

12. Survey Results in “Communication”

12.1. Trends in areas of attention

12.1.1. Digital broadcasting

In October 1996, multi-channel digital broadcasting began in Japan using a CS communications satellite. In December 1996, the Study Group on Satellite Digital Broadcasting Technology of the Ministry of Posts and Telecommunications reported that two-channel digital HDTV broadcasting would become technically possible using a repeater mounted on a BS broadcasting satellite around the year 2000. On the heels of this, the Study Group on the BS-4b Satellite reported in February 1997 that the BS-4b broadcasting satellite to be launched around 2000 should center around digital HDTV. In consideration of the need for a smooth transition from analog to digital, the study groups report recommended that the analog-to-digital transition channel based on analog-digital simultaneous broadcasting be incorporated and that the reception of digital broadcasts using existing analog receiver be made possible through the attachment of an adapter. These studies have paved the way for the dawn of an era of full-fledged digital broadcasting in Japan.

Regarding terrestrial digital broadcasting, the Ministry of Posts and Telecommunications Communications Research Laboratory, the NHK Science and Technical Research Laboratories and the Next-generation Digital Television Broadcasting System Laboratory announced in January 1997 that they would undertake a joint research project on terrestrial digital transmission methods. In March of the same year, the Ministry of Posts and Telecommunications announced that it would carry out the adoption of a broadcasting method and preparation of a channel allocation plan, development of a regulatory framework, etc. so that terrestrial digital broadcasts could begin by the year 2000.

While the current CS digital broadcasting service centers on the multi-channel broadcasting of standard TV programs, BS digital broadcasting is expected to revolve around HDTV, and provides a high-image-quality high-functionality integrated digital broadcasting service incorporating various data transmission services.

The forecasted realization time for “35: Widespread use of integrated digital broadcasts based on ground or satellite waves” was 2009. At the time the survey was conducted, the announcement on the use of the BS-4b satellite had not been made. Taking this into consideration, it is possible that services based on satellite waves will spread more quickly. As part of the topic “14: Practical use of waveform equalizers and Orthogonal Frequency Division Multiplexing (OFDM) for mobile TV reception”, the realization time for OFDM, a modulation method considered promising for terrestrial digital broadcasting, was forecasted as 2006.

The following topics are expected to be realized before the forecasted realization time for the widespread use of an integrated digital broadcasting service “42: Development of a home TV set capable of automatic search, recording and replay of up to several hundred programs” (an important technology for the realization of an integrated digital forecasting service) and “30. Practical use of information filters that automatically sort large amounts of information and selectively choose only those items needed” (to allow viewers to selectively record and replay TV programs that they wish to watch). The survey results confirmed that a suitable environment for the realization of a high-image-quality high-functionality integrated digital broadcasting service was developing.

The integrated digital broadcasting service is an evolving one. New features, which have not even been conceived at the present time, will gradually be introduced. To address this, “54: Development of a digital broadcasting technology that allows flexible changes in the broadcasting mode” (forecasted realization time 2007) is desired. With image pickup and display, “27: Development of a 4,000 × 4,000 pixel high-definition display, image sensor, etc.” is forecasted to be realized by 2005, and R&D efforts are expected to make further progress towards superior image quality in the future. At present, a project aimed at commercializing a 40 in.-class high-definition display by the Nagano Winter Olympics in 1998 is in progress, while the realization time for “28: Practical use of 90 in. large wall-mountable high-definition flat color displays” was forecasted as 2005. Thus, there are great expectations for large wall-hung TVs.

The forecasted realization times for some topics including the following were in the 2009~2011 range “40: Development of a 3-D TV system capable of displaying hidden portions of an object in response to a shift in the focus of the eye” “41: Widespread use of binocular stereoscopic TV broadcasts that can be enjoyed at home” and “44: Practical use of an ultra-low bit rate encoding method for high quality image and sound signals.” It is expected that, if these technologies are realized, digital broadcasting services will be further expanded and enhanced.

To enhance the content of broadcasting services, it is essential to bolster the content production structure. R&D on desktop program production (DTPP), which allows diverse images, such as high-definition images and 3-D images, to be created, composed and processed freely, has already begun. The realization times for topics relating to some component technologies for this system are as follows “47: Practical use of virtual studio technology capable of taking images of an object from difficult angles” (2008); and “46: Development of a TV program production technology capable of converting a scenario to an actual visual format” (2014).

In the face of an approaching aging society, R&D on the receiver human interface as part of the implementation of easy-to-use broadcast receivers will become an important task. The following technologies will also be incorporated in future broadcasting services “31: Practical use of information media conversion technologies such as a sign language interpretation communication system” and “32: Practical use of a support system for visually-impaired persons that converts visual images into audible sounds etc..”

(Keiichi Kubota)

12.1.2. Move towards ultrafast intelligent networks

Since the announcement of the GII (Global Information Infrastructure) concept by the US Vice President in March 1994, the development of information superhighways on a global-scale, including developing countries, has been making a steady progress. In Japan, a shared multimedia use experiment was conducted by NTT over two and a half years starting in September 1994 using a 10 Gb/s backbone network and 156 Mb/s access circuits, and technological know-how for the development and utilization of ultrafast high-capacity networks etc. is being accumulated. With definite needs for services such as telemedicine and telelectures or VOD (Video on Demand) emerging, the importance of R&D for ultrafast intelligent networks aimed at further reducing communications costs is increasing.

Around 1993, Internet use became easier and more common as information supply via WWW (World Wide Web) and information retrieval using WWW browsers started to spread rapidly. In 1994, services by commercial Internet access providers began, thus expanding the Internet, which was until then academically oriented, to include private companies and individuals as users. This has resulted in the Internet share of the combined capacity of Japan-US communications circuits exceeding the telephone share in 1996. Through the establishment of security technologies, the Internet will be also be used for electronic commerce in the future.

(1) Ultra high-speed high-capacity network configuration technologies

“03: Practical use of modes of transmission over extremely long distances without repeaters based on an ultra low loss optical fiber cable” (forecasted realization time 2009) is expected to contribute to cost reductions in international information highway, while “05: Development of an optical fiber communication method based on the manipulation of the quantum state of photons” (forecasted realization time 2013) may possibly bring about a dramatic increase in the capacity of optical communications. The realization times for “10: Practical use of optical switching equipment that directly switches light signals” (aimed at ultra high-speed signal switching) and “11: Development of high-speed switching devices using high-temperature superconductors” are forecasted to be 2009 and 2012, respectively. In the application area, “08: Development of a super high-speed communications protocol capable of achieving a throughput of hundreds of Mbps” is forecasted to be realized by 2003.

