

13. Survey Results in “Transportation”

13.1. Trends in areas of attention

13.1.1. Trends towards computerized and intelligent transportation systems

— Computer-based harmonized transportation systems and elimination of human factors —

In any industrial field, the sophistication of systems through the application of information technology is regarded as a priority issue. In the transportation field, efforts are being made to enhance transportation systems in terms of safety, speed, convenience, efficiency and environmentally friendliness, which are basic requirements for any transportation system, through, for example, an improvement in overall system efficiency via control and guidance and an improvement in safety and efficiency via the elimination of human error mainly by means of sensing and artificial intelligence technology.

In the transportation field, computerization or intelligent systems featured in 18 topics, which were broken down by type of transportation as follows: 3 out of 9 topics for rail and track transportation; 5 out of 23 topics for road transportation; 7 out of 13 topics for water and underwater transportation; 2 out of 11 topics for air transportation; and 1 out of 4 topics for other new transportation. This represents a slight fall from the previous survey.

It is interesting to note that the information technology share of topics was large in areas where hardware has matured, while it was relatively small in areas where there is still considerable room for further hardware development, ranging from more than half for water transportation, e.g. ships, to a mere 2 out of 11 for air transportation.

Although it is not clearly reflected in the topics in the latest survey, computerized systems for which technical feasibility has been fully investigated, such as a uniform fare collection system based on a smartcard, a bus operation information display system and a computerized physical distribution system, already exist, and the large-scale introduction of information technology is now on the agenda.

The three topics from the area of rail and track transportation were “01: Development of intelligent railway vehicles able to obtain improved riding comfort” (2006), “05: Inspection robots” (2008) and “06: Automatic train control system based on the detection of obstacles” (2005), which relate to intelligent systems and robotization centering on sensing. The four topics from the area of road transportation were “10: VR driving simulators” (2002), “14: City traffic control systems” (2007), “19: Motor vehicle driver support system” (2008), and “20: Automatic motor vehicle operation via guidance and control” (2015) and “24: Bridge fatigue monitoring” (2009) which aim to achieve efficient transportation by tackling road congestion via control and guidance, instead of allowing individual vehicles arbitrary operation. Motor vehicles represent highly convenient door-to-door means of transportation, and at present, this is achieved through the independent operation of individual vehicles. However, efforts are being made to develop a control and guidance system capable of bringing collective efficient operation to vehicles based on information technology as well. The seven topics from the area of water and underwater transportation were 36. Fully automatic ships (2014), “37: Autonomous, unmanned, underwater investigation vessels” (2009), “38: CIM for shipbuilding” (2006), “41: Fully automated container yards” (2007), “42: Marine traffic control systems” (2011), “43: Vessel collision avoidance systems” (2007) and “44: High-reliability vessels” (2008), which center on automation and intelligent systems aimed at replacing human judgment with computers to increase operation efficiency. This reflects the present state of shipbuilding and shipping industries. For a long time, ships and boats have been operated as self-contained systems, where the captain is held totally responsible for any accident involving his vessel, without instructions, monitoring or any other form of intervention from outside. Monitoring, control/guidance, full automation, etc., therefore, represent a complete turnaround from traditional practices, and this shows the significance of the impact of information technology and artificial intelligence.

The two topics from the area of air transportation were “53: Computerized air traffic control” (2009) and “54: All-weather fully automatic aircraft takeoff and landing” (2009), which aim to increase safety and

reliability by having computers take over many complex procedures traditionally undertaken by humans. The only topic from the area of other transportation systems was “58: Intelligent wheel-chairs” (2008).

According to a rough classification, component technologies include robotics, sensing/monitoring, control/guidance, and autonomous operation/artificial intelligence application. In rail and track transportation, the systematic operation of trains and cars is a prerequisite. In contrast, the operation of transport vehicles is basically autonomous in road transportation, water and underwater transportation and air transportation, and efforts are focused on control/guidance aimed at the overall harmonized operation of individual vehicles to achieve congestion alleviation, environmental load reduction, efficient operation, etc. A reduction in human involvement in transport vehicle operation itself will lead to a reduction in human errors, which is said to be responsible for 80% of all accidents, and costs. The computerization of and robotization of design, manufacturing and maintenance processes will also lead to a reduction in costs and inspection errors.

In search of safe, efficient and highly-capable transportation systems, the application of information technology is under consideration, with efforts focused on establishing a technology which, while maintaining plenty of freedom and convenience for individual vehicles, increases overall efficiency, reduces tedious work associated with vehicle operation, and is comfortable for vehicle operators and very safe.

(Hiroyuki Yamato)

13.1.2. Sophistication of transportation functions (high speed, convenience and more sophisticated services)

Coinciding with the arrival of an information society, etc., the sophistication of transportation functions is being called for. Instead of single-mindedly evolving in the direction of reducing the movement of people, the information society has added a new meaning to meeting for people and actually increased its importance. For this reason, amid increased sophistication in people’s social lives, demands for faster and more convenient transportation systems are expected to intensify. As people’s leisure life becomes more substantial and their values change, demands for greater comfort during transit have begun to be voiced as an important element of transportation services in addition to simple conveyance. Meanwhile, advances in the aging of the population, etc. have led to consideration for disadvantaged people in transportation, with advanced services, such as the introduction of escalators and elevators at transportation terminals and special arrangements to accommodate wheelchairs, gradually spreading. In various transportation modes, technological development and improvements aimed at increasing the sophistication of transportation functions are taking place, with high expectations expressed in the latest survey.

