technologies that translate foreign documents (English)	62	1999
217009: Acquisition of observation data from unmanned probes around Uranus, Neptune, Pluto and outside the solar system	32	1999
203016: Development of optical communication technology that can realize substantial savings in the use of copper and aluminum	60	1999
202001: Development of improved major tree varieties that display excellent disease-, insect- and weather-resistant characteristics	72	2000
205015: Development of high-temperature rock power-generating systems in which heat energy is drawn out artificially from high-temperature rock base for power generation	53	2000
201003: Development of useful animals and plants (excluding microorganisms) through cell fusion or cell nucleus fusion	49	2001

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