(2) Intelligent network technologies

There are high expectations for networks to make advanced services possible, with “61: Widespread use of ambulance-hospital data communication systems for the transmission of images etc. for emergency

medical care” “62: Practical use of a technology that ensures a crash-proof network” and “63: Practical use of integrated building management systems etc.” which are linked to an earthquake detection system forecasted to be realized by 2006, 2008 and 2011, respectively.

(3) Security technologies

As a large number of unspecified persons try to conduct business and carry out commercial transactions via networks such as the Internet, the establishment of security technologies, such as authentication and encryption, become very important. The realization times for “67: Widespread use of electronic commerce carried out via a network” “66. Widespread use of on-line seal-less document preparation services for various official documents such as contract documents” and “68: Widespread use of a security technology that automatically monitors illicit activities involving info-communications ethics are forecasted 2006, 2008 and 2009, respectively.

(Toyomichi Yamada)

12.1.3. Mobile communication

Since the early 1990s, mobile communication has spread at a remarkable rate following an easing in government regulations in this area, with other possible factors involving advances in equipment performance and increased mobility in people’s lives. While the term personal communication in many cases refers to mobile communication, it is also very much a reflection of the ongoing shift in the identities of the information sources from companies and governments to individuals. The sight of female senior high school students carrying around paging terminals (beepers), PHS (Personal Handyphone System) receivers or mobile phones has become common place. This demand has arisen from independent-minded teenagers needs to keep personal information among themselves without being intruded on by parents and teachers. The business sector is in the process of undergoing a major change. For example, mobile phones provide each sales representative with a mobile office, while navigation systems, such as the GPS (Global Positioning System), supply drivers with traffic information relating to fuel efficiency and safety.

The widespread use of mobile communication is a phenomenon that has inevitably arisen from the convergence of the following two social trends: the information age and the mobile age. Information entices people to move, people need information to move, people exchange information, while they are on the move, and so on. Some selected topics from the 6th technological forecast survey will be discussed below to predict the future direction of this field.

(1) Development of millimeter wave devices

Millimeter waves, which have the shortest wavelengths among all radio waves, not only make high-speed telecommunication possible but are also suitable for distance measurement as in the case of radar. As such, they play a central role in ITS (Intelligent Transport Systems), with strong expectations expressed for the development of devices based on them.

(2) Subminiature variable directional planar antennas for mobile stations

Antennas that receive and transmit radio waves, particularly small antennas that save space, are indispensable for mobile communication. Directivity is a powerful property in avoiding the emission or reception of unwanted radio waves, and variable directivity is also indispensable for mobile communication. R&D aimed at obtaining superior characteristics than are possible from the current lines of development, which depend on modulation, coding and diversity, is required.

(3) Mobile communication at speeds greater than 10 Mbps

Mobile communication is not limited to voice transmission. Today’s widespread use of notebook PCs or PDAs (Personal Digital Assistants) has given rise to expectations for an integration of these devices with radio communication. The devices handle digital data and images, which necessitate the transmission of large volumes of data. Multimedia has penetrated the area of mobile communication.

(4) Practical use of low earth orbit satellite communication

This is a type of mobile communication that reaches anywhere on earth, including blind spots of terrestrial mobile communication. As it has a position determining function similar to that of GPS, feature-rich services will be possible.

(5) Emergency mobile communication for distress situations

In light of the fact that mishaps could happen anytime anywhere, mobile communications capability to determine locations and establish radio contact is a particularly great asset. Satellite use is a possibility.

(6) Development of small-size light-weight batteries for portable communications terminals

The promotion of the widespread use of mobile communication boils down to the advancement of battery development. As discussed in 12.1.3. (3), with high-speed large-volume data communication being the central feature of mobile communication, high capacity batteries are essential, as the high-speed transmission of a large volume of data would result in a large energy consumption.

In summary, there are expectations for the development of devices that support high-speed large-volume data transmission, as a consequence of the evolution from voice communication to multimedia communication, including batteries, as well as that of additional mobile communication features, such as a truly global communication coverage, instead of limited area coverage, and the determination of the locations of mobile stations.

(Masao Nakagawa)

12.1.4. Advances in multimedia communication

One of the typical examples of technological innovation this century is computer technology. A few years ago, computers reached the level of sophistication where they are capable of handling a wide range of data, including human languages, voices, still images, animation and full-motion videos, apart from numerical data ó giving rise to the advent of multimedia, a symbolic event for the 1990s. Compared to a previous-generation technology known as new media, which was a buzz word of the 1980s, computer and computer-related technologies have come a long way. For example, the introduction of ISDN in the 1980s resulted in a dramatic increase in data transmission speed from the previous 1.2~9.6 Kbps range based on analog telephone networks to the 64 Kbps~1.5 Mbps range, and this has now been further increased to the 100~600 Mbps range, which represents a nearly 10,000 fold performance improvement. Alongside this, data compression technologies based on digitization, combined with fast computer processing speeds, have made the transmission of animation and full-motion videos possible, thus setting a technological foundation on which multimedia technology can flourish. Through computer chip downsizing (fruit of micromachining technology), the operating frequencies of PCs have surpassed 100 MHz, paving the way for the comfortable handling of voice and animation/full-motion videos, and this has made multimedia suddenly accessible to everyone.

As well as mixed-media presentation, the concrete goals of multimedia technology include real-time response and bidirectional communication. In this regard, the Internet, which has shown rapid growth over the last couple of years, can be taken as embodying the essence of multimedia, for it is capable of transmitting different types of data encompassing most forms of expression used in human communication ó such as hand-written characters, printed characters, illustrations, maps, photos, still images, animation/full-motion videos, speeches/conversations, and musical sound as well as bidirectional communication, although it has limited abilities regarding real-time response. Tasks that remain include improving content quality and the price/performance ratio, as well as general performance enhancement, encompassing transmission capacity, transmission speed, processing speed, storage capacity, and the like through a synergy of improvements in multimedia component technologies.