First of all, in the area of rail and track transportation, the development of 0.4 Superconducting magnetically levitated railways with a maximum speed of 500 km per hour (2011) is under way in pursuit of high-speed transportation. Efforts are also being made to speed up existing wheel traction systems, with 08. Operation of Shinkansen bullet trains at a speed of 350 km/h with environmental protection measures expected to be realized relatively soon (2006). With road transportation systems, a call for environmental friendliness and safety was expressed more frequently than that for high-speed transportation due to their nature of being designed primarily for short-distance transportation. Nevertheless, there are expectations for the development of 15. Dual-mode motor vehicle transportation system in which vehicles travel at ultrahigh speeds along specified sections (2016). With water and underwater transportation systems, “33: Widespread use of sea traffic transportation network systems operating at speeds of 30 knots or faster carrying 300 passengers or more” was forecasted to be realized in the early 21 century (2010) to cater for the needs of commuters and business travelers around major cities. In water freight transportation, the modal shift concept geared towards encouraging a shift from motor vehicle transportation to water transportation has been proposed in view of the energy problems, with expectations expressed for the following topics: “34: Development of an ocean freight transportation facility based on technologies including superconductivity” (2017) and “35: Development of large high-speed boats about 500 tons in dead-weight, constructed entirely of non-steel new materials” (2008). However, regarding the development of an ocean freight transportation facility based on technologies including superconductivity, doubts about its realizability or at least the need for a long development period was raised, partly due to the numerousness of technical problems to be

overcome. In air transportation, current systems are considered to have sufficient high-speed capabilities, compared to other types of transportation systems, with a further speed increase expected through “48: Development of a supersonic passenger capable of speeds up to Mach 3~4 with a maximum of 300 passengers on board” though its forecasted realization time is rather distant (2016).

Many of the forecast topics relating to improvements in convenience and sophistication in service, rather than high speed involve people’s needs. In rail and track transportation, inter-company mutual train operation arrangements have been established for various subway and suburban railway lines to improve user convenience. Although these arrangements are sometimes impossible, when connecting lines use different rail gauges, the early realization (2007) of “02: A system that enables railway vehicles mounted on motorized-trucks to roll onto tracks of different rail gauges” is expected. Rail freight transportation is important in view of global environmental problems etc., and the task ahead is believed to lie with connection on to road transportation, with “03: A system in which road trucks become railway vehicles” (2009) under development. In road transportation, hopes were pinned on “14: Widespread use of road traffic control systems for optimal control” (2007) and “16: Practical use of a shared connection-vehicle system with a re-location function” (2013) to address urban and local transportation needs, while expectations were raised for “18: Development of a construction method that can halve the time required for pavement repairs” (2006) for expressways as inter-city transportation facilities. In water and underwater transportation, the realization of “36: Development of fully automatic ships” (2014) and “40: Achievement of some 20% increase in propeller efficiency” (2009) were expected against a background of calls for greater safety and efficiency and shortages of specialists in freight transportation. In air transportation, expectations were raised for technological development aimed at service improvements through greater physical convenience and lower air fares. Examples include 46. Practical use of flying boats featuring new materials etc. for regular transportation services (2014), “49: Development of an ultra-large passenger aircraft” (2015) and “51: Reductions in direct aircraft operating costs to about half (2013). With new transportation systems, consideration for disadvantaged persons has become an important aspect of technological development, with expectations raised for “57: Practical use of robotic guidance systems for visually impaired people” (2006) and “58: Practical use of intelligent wheel-chairs capable of coping with stairs, slopes, etc.” (2008), along with “59: Practical use of cableways used in mountainous areas in urban transportation through technical sophistication and refinement”(2009) and “60: Practical use of vertical transportation systems for super high-rise buildings with a transporting capacity at least five times that of current elevators” (2011).

(Naoto Egawa)

13.1.3. Environment, energy and recycling

Environment, energy and recycling are issues that are at present a focus of keen attention.

In the 1970s, when this survey first began, environmental problems involving transportation systems were mainly of a local nature. Examples include air pollution by motor vehicle exhaust along major roads and the Shinkansen bullet train noise. As well as local problems, however, environmental problems have become recognized as global problems involving many different sources apart from transportation systems in recent years, and have expanded in scope to include socioenvironmental issues, such as global warming (caused by excessive carbon dioxide emissions and heat generation), the heat island phenomenon, depletion of the ozone layer, acid rain (and other secondary environmental problems), resource recycling, industrial waste problems and energy consumption reductions.

Against this background, topics relating to environmental protection and recycling were recognized as most important in the latest survey, accounting for 5 out of the 10 topics that had highest degree of importance index scores. There were 60 topics altogether including 14 from the environment-related area.

Regarding motor vehicle emissions, which were the No. 1 issue, there have recently been calls for the development of more advanced technologies geared toward meeting more stringent regulations, such as the introduction of an LEV regulation in the state of California, U.S.A., and the setting of short and long-term emission targets for diesel-powered vehicles in Japan. As a result, 26. Widespread use of electric vehicles

(2011) and 30. Emission control technologies for diesel-powered vehicles (2010), which are topics from this area, were ranked high among the 10 most important topics, and an increase in the government's funding for research, fostering of researchers and promotion of exchanges among industrial, academic and government sectors/different fields were called for as necessary measures for the realization of these technologies. Although there was no topic with direct reference to global warming, attributable to carbon dioxide emissions, great interest was shown in exhaust emission reduction measures in the context of energy problems, which are discussed below. It is anticipated that strong calls for the development of technologies that reduce the emission of pollutants from mobile emission sources other than motor vehicles also exist, although this was not included in the questionnaire.

Regarding traffic noise problems, efforts have been made to develop noise reduction technologies for the Shinkansen to address increases in its train operating speeds, while environmental quality standards for railway noise have been set as control guidelines, covering the Shinkansen as well as conventional railway lines. Against this social background, there is an urgent need to develop noise reduction technologies, and topics relating to this issue, such as "04: Superconducting magnetically levitated railways" (2011) and "08: Operation of Shinkansen bullet trains at a speed of 350 km/h while satisfying environmental quality standards" (2006) were rated high in terms of the degree of importance index. In air transportation, "55: Floating off-shore airports" (2009) were rated high, reflecting recent social trends. However, "47: A low noise vertical take-off and landing (VTOL) airplane" (2014) and "56: A low-noise helicopter" (2012), which relate to pure aircraft technologies, did not enjoy high importance ratings, while Japanese technology was rated low compared to that of the United States, with late realization times forecasted. In motor vehicle transportation, 28. Noise reduction for heavy-duty freight trucks (2010), was rated high, ranking among the 10 most important topics. Apart from this, "12: Noise reduction through improvements in road paving" (2009) and "29: Active noise control devices" (2014) were regarded as relatively important.