One area of expectation relating to multimedia communication is video-on-demand (VOD) services, which cater for the needs for customized information supply, as opposed to the conventional distribution of

uniform information via broadcasting. The forecasted realization times for “30: Practical use of information filters that automatically select desired data only” and “48: Widespread use of a motion video image replay/transmission and home reception/recording system which is 10 times as fast as the normal speed” were 2005 and 2009, respectively.

In further advancing multimedia communication, the importance of video compression technologies, such as MPEG2 (Moving Picture Expert Group phase 2) and MPEG4, will increase in the future. The forecasted realization times for “45: Development of an encoding technique that can compress motion video image information to about 1/250 of the original size” and “44: Practical use of an ultra-low bit rate encoding method for high quality image and sound signals” were 2008 and 2009, respectively. On the other hand, the forecasted realization time for both “36: Widespread use of communication systems for retrieval of still or motion video information from electronic libraries” and “39: Widespread use of a multimedia protocol that handles different media protocols” was 2008.

With advances in multimedia, the importance of computer intelligence and human interface will increase in the future. The forecasted realization times for “38: Development of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality” and “31: Practical use of information media conversion technologies such as a sign language interpretation communication system” were 2012 and 2009, respectively. On the other hand, the forecasted realization times for “51: Widespread use of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more” “52: Practical use of technologies capable of automatically turning written information into speech of a quality level nearly equal to that of human speech” and “55: Widespread use of multi-modal environments as a common means of human-computer interface” topics all relating to human interface, were 2008, 2007 and 2009, respectively, i.e. basically the same period.

While computer processing power is tied closely to the transmission capacity of multimedia communication, there are numerous instances of purpose-specific computer processing power making headway regardless of progress in communication technology. A typical example is virtual reality (VR), a cutting-edge multimedia area where ultra high-speed image processing and real-time response are pursued to the limit. The forecasted realization time for “57: Widespread use of image communication systems designed to closely interconnect satellite offices” was 2009. Other examples of cutting-edge multimedia communication include a high-quality teleconferencing system via a 156 Mbps transmission line based on MPEG2 video compression technology and the ATM (Asynchronous Transfer Mode) protocol, ultra high-speed computer-to-computer communication taking place at a data rate of 622 Mbps, and the creation of an imaginary space called cyberspace. Days when physical distribution and commercial transactions (electronic settlement of accounts) are carried out electronically, in addition to information exchange, will not be so far away. Indeed, once reliable security technologies are in place, they will spread like wildfire.

(Shigeru Ueda)

12.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

Table 12.2-1 Forecast Topic Framework for Communication Field

Domain Objective	Transmission technology	Switching technology	Satellite and mobile communication technology	Broadcasting, multimedia communication and intelligent system technology	Networking technology	Security technology	Common element technologies
Pursuit of human touch, culture and comfort and enhancement of measures to cope with aging of population			14	27 28 29 30 31 32 33 34 35 36 37			71
Pursuit of personalized/privatized information and convenience	01 02		15 16 17 18 19	38 39 40 41 42 43	58 59 60	66 67	72 73
Pursuit of greater efficiency and cost cutting	03 04 05 06 07 08	10 11 12 13	20 21 22 23	44 45 46 47 48 49 50			74
Environmental protection, recycling, improvement of social environment and problem solving			24 25		61		75 76 77
Provision of sense of security and reliability (disaster preparedness, safety, privacy protection, etc.)			26		62 63 64 65	68 69 70	78
Greater user-friendliness (improved ease of use and interaction)	09			51 52 53 54 55 56 57			

* Figures appearing in the table represent topic numbers.

12.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 62.5 for topics in the communication field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. 01. Practical use of a highly secure next-generation Internet that allows the transmission of real-time information was rated most important (92 points), while 37. Realization of electronic courts based on a teleconferencing system and electronic filing system was rated least important (37 points). As many as 7 topics featuring in the top 20, including No. 1 and No. 2, related to pursuit of personalized/privatized information and convenience.

Table 12.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
01 <u>Practical use</u> of a highly secure <u>next-generation internet</u> that allows the transmission of real-time information, leading to the implementation of internet-based telephone services and motion video broadcasts.	92	2003
72 <u>Development</u> 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
63 <u>Practical use</u> 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 <u>non-direct-hit earthquake</u> , <u>taking advantage of the time lag to the arrival of seismic waves</u> .	86	2011
67 <u>Widespread use</u> of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	85	2006
08 <u>Development</u> of a super high-speed computer communication protocol capable	84	2003

Topic	Degree of importance index	Forecasted realization time (year)
of achieving a <u>throughput</u> of hundreds of Mbps.		
09 <u>Widespread use</u> 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
74 <u>Practical use</u> 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
68 <u>Widespread use</u> 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.	81	2009
38 <u>Development</u> of an automatic Japanese-English, English-Japanese speech translation telephone system comparable to human simultaneous interpretation in service quality.	81	2012
66 <u>Widespread use</u> 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.	79	2008
19 <u>Practical use</u> of a personal mobile communication system that enables communication with anyone anywhere in the world through advances in distributed databases and personal ID technology.	79	2008
62 Advancements in the autonomous distributed control of wide-area communication network management, leading to the <u>practical use</u> of a technology that ensures a crash-proof network.	79	2008
18 <u>Practical use</u> of a personal mobile communication system with a bandwidth of at least 10 Mbps capable of providing multimedia services.	74	2006
35 <u>Widespread use</u> of integrated digital broadcasts based on ground or satellite waves (a service that dynamically combines standard TV, HDTV, and voice and data communication).	73	2009
30 <u>Practical use</u> of information filters that automatically sort large amounts of information and selectively choose only those items needed.	72	2005
51 <u>Widespread use</u> of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more.	72	2008
12 <u>Practical use</u> of automatic protocol conversion technology, enabling easy interconnection of various communications networks.	72	2006
61 <u>Widespread use</u> of ambulance-hospital data communication systems for the transmission of images and emergency medical care instructions.	72	2006
06 <u>Development</u> of millimeter wave semiconductor devices for use in wireless LANs, radar for vehicle collision prevention systems, etc.	71	2003
69 <u>Widespread use</u> 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.	71	2009

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

12.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below. With 60% of the topics in the communication field forecasted to be realized between 2006 and 2010, forecasted realization times were generally earlier than the general trend covering all topics.

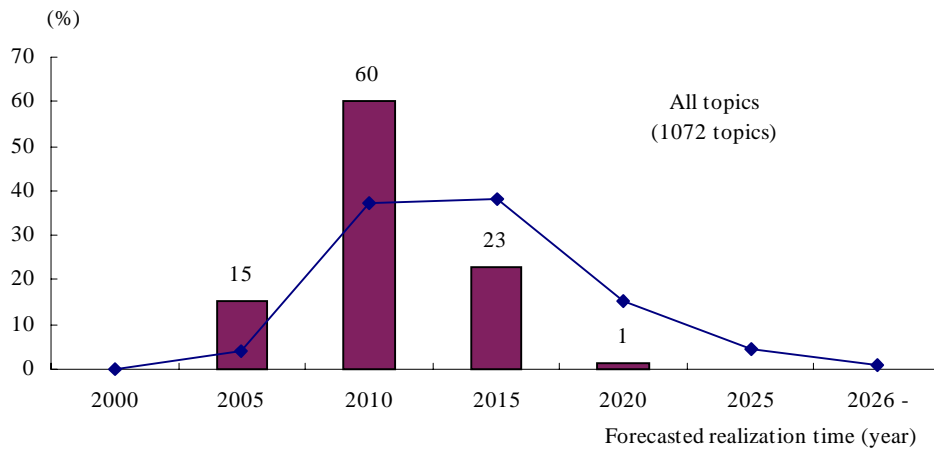


Fig. 12.4-1 Trends in Forecasted Realization Times

12.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Although the U.S. was named by the greatest number of respondents in the communication field as a whole, Japan followed fairly closely, highlighting the leadership role played by the two countries in technological development. In contrast, the third-placed EU and other countries/regions were rated extremely low.

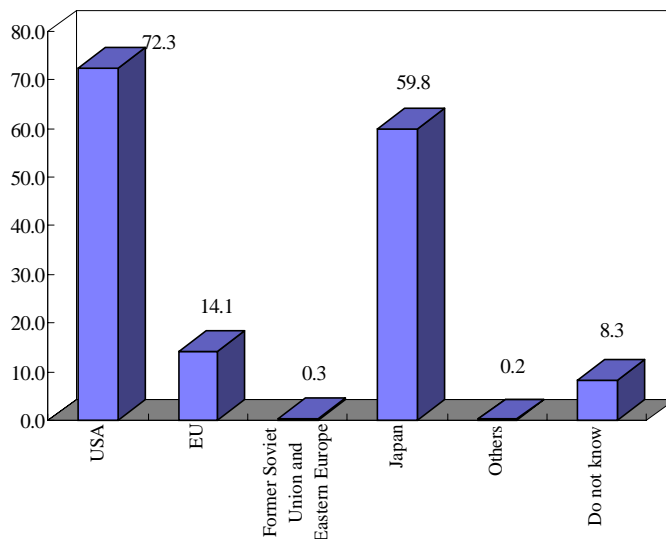


Fig. 12.5-1 Current Leading Countries etc. (%)

12.6. Comparison with the 5th Survey (previous survey)

Of the 78 topics included in the latest survey, 19 (24%) were identical to the previous survey, 16 (21%) were modified, and 43 (55%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 9 topics and fell for 10. 04. Development of non-linear optical fiber transmission methods applying non-linear effects saw the greatest jump, up 11 points, while 03. Practical use of modes of transmission over extremely long distance without repeaters based on realization of optical fiber with ultra low rate of transmission loss saw the greatest drop, down 13 points.

Forecasted realization times were pushed further into the future for all topics, by 1 to 7 years. The topics whose forecasted realization times were pushed back 7 years were 20. Development of ultra-high sensitivity receiving technologies of terahertz-band electromagnetic waves based on high-temperature superconductive Josephson devices and 21. Practical use of high-output semiconductor microwave amplifiers in broadcasting satellite etc.

Table 12.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
03 <u>Practical use</u> of modes of transmission over extremely long distance without repeaters based on realization of <u>optical fiber with ultra low rate of transmission loss</u> (less than 0.01 dB/Km), enabling installation of Japan-Hawaii optical trunk line without repeaters.	71/2009	84/2003
04 <u>Development</u> of <u>non-linear</u> optical fiber transmission methods applying solitons, induced Raman effect, and other non-linear effects.	59/2007	48/2005
05 <u>Development</u> of an optical fiber communication method capable of reducing the impact of quantum noise through the manipulation of <u>the quantum state of photons</u> .	54/2013	48/2012
07 <u>Development</u> of communications systems based on electromagnetic waves outside the visible to infrared light spectrum and <u>radio wave</u> (e.g., applying far infrared light or ultraviolet light).	48/2010	45/2006
10 <u>Practical use</u> of optical switching equipment that switches <u>light signals without converting into electrical signals</u> .	71/2009	81/2007
11 <u>Development</u> of A/D converters and high-speed switching devices using high-temperature superconductors.	49/2012	54/2007
12 <u>Practical use</u> of automatic protocol conversion technology, enabling easy interconnection of various communications networks.	72/2006	79/2002
13 <u>Practical use</u> of satellite systems capable of switching multiplexed signals transmitted from numerous ground stations.	60/2007	63/2003
15 <u>Practical use</u> of subminiature variable directional planar antennas for mobile objects.	59/2005	63/2001
20 Realization of high-temperature superconductive Josephson devices, leading to the <u>development</u> of ultra-high sensitivity receiving technologies of terahertz-band electromagnetic waves which use harmonics mixing mechanisms.	45/2013	55/2006
21 <u>Practical use</u> of semiconductor microwave amplifiers with high outputs comparable to those of TWTs (Traveling Wave Tubes), leading to its application to broadcasting satellite etc.	58/2009	64/2002
36 <u>Widespread use</u> of communication systems for retrieval of still or motion video information from electronic libraries (containing character data, books, still videos, movies, TV, documentary films, etc.) through broad-band lines.	66/2008	60/2005
44 <u>Practical use</u> of an ultra-low bit rate encoding method for high quality image and sound signals, which are almost indistinguishable to original signals (at 10 Mbps or less for HDTV-class images with a 1/100 data compression, and 64 kbps or less for CD-class sounds).	63/2009	67/2003