Regarding energy problems, "17: Motor vehicles 30% more fuel efficient than today's vehicles" (2007) was ranked No. 3 in the entire transportation field in terms of the degree of importance index, indicating strong interest, while, with "26: Electric vehicles" (2011) and "27: Electric vehicles based on fuel cells" (2014), which relate to oil-alternative energy sources, greater importance tended to be attached to the social environment and operational infrastructure than technological development. Although topics such as "09: Regenerative energy storage device" (2009), which relates to rail vehicles, attracted great technical interest, their feasibility was rate fairly low. There were quite a few voluntary opinions which pointed out, from outside the context of the questionnaire, that improvements in transportation systems and congestion alleviation measures would indirectly lead to energy savings.

Regarding recycling, "31: Recycling of motor vehicle parts and materials" (2009) were considered most important among all topics, indicating the existence of a high level of interest, along with "45: FRP vessel disposal technology" (2007), which relates to industrial waste disposal.

In the environment, energy and recycling area, a number of voluntary opinions were offered, expressing the need for an integrated approach encompassing issues such as the social environment (e.g. infrastructure and legal controls), costs and recycling, as well as the development of cutting-edge and innovative technologies. It was pointed out that this was a major reason why forecasted realization times were pushed back in most technological areas, along with the realization of the enormity of technological challenge, which became more apparent as R&D progressed.

(Shin Narasaka)

13.1.4. Safety and disaster prevention/preparedness

Safety is the most fundamental requirement for transportation, and its importance cannot be overstated. The share of topics relating to safety was 3 out of 9 in railway transportation, 6 out of 23 in road transportation, 3 out of 13 in water transportation, 2 out of 11 air transportation, and 1 out of 4 in other new types of transportation. As safety is the prerequisite for all new transportation technologies, all topics relating to transportation should, in a broad sense, be interpreted as including safety improvement technologies. In addition to technological development as a measure to reduce conventional types of accidents, safety

improvement technologies developed in preparation for changes in social conditions in the future, such as labor shortages and the aging population, and safety technology as a prerequisite for the establishment of new transportation technologies, such as high speed transportation, were included as topics of direct relevance, with their importance rated high.

Remote sensing, GPS, laser, sensor technology, such as ultrasound, information technology/artificial intelligence form the basis of safety improvement technologies, and, building on technological innovation in these areas, the development of control and guidance systems that assist human decision-making and total systems that achieve automation are being pursued. As a result, individual topics overlap with those mentioned in 13.1.1.~3., and are therefore not discussed here. Other technologies include “13: Development of composite materials that adapt to external stimuli by changing characteristics for use in motor vehicle bodies to change their crash rigidity”. (2014), “24: Monitoring of fatigue levels of bridges” (2009) and “22: Road surface snow-melting systems based on solar heat” (2010).

Just featuring earthquakes, there were only three topics that related to disaster prevention/preparedness as follows: “07: An automatic train stopping system based on the detection of the initial mild tremors of an earthquake” (2006), “23: Road structures with self-repairing functions to overcome damage sustained in major earthquakes” (2021) and “52: An observation and communication system deployed in midair for disaster prevention and other purposes” (2013). Due to restrictions on the number of topics and the need to avoid overlapping with other fields, there were not many topics relating to disaster prevention/preparedness in the transportation field. However, technological development geared toward disaster prevention/preparedness is extremely important in Japan as a disaster-prone country.

For accident prevention and disaster prevention/preparedness, a systems approach is particularly important, even more so than the development of individual technologies, giving rise to the need for system designs that regard the occurrence of accidents/disasters as a real possibility and improve overall safety encompassing transportation systems, transportation spaces, social and natural environments, and human beings. The Great Hanshin-Awaji Earthquake of 1996 reminded us anew of the importance of incorporating transportation safety into the social crisis management system, as well as the adoption of transportation system designs that take into account the desired functions of transportation systems in emergency situations. To this end, however, numerous problems must be overcome.

(Shigeru Morichi)

13.1.5. Transportation systems for affluent and fulfilling future society

Transportation systems in an affluent and fulfilling future society must be safe and environmentally-friendly, and capable of transporting passengers to their destinations with promptness, speed, comfort and low cost, with these individual requirements already discussed elsewhere in this report. To meet the needs such a future society, therefore, transportation systems must evolve to combine these elements in a comprehensive and balanced manner.

Major recent technological advances made in the field of transportation include i) greater reliability and speed and lower prices and size/weight in computer technology, as well as ii) greater reliability and lower prices in new materials centering on composite materials and new alloys. In the software area, there has been rapid progress in the iii) transportation system and transportation demand management techniques. Supported by progress in these areas, advances in transportation systems are expected to continue in the future, particularly in terms of labor saving, automation and effective management in areas of control/guidance, operation, maintenance and design though they are still at the conceptual stage, where there are plenty of ideas but few concrete achievements. Technologies expected to become important in the future include a design approach that takes recycling into consideration, a social penalty system that encourages consideration given to the environment, sacrificing performance and cost advantage, if necessary, and disaster prevention/preparedness design techniques that quantitatively incorporate estimated parameter values of disasters that are considered possible. With transportation systems that depend on internationally standardized hardware, such as vessels, aircraft and motor vehicles, new technologies must be implemented in accordance

with international standards. While this would require a global-scale research cooperation structure, there is a high possibility that it will become a particularly disadvantageous area for Japan due to a language barrier and its unique social structure.

In the future, advances in the transportation field will be made within each of the railway, aircraft, motor vehicle, vessel, and other areas by incorporating new technologies, but the realization of large-scale new transportation systems do not seem likely. This is because conventional systems are capable of satisfying a large part of basic transportation needs, while the establishment of new systems would require enormous amounts of time and money. However, the realization of small-scale systems which cater for needs that cannot be covered by existing systems, such as the following, are forecasted: “57: Robots to guide blind people in particular districts such as stations and shopping centers” (2006) and “58: Intelligent wheel-chairs capable of coping with stairs, escalators, slopes, etc.” (2008) (systems designed for ease of use by the elderly and the disabled); and “60: Vertical transportation systems for super high-rise buildings” (2011) (a system designed for new architectural spaces), with fairly early realization expected, according to the survey results. Other future challenges include the following: “16: Shared connection-vehicle system used for transportation between specified areas or terminals” (2013) and “59: Cableways and other transportation systems that can be used for moving between a hilltop residential area and a railroad station below or between downtown building” (2009) (short-distance, diverse and convenient transportation systems for conveyance between the home and station); and “02: System that enables railway vehicles mounted on motorized-trucks to roll onto tracks of different rail gauges” (2007), “03: System in which road trucks become railway vehicle” (2009) and “15: Dual-mode motor vehicle transportation system” (2016) (mutual ride-in system between transportation systems of different modes).