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
51 <u>Widespread use</u> of character recognition technologies which enable a recognition rate with handwritten Chinese character of 99% or more.	72/2008	63/2003
52 <u>Practical use</u> of high-quality speech synthesizing technologies for <u>automatically</u> turning written information into speech of a quality level <u>nearly equal to that of human speech</u> .	60/2007	58/2003
53 <u>Practical use</u> of large-scale adaptive digital filters., eliminating howling caused by interference between microphones and speakers and deterioration in sound quality.	45/2006	50/2000
56 <u>Widespread use</u> of 3-D teleconferencing based on highly realistic 3-D imaging devices.	44/2013	43/2011
61 <u>Widespread use</u> of ambulance-hospital data communication systems for the transmission of images and emergency medical care instructions.	72/2006	67/2003
65 <u>Widespread use</u> of interconnected home security systems with functions such as crime and disaster prevention as a <u>community-wide security system</u> .	59/2010	54/2006

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)				Expected effect (%)			Forecasted realization time					Leading countries (%)					Measures the government should adopt (%)					Potential problems (%)								
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001 2006 2011 2016 2021 2026					USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	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)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
					Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	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)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects															
Switching technology	11	Development of A/D converters and high-speed switching devices using high-temperature superconductors.	1	125	4	18	78	53	20	54	23	2	66	13	9	28		8	13	65	23	1	52	2	17	45	30	20	0	42	0	0	2	3	6	4		
			2	114	4	18	77	49	12	64	22	3	77	11	4	25		8	5	75	20	1	58	1	11	55	29	16	2	48	0	1	2	3	4	2		
			X	5	100	0	0	63	25	75	0	0	80	0	0	0		0	0	100	20	0	40	0	0	100	0	0	0	40	0	0	0	0	0	20	0	
	12	Practical use of automatic protocol conversion technology, enabling easy interconnection of various communications networks.	1	208	17	35	48	70	45	44	10	1	86	4	35	9		4	6	80	17	0	35	0	12	42	36	16	3	29	18	1	0	31	13	2		
			2	184	19	33	48	72	48	47	6	0	90	2	35	5		2	3	86	11	0	32	0	7	52	34	13	1	32	18	2	1	32	10	1		
			X	35	100	0	0	77	56	41	3	0	91	0	37	3		3	6	89	11	0	34	0	3	37	37	14	0	29	23	3	0	43	11	0		
	13	Practical use of satellite systems capable of switching multiplexed signals transmitted from numerous ground stations.	1	199	13	36	51	61	32	48	20	1	78	20	31	5		3	5	82	22	3	44	0	8	39	23	21	2	43	19	1	2	20	10	3		
			2	172	13	34	53	60	27	59	14	0	84	15	28	3		2	3	89	17	1	52	0	5	42	21	21	0	53	14	2	1	23	7	1		
			X	22	100	0	0	63	33	52	14	0	77	18	27	9		5	9	95	32	0	64	0	5	41	27	27	0	64	14	0	0	14	9	0		
Satellite and mobile communication technology	14	Practical use of waveform equalizers, Orthogonal Frequency Division Multiplexing (OFDM), etc. capable of adapting to rapidly fluctuating radio reception conditions, making high-quality TV reception possible even in traveling motor vehicles or trains.	1	170	25	32	43	61	30	53	16	1	77	1	67	4		2	4	59	45	1	54	0	11	48	31	22	1	36	18	1	2	19	17	4		
			2	146	24	34	42	62	30	59	10	1	81	1	72	1		1	1	66	49	0	64	0	8	53	29	18	0	39	20	2	2	23	15	2		
			X	35	100	0	0	79	62	32	6	0	91	0	77	3		0	0	57	69	0	57	0	0	60	26	20	0	63	20	0	3	17	17	0		
	15	Practical use of subminiature variable directional planar antennas for mobile objects.	1	159	13	38	48	57	24	59	16	1	74	3	56	4		1	7	67	26	1	69	1	13	42	23	17	1	31	10	1	1	18	9	3		
			2	140	14	37	49	59	23	66	10	1	83	0	62	1		0	4	75	21	0	78	0	8	51	24	14	1	33	10	1	0	18	4	1		
			X	20	100	0	0	68	42	47	11	0	80	0	65	5		0	0	75	30	0	85	0	0	45	35	25	0	25	0	5	0	20	5	0		
	16	Widespread use of battery-free wireless cards in automatic train ticket inspection and physical distribution systems.	1	181	10	29	60	69	43	47	9	1	81	7	73	3		1	3	64	33	0	65	1	10	29	37	12	2	25	35	3	1	47	18	2		
			2	159	10	23	67	70	42	53	4	1	81	4	75	1		0	3	70	31	0	76	0	7	31	39	8	0	22	45	3	2	52	16	1		
			X	16	100	0	0	80	60	40	0	0	88	0	63	6		0	0	63	50	0	81	0	0	31	38	31	0	25	25	0	0	50	13	0		
	17	Practical use of super high-speed wireless LANs capable of a bit rate of 600 Mbps, and advances in the shift towards wireless communication with office and home information systems.	1	225	17	40	44	59	29	52	17	2	80	4	64	4		1	5	81	18	1	59	0	7	42	28	20	1	28	34	1	7	40	10	4		
			2	191	17	39	45	61	28	61	11	0	85	3	66	2		1	1	86	12	0	61	0	5	48	21	15	0	25	42	2	3	48	10	2		
			X	32	100	0	0	66	35	58	6	0	84	3	59	6		0	0	91	19	0	59	0	0	47	19	34	0	31	38	3	0	47	6	0		
	18	Practical use of a personal mobile communication system with a bandwidth of at least 10 Mbps capable of providing multimedia services.	1	237	24	34	42	72	48	44	8	0	87	5	73	4		3	1	80	33	0	64	0	7	43	29	14	0	31	44	1	4	41	21	3		
			2	205	21	34	44	74	50	46	5	0	83	2	78	0		1	0	83	32	0	71	0	4	46	27	9	0	28	54	1	2	47	17	1		
			X	44	100	0	0	85	72	26	2	0	89	0	73	0		0	0	82	50	0	77	0	0	55	32	25	0	43	39	5	5	48	7	0		
	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.	1	242	22	38	40	77	57	39	4	0	85	15	74	6		0	1	87	46	1	54	0	3	39	35	12	2	34	48	3	0	52	26	2		
			2	208	21	39	40	79	60	38	2	0	88	7	77	3		0	0	92	50	0	59	0	2	45	31	10	1	32	56	2	0	59	29	0		
			X	43	100	0	0	87	74	26	0	0	91	9	70	2		0	0	88	58	0	60	0	0	42	35	19	2	37	40	0	2	67	23	0		
	20	Realization of high-temperature superconductive Josephson devices, leading to the development of ultra-high sensitivity receiving technologies of terahertz-band electromagnetic waves which use harmonics mixing mechanisms.	1	95	5	26	68	45	11	49	38	1	65	9	20	32		8	21	66	16	2	51	1	19	49	24	20	0	48	1	1	3	6	4	5		
			2	83	5	22	73	45	12	47	37	4	71	4	12	24		10	8	72	12	2	53	1	14	61	24	13	0	57	0	1	1	6	4	2		
			X	4	100	0	0	75	50	50	0	0	75	0	25	0		0	0	25	0	0	25	0	50	75	25	0	0	50	0	0	0	0	0	0	0	

(Note) See page 7 for the interpretation of the graphs.

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					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources						USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	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)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects
					2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)																										
Broadcasting, multimedia communication and intelligent system technology	41	Widespread use of binocular stereoscopic TV broadcasts that can be enjoyed at home.	1	175	14	25	61	42	13	36	46	6	47	1	63	6		15	15	45	14	0	64	1	15	34	23	10	0	23	5	5	0	5	17	6		
			2	155	12	22	66	39	9	34	52	5	43	0	74	3		14	10	45	9	0	72	1	12	46	22	7	0	21	3	5	0	3	19	3		
			X	19	100	0	0	54	26	42	26	5	47	0	58	5		21	0	42	16	0	95	0	0	42	16	5	0	37	5	16	0	0	16	16		
	42	Development of a home TV set capable of automatic search, recording and replay of up to several hundred programs.	1	199	20	26	54	50	15	58	26	2	64	1	71	10		3	3	70	13	0	58	1	10	26	27	13	4	21	23	3	0	8	26	2		
			2	175	18	22	60	49	10	66	24	1	61	0	82	5		2	1	76	9	0	62	0	9	33	30	8	1	18	29	2	0	2	27	1		
			X	31	100	0	0	60	29	52	19	0	74	0	94	0		3	0	81	6	0	77	0	0	26	32	6	0	32	42	3	0	6	35	0		
	43	Practical use of portable information terminals approximately of the size of a watch which are capable of transmitting/receiving images, sound and data worldwide.	1	231	16	33	51	64	36	49	14	0	76	7	72	6		7	5	66	15	0	74	1	8	38	29	16	1	32	20	2	1	24	24	2		
			2	202	15	30	55	61	28	60	11	0	72	3	78	2		6	2	70	14	0	86	0	2	42	28	12	0	35	22	2	1	23	27	1		
			X	31	100	0	0	77	55	42	3	0	77	3	77	0		10	0	84	13	0	87	0	0	48	35	16	0	42	26	3	3	19	32	0		
	44	Practical use of an ultra-low bit rate encoding method for high quality image and sound signals, which are almost indistinguishable to original signals (at 10 Mbps or less for HDTV-class images with a 1/100 data compression, and 64 Kbps or less for CD-class sounds).	1	200	20	27	53	64	35	54	9	2	73	8	56	13		8	7	74	29	0	70	1	9	51	25	12	3	31	6	3	0	5	13	3		
			2	174	21	25	55	63	30	66	3	1	79	5	59	7		7	4	80	21	0	76	0	7	58	20	9	1	32	5	3	0	2	13	2		
			X	36	100	0	0	75	53	44	0	3	78	3	64	11		11	3	78	19	0	89	0	3	61	22	14	0	39	8	3	0	3	11	6		
	45	Development of an encoding technique that can compress motion video image information to about 1/250 of the original size.	1	186	19	26	55	63	34	53	12	1	73	4	52	11		2	9	76	31	1	63	1	9	51	22	12	1	33	3	3	0	4	11	4		
			2	162	17	27	57	60	25	67	7	1	79	2	52	6		2	8	83	24	1	70	0	7	61	15	9	0	36	2	2	1	2	8	2		
			X	27	100	0	0	69	41	56	4	0	78	0	67	7		0	7	81	30	4	85	0	4	70	15	11	0	48	4	0	4	0	7	7		
	46	Development of a TV program production technology capable of converting a scenario to an actual visual format.	1	102	19	21	61	42	13	39	40	9	57	3	41	19		19	15	44	4	0	30	0	25	40	25	9	3	23	5	3	0	5	24	1		
			2	88	15	24	61	41	9	41	46	4	65	0	40	17		18	11	57	1	0	30	0	20	48	23	7	1	26	3	3	0	1	24	1		
			X	13	100	0	0	73	50	42	8	0	62	0	62	23		8	15	85	0	0	69	0	0	54	31	15	0	54	8	8	0	0	46	0		
	47	Practical use of virtual studio technology capable of taking images of an object from difficult angles.	1	113	15	22	63	45	11	50	35	4	56	5	44	12		3	5	69	9	0	42	2	8	39	29	16	0	23	3	4	1	7	16	4		
			2	104	13	17	69	42	8	49	42	2	65	3	40	11		3	2	73	4	0	46	2	7	45	26	14	0	17	2	2	1	4	16	2		
X			14	100	0	0	68	43	43	14	0	71	14	50	14		0	7	71	7	0	79	0	7	43	29	14	0	36	7	0	7	14	29	7			
48	Widespread use of a motion video image replay/transmission and home reception/recording system which is 10 times as fast as the normal speed, leading to the introduction of video-on-demand services based on broadband ISDN communication, etc.	1	212	17	30	52	55	24	51	22	2	73	2	65	3		6	2	74	16	0	64	0	6	32	29	14	1	25	19	2	0	8	23	2			
		2	181	14	31	54	53	17	62	20	2	75	1	73	1		6	1	83	10	0	69	0	4	41	29	12	0	27	20	3	0	3	25	1			
		X	26	100	0	0	71	50	38	8	4	81	0	85	0		4	0	85	15	0	81	0	0	46	27	23	0	35	23	4	0	8	35	0			
49	Practical use of "electronic secretary" terminals featuring an information agent function for schedule management and database access via a network, as well as voice recognition and fuzzy search functions.	1	224	17	24	60	58	27	53	19	2	78	4	71	9		3	4	81	16	0	50	0	8	40	28	13	4	26	10	3	0	27	24	3			
		2	195	16	19	65	55	20	64	15	2	77	1	75	4		2	2	87	11	0	49	0	5	54	29	8	2	25	8	2	0	22	22	3			
		X	31	100	0	0	74	50	47	3	0	77	3	77	6		0	0	87	10	0	65	0	0	65	35	13	0	42	10	6	0	13	35	0			
50	Spread of various multimedia networks, leading to the practical use of a system that automatically chooses the most suitable network in terms of communication medium and service quality relative to the cost according to the intended purpose of the user.	1	206	26	27	47	59	29	50	21	1	68	2	67	4		1	4	73	13	0	42	0	15	32	22	10	1	20	21	3	0	17	17	3			
		2	177	20	29	51	54	17	66	17	0	68	1	76	2		1	3	82	7	0	43	0	10	44	24	5	0	21	22	3	0	14	16	1			
		X	35	100	0	0	68	38	59	3	0	69	0	74	3		0	3	91	9	0	51	0	0	49	31	3	0	26	26	6	0	14	26	0			