In the transportation field, integration with the environment and city planning is an area which should be addressed in the future. While there are high expectations for transportation systems that give consideration to the environment, as discussed in detail under the environment in this report, this will be taken a step further, and transportation systems that are integrated with economic systems in terms of where to produce, consume and recycle or dispose of goods will be considered as part of city planning or regional development planning at the national level. In the near future, this will be accelerated by the fact that the supply of land, air and energy, which are resources until now considered unlimited, is in fact finite and places constraints on various human activities as industrial and economic activities intensify. As the availability of resources varies widely from one country to another, transportation systems will exhibit country-specific characteristics, resulting in the international coexistence of various transportation system models. In light of the fact that most developing countries are not resource-rich like the United States, Japan could play an important role, if it was able to propose and implement a transportation system model worth pursuing for developing countries, and this gives rise to an urgent need for the development of human resources and research environments suitable for proposing and establishing international standards leading to such a transportation system model under a global-scale research cooperation structure.

Recent history shows that, as receiving information from remote areas at fast speeds via written text, conversation and images stimulates becomes easier, people’s curiosity and sense of need is stimulated, and the demand for fast, comfortable and safe means of transportation increases. In view of the rapid increase in the number of people leaving for overseas destinations, which now far exceeds 10 million, and rapid progress in global computerized information handling, the growth in the demand for transportation services is expected to continue in the future.

(Keiji Kawachi)

13.2. 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 13.2-1 Forecast Topic Framework for Transportation Field

Domain / Objective	Rail and track transportation systems	Road transportation systems	Water and underwater transportation systems	Air transportation systems	Other new transportation systems
Transportation services that are comfortable and convenient to use (comfort, human touch, culture, convenience, elements of play and response to aging population)	01	10 11 12 13 14	33	46 47	57 58 59
Provision of efficient transportation services (high speed, reliability, economy, and automation/labor saving)	02 03 04 05	15 16 17 18	34 35 36 37 38 39 40 41	48 49 50 51 52	60
Provision of safe transportation services (safety and reliability/maintainability)	06 07	19 20 21 22 23 24 25	42 43 44	53 54	
Provision of environmentally-friendly transportation services (environmental protection and resource/energy conservation)	08 09	26 27 28 29 30 31 32	45	55 56	

* Figures appearing in the table represent topic numbers.

13.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 60.3 for topics in the transportation 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. As many as 10 topics that featured in the top 20 related to road transportation systems. Across the fields, 10 environment-related topics were included (8 from road transportation systems and 1 each from road transportation systems and Water and underwater transportation systems).

Table 13.3-1 Top 20 Topics in Terms of Degree of Importance Index

Topic	Degree of importance index	Forecasted realization time (year)
31 <u>Achievement</u> of a <u>90%</u> recyclability for motor vehicle parts and material (scrapped vehicles).	88	2009
07 <u>Development</u> of a system that detects the initial mild tremors of an earthquake at appropriate locations, and safely stops trains as necessary to <u>avoid places that have a high risk of collapse</u> (because of the earthquake).	87	2006
17 <u>Widespread use</u> of motor vehicles with <u>fuel efficiencies 30%</u> 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
30 <u>Practical use</u> 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 <u>the harmful components of exhaust to 1/10</u> of present levels.	84	2010
14 <u>Widespread use</u> of traffic control systems on road, for <u>optimal control of the</u>	84	2007

Topic	Degree of importance index	Forecasted realization time (year)
<u>flow of traffic in cities</u> based on identification of vehicles on road, speed, and level of congestion.		
55 <u>Practical use</u> of floating off-shore airports.	78	2009
26 <u>Widespread use</u> of <u>electric vehicles</u> 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	2011
51 <u>Reductions in direct operating cost</u> per passenger per unit distance to <u>about half present levels</u> through more efficient aircraft production, and cuts in maintenance cost and crew numbers.	75	2013
28 <u>Reduction</u> of the noise generated by heavy-duty freight trucks to the passenger car levels through improvements in engines, transmissions, mufflers, tires, road surfaces, etc.	74	2010
38 <u>Practical use</u> 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.	74	2006
42 <u>Completion</u> of marine traffic control systems which enable safe and efficient movement of all ships in congested areas such as Tokyo Bay.	72	2011
27 <u>Widespread use</u> of <u>electric vehicles</u> carrying <u>fuel cells</u> which have high energy conversion efficiencies.	71	2014
29 <u>Practical use</u> of active noise control devices installed along roads to <u>absorb traffic noise in the form of energy</u> , and thereby reduce the noise level so that it conforms to environmental standards.	70	2014
08 Utilization of new materials in rails and wheels and improvements in the technology of vehicle structures, <u>leading to the continuous operation</u> of Shinkansen bullet trains <u>at a speed of 350 Km/h while satisfying environmental quality standards</u> .	69	2006
32 <u>Widespread use</u> of <u>permeable road pavement</u> , leading to improvements in the urban environment in ways such as the recharging of ground water and alleviation of the “heat island” phenomenon.	69	2008
45 <u>Practical use</u> of <u>safe and simple FRP vessel</u> disposal technology via pulverization, incineration, chemical treatment, etc.	69	2007
12 <u>Widespread use</u> of elastic body and other new materials in road paving, leading to a reduction in road traffic noise sufficient to <u>satisfy government regulation</u> .	69	2009
05 <u>Spread</u> of the automation and mechanization of the inspection/construction of railway vehicles, railroad tracks, etc. using robotics technology to cope with labor shortages and increase safety.	66	2008
54 <u>Practical use</u> of an all-weather category 3 (fully automatic) aircraft takeoff, landing and automatic taxiing system through advances in GPS, radar and other non-visual technologies.	65	2009
53 Achievement of radical automation of air traffic control through advances in computer technology, <u>leading to a labor saving of about 50% compared to the present level</u> .	65	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

13.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below.