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																	2001	2006	2011	2016	2021	2026																	
Networking technology	61	Widespread use of ambulance-hospital data communication systems for the transmission of images and emergency medical care instructions.	1	195	11	29	61	71	48	42	10	1	37	2	98	2		0	1	72	18	0	46	1	16	27	35	16	7	48	31	4	0	29	18	2			
			2	173	9	27	65	72	47	44	9	0	32	1	95	1		1	1	79	13	0	47	0	13	29	39	11	5	61	34	2	0	30	18	1			
			X	15	100	0	0	87	73	27	0	0	33	0	93	0		0	0	80	13	0	80	0	0	33	40	27	0	73	47	0	0	40	40	0			
	62	Advancements in the autonomous distributed control of wide-area communication network management, leading to the practical use of a technology that ensures a crash-proof network.	1	188	22	36	41	76	56	37	6	1	78	6	49	6		3	3	81	21	0	60	0	7	46	22	20	1	28	8	2	0	15	7	2			
			2	162	20	38	42	79	60	36	3	0	86	4	49	2		0	1	88	15	0	68	0	3	58	20	15	1	31	6	1	0	14	5	1			
			X	33	100	0	0	89	79	18	3	0	76	6	45	3		0	0	91	15	0	76	0	3	55	9	27	0	30	6	3	0	12	9	0			
	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.	1	125	10	16	74	83	69	25	4	2	43	26	87	4		7	3	29	5	2	64	0	18	36	41	22	3	65	10	1	1	27	10	1			
			2	109	6	7	87	86	75	20	4	1	39	25	89	3		6	2	26	7	2	77	0	12	37	34	18	2	78	7	1	1	37	9	0			
			X	6	100	0	0	83	67	33	0	0	50	33	67	0		0	0	50	33	0	67	0	17	33	17	33	17	100	17	0	0	17	33	0			
	64	Practical use of communication networks allowing the easy control of the network service quality aimed at the efficient utilization of network resources and improvements in heavy-traffic robustness and reliability.	1	204	29	31	40	69	41	51	7	1	83	7	41	4		1	1	79	18	0	59	0	7	43	20	17	1	25	14	2	0	13	9	2			
			2	178	26	32	42	68	38	59	3	0	89	2	38	1		0	0	85	13	0	62	0	4	54	20	11	1	29	10	1	0	11	7	0			
			X	46	100	0	0	74	49	51	0	0	87	2	43	0		0	0	83	20	0	74	0	0	52	13	15	2	26	11	2	0	9	7	0			
	65	Widespread use of interconnected home security systems with functions such as crime and disaster prevention as a community-wide security system.	1	168	8	20	71	63	34	49	15	2	48	6	95	2		6	6	61	15	0	48	0	23	23	35	12	3	34	39	2	0	49	28	1			
			2	145	6	22	72	59	24	65	8	2	42	1	92	1		3	2	70	12	0	50	0	15	26	32	7	0	40	48	1	0	54	27	1			
			X	9	100	0	0	69	44	44	11	0	78	0	89	0		0	0	100	44	0	67	0	0	22	22	22	0	44	67	11	0	44	22	0			
Security technology	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.	1	216	9	28	63	74	52	39	8	0	85	8	68	3		1	4	86	27	0	42	0	6	31	29	8	4	24	58	3	0	62	35	2			
			2	182	8	27	65	79	62	33	5	1	88	5	70	2		1	2	90	22	0	44	1	4	37	28	7	2	24	74	2	0	66	40	0			
			X	14	100	0	0	89	79	21	0	0	93	14	71	0		0	0	100	29	0	57	0	0	43	14	7	7	43	79	14	0	71	36	0			
	67	Widespread use of electronic commerce carried out via a network based on an electronic funds transfer system and electronic money system.	1	225	10	30	60	81	64	32	3	0	89	8	69	4		1	3	92	44	0	40	0	2	29	34	10	5	24	62	3	0	66	38	1			
			2	195	9	28	64	85	72	26	2	1	90	4	68	2		1	1	93	43	0	41	1	1	32	38	6	2	24	77	1	0	67	41	0			
			X	17	100	0	0	91	82	18	0	0	94	12	59	0		0	0	100	29	0	41	0	0	35	35	6	6	29	82	12	0	59	53	0			
	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.	1	186	11	21	68	75	54	35	10	0	75	5	57	12		10	11	79	20	0	25	1	13	35	31	10	3	27	45	2	0	54	37	1			
			2	166	10	19	72	81	64	31	4	0	84	2	59	8		7	7	86	18	0	25	0	7	36	27	6	1	25	62	1	0	59	38	0			
			X	16	100	0	0	88	75	25	0	0	88	6	69	6		0	0	94	19	0	44	0	0	50	31	13	6	31	56	13	0	44	38	0			
	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.	1	187	16	17	67	67	43	43	14	1	73	3	72	6		2	4	75	19	1	61	1	10	43	33	11	4	29	29	2	0	60	34	1			
			2	165	13	18	68	71	46	48	5	1	79	2	72	2		0	2	84	16	0	67	1	5	53	31	8	1	30	33	2	0	64	35	0			
			X	22	100	0	0	84	73	23	0	5	82	0	64	0		0	0	95	9	0	82	5	0	45	59	0	5	50	41	0	0	64	45	0			
70	Realization of high-security communication, and widespread use of electronic secret ballots.	1	176	11	18	72	53	25	41	31	3	55	6	66	2		9	11	57	18	1	29	0	28	23	20	9	3	23	53	3	0	49	48	1				
		2	159	8	15	77	53	21	52	26	2	57	2	75	2		9	6	69	14	0	29	0	22	26	18	7	1	18	71	1	0	57	53	0				
		X	12	100	0	0	81	67	25	8	0	75	8	67	0		8	0	92	17	0	58	0	8	33	33	0	0	42	75	0	0	42	58	0				

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																		2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)													
Common element technologies	71	Practical use of low bit rate high quality video encoding technology capable of a bit rate of around 10 Kbps (with a 1/20,000 data compression) suitable for mobile communication and the Internet.	1	206	15	33	52	65	37	50	13	1	80	6	61	9		13	10	74	28	0	60	1	12	47	25	17	1	32	3	1	0	12	12	2		
			2	180	14	33	53	62	30	59	10	1	82	3	67	2		13	7	82	27	0	67	1	8	59	24	11	1	34	1	2	1	11	10	1		
			X	25	100	0	0	67	40	52	4	4	72	0	84	4		12	8	84	36	0	80	0	0	64	20	20	4	44	0	4	0	8	4	4		
	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.	1	103	6	20	74	86	73	25	3	0	78	49	57	9		1	10	44	17	2	65	0	18	50	22	19	3	49	0	3	21	6	8	2		
			2	90	6	21	73	87	75	21	3	0	87	41	60	1		1	7	44	7	0	79	0	11	59	22	19	1	59	0	2	27	4	7	1		
			X	5	100	0	0	90	80	20	0	0	100	40	80	0		0	0	40	0	0	100	0	0	80	20	20	0	100	0	0	20	0	20	0		
	73	Development of light-reflecting liquid crystal color displays (no backlighting) with the advantage of low power consumption.	1	101	7	25	68	71	46	46	8	0	70	25	50	3		1	8	25	5	1	85	1	6	41	27	13	0	35	0	3	8	2	11	5		
			2	88	6	22	73	71	44	53	3	0	83	17	49	1		0	5	27	1	0	89	1	3	55	22	6	0	39	0	5	7	1	7	3		
			X	5	100	0	0	100	100	0	0	0	100	0	60	0		0	20	20	0	0	80	0	20	40	20	0	0	80	0	0	20	0	20	0		
	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).	1	67	6	15	79	75	55	34	9	2	84	21	37	33		7	21	57	13	0	46	1	19	49	30	24	9	57	0	3	6	6	12	4		
			2	59	5	10	85	82	68	23	9	0	88	12	29	27		8	14	68	2	0	63	3	14	61	25	14	5	58	0	2	5	5	12	5		
			X	3	100	0	0	100	100	0	0	0	67	33	33	33		0	0	67	0	0	100	33	0	100	33	0	33	100	0	0	0	0	0	0	0	
	75	Practical use of a technology that makes power transmission between a space-based and earth-based sites and between space-based sites at microwave frequencies or higher possible.	1	117	3	22	74	57	27	52	17	4	56	68	9	9		9	15	70	8	4	31	0	19	38	26	26	1	50	3	2	40	8	7	2		
			2	103	4	20	76	53	17	65	16	3	52	77	5	4		8	15	82	5	3	33	0	12	46	22	20	0	63	1	2	46	11	3	1		
			X	4	100	0	0	75	75	0	0	25	50	50	0	0		50	0	100	0	0	100	0	0	50	25	25	0	50	0	25	50	0	0	0		
	76	Development of a satellite-borne ultra-high resolution spectroscopy for the monitoring of the upper-atmosphere, capable of discerning the spectral distribution (far infrared to submillimeter range) to an accuracy level of one 10 millionth of the frequency used.	1	54	2	22	76	63	35	44	20	0	39	76	19	28		0	11	67	20	6	43	2	20	54	22	33	2	69	0	2	17	4	6	2		
			2	49	2	20	78	59	27	57	14	2	31	80	4	16		2	12	76	14	0	47	0	14	59	6	27	0	73	0	2	12	0	2	0		
			X	1	100	0	0	100	100	0	0	0	0	100	0	0		0	0	100	100	0	0	0	0	100	0	0	0	100	0	0	0	0	0	0	0	
	77	Practical use of an atomic frequency standard with stability and accuracy levels of 10 ⁻¹⁶ - 10 ⁻¹⁷ .	1	51	4	27	69	53	19	54	27	0	57	14	6	49		4	18	55	24	4	47	0	24	43	14	25	4	47	0	2	6	4	8	2		
			2	49	2	22	76	52	16	61	20	2	59	4	2	41		4	10	59	8	0	49	0	16	55	6	24	0	63	0	2	0	0	10	0		
			X	1	100	0	0	25	0	0	100	0	100	0	0	100		0	0	0	0	0	100	0	0	100	0	0	0	100	0	0	0	0	0	0	0	
	78	Development of a space environmental fluctuation prediction system involving radiation, high-energy particles, etc. that can cause such phenomena as the malfunctioning of satellite-borne equipment, degradation of solar cells, abnormal charging of satellites, etc.	1	49	2	31	67	52	18	53	29	0	45	43	10	24		6	6	82	22	12	41	0	14	47	12	41	6	53	0	2	14	8	0	2		
			2	47	2	30	68	51	15	62	21	2	57	40	4	19		6	6	85	11	2	34	0	9	60	9	30	4	66	0	2	15	0	2	0		
			X	1	100	0	0	50	0	100	0	0	100	0	0	0		0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

(Note) See page 7 for the interpretation of the graphs.