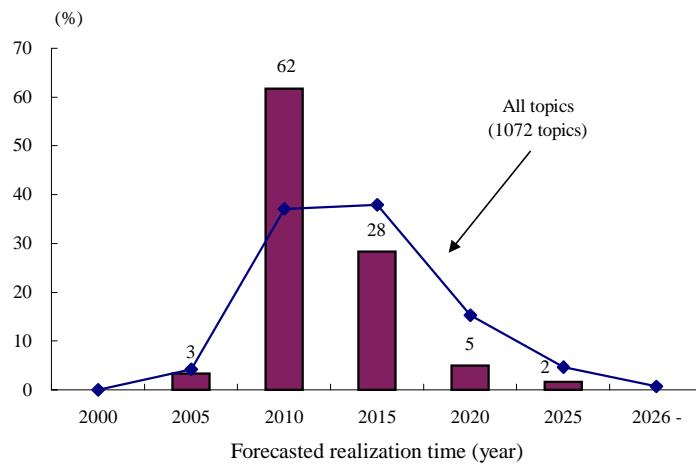


Fig. 13.4-1 Trends in Forecasted Realization Times

About 60% of the topics saw their forecasted realization times fall in the 2006-2010 range in the transportation field as a whole. Compared to the general trend covering all topics, many topics were forecasted to be realized relatively early.

13.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below. Named by more than 50% of respondents, Japan ranked No. 1 overall in the transportation field, followed by the U.S. and the EU, both scoring more than 30%. Ratings of the former Soviet Union/Eastern Europe and other countries were extremely low.

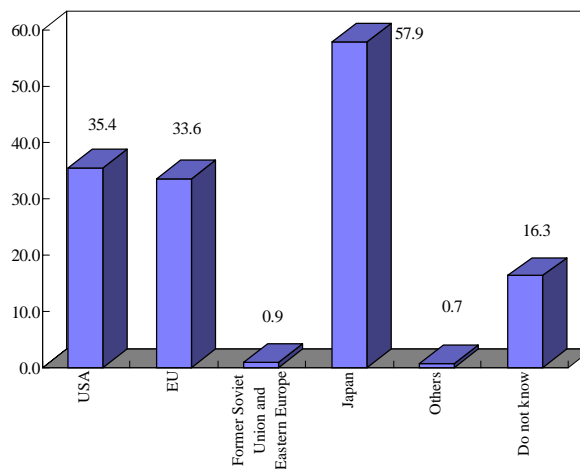


Fig. 13.5-1 Current Leading Countries etc. (%)

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

Of the 60 topics included in the latest survey, 21 (35%) were identical to the previous survey, 15 (25%) were modified, and 24 (40%) 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 7 topics, fell for 11 topics and remained the same for 3 topics. “55: Practical use of floating off-shore airports” saw the greatest jump up 16 points, while “21: Widespread use of studless tires with road grips equal to or greater than those of studded tires” saw the greatest drop, down 18 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all but one topic. Likewise, from the 5th to the 6th Survey, forecasted realization times were pushed back for all topics except for three, which saw their forecasted realization times remain the same. “46: Practical use of flying boats for regular transportation services between cities or between the mainland and an isolated island had its forecasted realization time pushed back most” (8 years).

Table 13.6-1 Comparison with 5th Survey for Identical Topics

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
01 <u>Development of intelligent railway vehicles</u> to be able to obtain improved riding comfort and reduce maintenance cost of ground facilities automatically controlling running speed and adjusting suitable parameters to control suspensions in response to track and catenary conditions.	54/2006	55/2000
04 <u>Practical use of superconducting magnetically levitated railways</u> with a maximum speed on the order of 500 Km per hour.	64/2011	73/2007
06 <u>Practical use of systems</u> that use laser or ultrasonic technology to detect people, automobiles and other obstacles on railway tracks (including areas other than crossings), and <u>brake the train automatically</u> .	62/2005	69/1999
09 <u>Practical use of energy storage equipment on electrically powered trains</u> to accumulate regenerative energy and reduce the load on transformer substation at peak time.	56/2009	49/2004
14 <u>Widespread use</u> of traffic control systems on road, for <u>optimal control of the flow of traffic in cities</u> based on identification of vehicles on road, speed, and level of congestion.	84/2007	78/2003
17 <u>Widespread use</u> of motor vehicles with <u>fuel efficiencies 30% greater</u> 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	79/2003
18 <u>Development</u> of a construction method that can <u>halve the time required for</u> expressway pavement repairs.	61/2006	75/2001
21 <u>Widespread use</u> of studless tires with road grips equal to or greater than those of studded tires.	60/2006	78/1999
28 <u>Reduction</u> of the noise generated by heavy-duty freight trucks to the passenger car levels through improvements in engines, transmissions, mufflers, tires, road surfaces, etc.	74/2010	74/2005
29 <u>Practical use</u> of active noise control devices installed along roads to <u>absorb traffic noise in the form of energy</u> , and thereby reduce the noise level so that it conforms to environmental standards.	70/2014	65/2014
33 <u>Widespread use</u> of commuter and business sea traffic transportation network systems (including the traffic control systems) which use mass-transportation (300 passengers or more), high-speed (30 knots or faster) vessels in the areas around big cities.	40/2010	41/2005
34 <u>Development</u> of an ocean freight transportation facility based on technologies including superconductivity, capable of crossing the Pacific Ocean in two days (<u>100 knots or faster</u>).	47/2017	48/2017
35 <u>Development</u> of large high-speed boats about 500 tons in dead-weight, constructed entirely of <u>non-steel</u> new materials to reduce weight etc.	53/2008	48/2004

Topic	Degree of importance index / forecasted realization time	
	6th survey	5th survey
36 <u>Development of fully automatic ships</u> which are able to navigate and dock automatically.	45/2014	48/2007
37 <u>Development of autonomous, unmanned, underwater investigation vessels</u> employing artificial intelligence which are capable of investigating sea-bottom resources and undertaking other activities without receiving any energy supply or external communication.	51/2009	51/2006
42 <u>Completion</u> of marine traffic control systems which enable safe and efficient movement of all ships in congested areas such as Tokyo Bay.	72/2011	72/2004
46 <u>Practical use of flying boats</u> for regular transportation services between cities or between the main land and an isolated island, through the development of new materials with a high salt damage resistance and advances in engine design.	41/2014	36/2006
47 <u>Practical use</u> of quiet, energy-saving vertical take-off and landing (VTOL) airplane <u>for intercity transportation</u> .	48/2014	55/2008
55 <u>Practical use</u> of floating off-shore airports.	78/2009	62/2008
58 <u>Practical use</u> of intelligent wheel-chairs capable of coping with stairs, escalators, slopes, etc.	54/2008	58/2003
60 <u>Practical use</u> of vertical transportation systems for super high-rise buildings capable of providing a <u>transporting capacity</u> per occupant volume which is <u>at least five times</u> that of current elevators. (e.g., systems equipped multiple car-gondolas, turn-back function, and passing function)	43/2011	51/2008

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																
Rail and track transportation systems	1	Development of intelligent railway vehicles to be able to obtain improved riding comfort and reduce maintenance cost of ground facilities automatically controlling running speed and adjusting suitable parameters to control suspensions in response to track and catenary conditions.	1	121	15	31	54	55	23	50	26	1	50	18	62	5		2	2	10	42	0	66	0	18	22	38	21	0	39	21	2	6	17	2	5			
			2	118	14	29	58	54	20	56	23	1	53	11	70	2		2	2	8	42	1	72	0	13	19	51	21	0	44	19	2	4	31	1	3			
			X	16	100	0	0	72	50	38	13	0	69	13	69	0		0	0	13	63	0	81	0	0	25	44	38	0	56	25	0	0	25	0	0			
	2	Practical use of a system that enables railway vehicles mounted on motorized-trucks to roll onto tracks of different rail gauges.	1	118	13	29	58	50	19	45	35	1	73	15	36	1		7	10	3	51	2	44	2	18	14	29	15	0	38	30	3	4	18	4	10			
			2	113	11	27	62	54	21	50	28	0	80	7	42	1		4	4	3	56	1	51	2	12	15	35	12	0	50	32	2	2	33	4	7			
			X	12	100	0	0	79	67	17	17	0	92	8	50	0		8	0	0	67	0	67	8	0	33	33	25	0	42	17	0	0	33	0	0			
	3	Practical use of a system in which road trucks become railway vehicle to make the transition between railway and road in freight transportation smooth.	1	142	11	22	68	49	21	41	31	7	65	48	18	1		17	11	20	31	1	26	3	35	11	40	12	0	37	44	1	7	19	2	8			
			2	140	9	21	70	49	17	52	24	7	76	44	14	0		14	6	17	38	0	31	2	31	8	46	6	0	39	56	1	3	34	1	5			
			X	13	100	0	0	69	54	15	31	0	92	85	8	0		15	0	31	54	0	62	8	8	15	46	0	0	46	46	0	0	38	0	0			
	4	Practical use of superconducting magnetically levitated railways with a maximum speed on the order of 500 Km per hour.	1	150	12	28	60	64	37	46	16	1	91	19	26	17		8	4	6	45	0	91	1	1	25	31	23	0	67	18	3	51	35	4	11			
			2	144	12	26	62	64	36	48	16	0	94	13	28	11		3	2	3	50	0	94	1	0	27	32	23	0	78	17	1	63	36	2	8			
			X	17	100	0	0	88	76	24	0	0	100	29	29	18		0	0	0	41	0	100	0	0	24	29	24	0	82	29	0	47	29	0	12			
5	Spread of the automation and mechanization of the inspection/construction of railway vehicles, railroad tracks, etc. using robotics technology to cope with labor shortages and increase safety.	1	131	15	37	48	66	38	50	12	0	70	8	49	7		4	2	18	33	1	73	0	17	30	38	15	1	37	26	2	4	25	9	4				
		2	130	12	34	55	66	37	53	9	0	78	3	43	3		2	1	12	32	0	78	0	13	26	47	11	1	42	30	1	4	39	5	2				
		X	15	100	0	0	90	80	20	0	0	93	0	53	0		0	0	13	53	0	73	0	7	47	53	27	7	33	33	0	0	33	13	0				
6	Practical use of systems that use laser or ultrasonic technology to detect people, automobiles and other obstacles on railway tracks (including areas other than crossings), and brake the train automatically.	1	148	11	35	54	64	36	48	16	1	25	1	82	4		1	3	20	23	2	68	0	16	21	30	16	1	39	30	2	3	27	3	3				
		2	144	10	30	60	62	30	58	11	1	19	1	92	3		1	0	19	25	0	82	0	10	17	38	9	0	53	34	1	3	36	2	2				
		X	14	100	0	0	68	43	43	14	0	14	0	100	0		0	0	21	21	0	93	0	0	14	21	7	0	50	71	0	0	50	7	0				
7	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).	1	123	12	28	60	80	63	29	8	0	29	4	81	8		3	5	11	6	0	78	0	16	32	36	17	5	54	6	6	2	24	1	6				
		2	116	10	26	64	87	77	19	4	0	28	3	84	3		1	3	11	3	0	86	0	9	31	43	16	2	66	5	3	1	32	0	4				
		X	12	100	0	0	85	75	17	8	0	33	0	92	0		0	0	25	8	0	92	0	0	33	42	25	17	42	0	0	0	17	0	0				
8	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.	1	128	13	28	59	68	44	42	13	1	73	23	44	5		2	5	1	66	0	79	1	4	29	34	23	1	47	20	3	30	27	5	5				
		2	127	13	28	59	69	45	43	11	1	75	14	54	5		2	3	0	75	0	85	0	1	25	42	20	1	61	17	1	46	32	1	4				
		X	17	100	0	0	88	75	25	0	0	76	24	65	0		0	0	0	82	0	82	0	0	47	41	35	6	53	41	0	47	35	6	0				
9	Practical use of energy storage equipment on electrically powered trains to accumulate regenerative energy and reduce the load on transformer substation at peak time.	1	106	9	25	66	57	25	51	22	1	31	80	8	4		4	9	24	28	1	56	0	26	31	38	25	2	42	13	1	9	10	0	1				
		2	105	7	17	76	56	20	63	17	0	23	88	5	4		1	3	20	31	0	75	0	13	30	50	23	0	60	10	0	10	16	0	0				
		X	7	100	0	0	64	29	71	0	0	29	100	0	0		0	0	14	29	0	86	0	14	57	43	29	0	57	14	0	0	14	0	0				
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).	1	172	16	35	49	57	26	53	22	0	16	4	92	8		1	2	61	38	1	54	1	17	27	42	26	1	40	15	1	1	19	9	1				
		2	167	13	36	51	55	21	56	23	0	13	1	92	3		1	1	69	35	1	61	0	11	22	56	23	0	50	11	1	1	30	5	1				
		X	22	100	0	0	69	45	41	14	0	14	5	91	5		5	0	64	55	0	68	0	0	36	68	27	0	73	0	0	5	18	5	0				

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

Table of Contents

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						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 (%)																	
Road transportation systems	11	Practical use of construction technology for suspension bridges with a center span of 2,500 - 3,000 m designed for channel crossings.	1	98	13	20	66	52	21	45	33	1	88	6	23	16		2	5	30	21	0	83	0	9	38	37	23	0	51	4	3	39	36	2	2		
			2	96	10	21	69	50	16	53	31	1	90	3	23	14		2	1	30	20	0	86	0	7	40	30	21	0	60	2	2	50	36	1	1		
			X	10	100	0	0	73	50	40	10	0	100	10	30	30		0	0	40	40	0	80	0	10	50	40	30	0	70	20	0	50	30	10	10		
	12	Widespread use of elastic body and other new materials in road paving, leading to a reduction in road traffic noise sufficient to satisfy government regulation.	1	104	18	25	57	66	41	43	14	2	27	37	76	2		6	8	13	27	1	40	1	40	33	54	22	2	51	19	2	22	12	4	5		
			2	101	18	22	60	69	45	43	10	2	18	36	83	2		4	4	12	30	0	46	1	41	32	63	14	1	61	11	1	36	8	2	2		
			X	18	100	0	0	81	61	39	0	0	11	33	89	0		0	0	6	61	0	72	6	17	50	67	6	0	61	6	0	44	11	6	0		
	13	Development of composite materials that adapt to external stimuli by changing characteristics - e.g. change stiffness in response to a load - to improve motor vehicle road performance, vibration resistance, riding comfort, crashworthiness, etc.	1	75	12	20	68	51	14	64	21	1	44	8	71	19		12	8	43	17	0	31	3	39	43	57	29	7	36	7	0	15	21	4	3		
			2	76	9	17	74	49	10	68	21	1	39	1	78	11		11	7	45	16	0	29	3	39	42	63	26	4	39	4	0	18	34	1	1		
			X	7	100	0	0	50	17	50	33	0	57	0	100	14		14	0	57	43	0	43	29	14	57	43	14	0	57	0	0	43	14	0	0		
	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.	1	158	17	37	46	79	60	35	5	0	65	54	66	4		3	3	42	36	0	69	1	15	30	56	15	6	49	34	3	7	31	6	2		
			2	155	15	33	52	84	70	28	2	0	65	47	79	3		1	0	48	34	0	79	1	11	28	59	8	4	61	33	3	6	43	5	1		
			X	24	100	0	0	98	95	5	0	0	75	54	83	4		0	0	71	75	0	92	0	0	33	58	4	0	83	38	0	4	46	13	4		
	15	Development of a dual-mode motor vehicle transportation system in which vehicles travel at high speeds without using wheels along specified sections (e.g. between major cities) as magnetically-levitated linear motor cars and travel on wheels along normal roads as convention vehicles.	1	136	13	26	61	43	11	43	42	4	67	34	48	6		17	11	15	24	1	40	1	36	25	44	18	1	48	21	4	15	28	1	4		
			2	127	11	27	62	43	9	48	41	2	71	29	56	3		13	8	9	25	1	54	0	31	24	48	12	0	63	20	5	15	41	0	2		
			X	14	100	0	0	66	36	57	7	0	79	57	86	7		14	7	21	50	0	79	0	21	36	43	14	0	79	43	7	36	36	0	0		
	16	Practical use of a shared connection-vehicle system with a re-location function, based on the use of ultra-small cars in transportation between specified areas or terminals.	1	119	13	29	57	48	17	45	36	2	46	42	72	2		6	13	23	45	0	31	0	31	22	36	10	0	43	44	3	5	35	8	2		
			2	115	13	24	63	46	11	54	35	1	44	42	79	1		4	12	19	54	0	35	0	26	17	37	4	0	61	50	2	6	53	4	0		
			X	15	100	0	0	56	23	54	23	0	40	60	73	0		0	0	40	80	0	40	0	7	27	40	0	0	60	93	0	13	60	7	0		
	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.	1	123	12	22	66	80	61	37	2	0	41	91	25	4		2	3	37	37	1	76	0	15	33	41	20	2	44	21	3	23	9	2	2		
			2	121	11	17	72	86	72	27	1	0	41	94	23	2		1	2	35	41	1	87	0	9	34	49	14	1	62	19	2	34	7	0	1		
X			13	100	0	0	100	100	0	0	0	38	100	31	0		0	0	31	62	0	92	0	8	38	38	15	0	62	31	15	38	15	0	0			
18	Development of a construction method that can halve the time required for expressway pavement repairs.	1	83	16	29	55	62	30	56	14	0	60	24	52	2		1	11	29	19	0	54	0	36	23	57	19	2	43	14	0	20	18	4	2			
		2	79	14	27	59	61	28	61	12	0	75	18	63	0		1	9	25	16	0	59	0	28	19	68	10	1	48	10	0	27	19	1	1			
		X	11	100	0	0	70	40	60	0	0	64	9	82	0		0	9	27	27	0	73	0	9	27	82	9	9	36	27	0	18	27	9	0			
19	Practical use of a driver support system that receives and recognizes information necessary for motor vehicle travel on normal roads and transmits danger avoidance signals to the on-board control systems of motor vehicles.	1	158	16	28	56	62	33	51	15	1	49	10	88	3		2	4	58	46	0	66	0	18	27	54	19	2	47	31	3	4	30	7	3			
		2	154	15	27	58	61	29	58	12	1	42	6	92	1		1	3	68	45	0	78	0	10	20	64	15	1	56	34	1	3	44	5	1			
		X	23	100	0	0	82	65	30	4	0	52	9	96	0		0	4	91	87	0	96	0	0	52	74	13	0	87	35	9	4	35	0	4			
20	Spread of the automatic operation of motor vehicles on expressways etc. via guidance and control to ensure safety, eliminate driver fatigue, increase traffic capacity, etc.	1	163	18	28	54	56	25	51	22	2	53	25	85	6		5	5	60	34	1	53	0	22	26	55	21	2	52	39	4	4	42	11	2			
		2	156	15	31	53	55	21	58	18	2	51	16	88	4		3	2	69	31	1	62	0	16	19	66	15	0	63	37	1	3	53	8	1			
		X	24	100	0	0	75	50	50	0	0	79	42	92	4		0	0	96	58	0	79	0	4	29	58	17	0	92	50	8	4	58	4	4			

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

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																
Road transportation systems	21	Widespread use of studless tires with road grips equal to or greater than those of studded tires.	1	87	3	34	62	60	30	52	18	0	30	36	80	2		7	3	22	51	1	54	0	20	25	37	15	1	26	24	1	22	24	2	2			
			2	85	2	33	65	60	27	60	13	0	22	32	87	4		5	1	20	52	0	67	0	14	21	48	8	1	29	27	0	26	36	1	0			
			X	2	100	0	0	100	100	0	0	0	0	50	100	100	0		0	0	100	100	0	100	0	0	50	50	0	0	50	100	0	50	50	0	0		
	22	Widespread use of snow-melting systems that store solar thermal energy and use it to melt snow and ice in the event of snow accumulation and road surface freezing on expressways and major national highways in snowy regions in Japan.	1	107	2	29	69	55	20	61	18	1	43	47	70	3		10	6	14	21	3	47	1	38	24	42	19	0	55	6	2	24	12	1	2			
			2	109	2	23	75	54	13	77	9	1	33	36	82	2		8	1	11	23	2	61	0	29	20	48	11	1	76	4	1	46	11	1	0			
			X	2	100	0	0	50	0	100	0	0	0	0	0	100	0		0	0	0	100	0	100	0	0	0	50	0	0	100	0	0	50	0	0	0		
	23	Widespread use of road structures using smart materials with self-repairing functions to be able to overcome damage sustained in major earthquakes.	1	57	14	28	58	62	38	41	16	5	58	5	68	25		32	18	30	11	0	33	0	47	32	33	12	7	44	9	2	19	21	2	4			
			2	58	7	21	72	59	31	47	19	3	60	3	67	16		31	16	31	5	0	36	0	45	40	33	14	0	53	7	0	16	29	2	0			
			X	4	100	0	0	75	50	50	0	0	75	0	100	0		75	0	75	0	0	50	0	25	75	25	0	0	50	25	0	0	25	0	0			
	24	Practical use of a technology to automatically monitor bridges for operational fatigue through strain-gauge measurement, ultrasonic testing, acoustic emission observation, etc.	1	98	12	32	56	62	34	48	16	2	50	9	62	10		3	7	37	26	3	58	0	33	45	40	20	2	46	7	1	6	29	1	3			
			2	98	11	24	64	61	32	52	14	2	50	4	66	7		2	8	34	20	0	65	0	24	45	43	17	2	54	5	1	4	43	0	3			
			X	11	100	0	0	73	64	9	18	9	82	0	55	9		0	9	36	0	0	55	0	27	55	18	27	9	45	0	0	45	0	9				
	25	Practical use of a technique to improve the wind resistance of bridges via active control.	1	96	13	22	66	49	17	47	33	3	44	7	63	5		7	9	27	11	0	49	0	26	39	34	22	2	47	9	0	6	21	0	2			
			2	97	10	20	70	49	13	57	29	1	48	2	72	4		5	6	27	8	0	67	0	19	44	35	15	0	59	7	0	1	40	0	2			
			X	10	100	0	0	63	40	30	30	0	60	0	60	20		10	0	30	0	0	90	0	10	80	40	10	0	80	20	0	0	50	0	0			
	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.	1	127	10	30	60	74	52	42	7	0	48	90	28	6		5	6	66	48	0	65	1	14	35	53	17	1	57	29	4	24	19	3	3			
			2	132	10	23	67	77	54	44	2	0	40	96	17	3		3	5	78	48	0	70	1	6	33	62	13	0	73	24	1	35	17	2	2			
			X	13	100	0	0	83	69	23	8	0	54	100	8	0		8	0	92	62	0	77	0	0	62	62	0	0	85	15	8	31	15	0	0			
	27	Widespread use of electric vehicles carrying fuel cells which have high energy conversion efficiencies.	1	114	10	29	61	70	44	49	7	0	45	91	23	9		2	7	60	33	0	50	2	19	42	46	19	4	59	20	4	25	12	0	3			
			2	114	8	25	67	71	42	58	0	0	32	93	16	3		0	4	76	33	0	58	1	11	40	55	13	2	76	16	2	38	14	1	1			
			X	9	100	0	0	83	67	33	0	0	33	100	0	0		0	0	89	56	0	44	11	0	89	33	0	11	78	22	11	33	11	0	0			
	28	Reduction of the noise generated by heavy-duty freight trucks to the passenger car levels through improvements in engines, transmissions, mufflers, tires, road surfaces, etc.	1	101	11	31	58	71	48	43	8	1	32	47	68	1		5	8	21	35	2	48	0	28	27	46	17	0	46	29	0	14	10	0	5			
			2	101	9	28	63	74	51	44	5	0	23	42	80	2		3	7	12	37	1	61	0	21	21	55	8	0	58	26	0	22	9	0	4			
			X	9	100	0	0	92	89	0	11	0	33	67	56	0		11	0	11	78	0	67	0	0	33	67	11	0	67	33	0	33	0	0	11			
	29	Practical use of active noise control devices installed along roads to absorb traffic noise in the form of energy, and thereby reduce the noise level so that it conforms to environmental standards.	1	96	11	29	59	67	41	45	13	1	29	41	70	5		13	10	14	19	1	39	1	39	38	44	13	1	40	15	1	16	11	1	6			
			2	98	7	28	65	70	44	48	7	0	20	33	76	5		11	6	12	19	0	48	1	34	36	50	8	0	55	9	2	26	12	1	6			
			X	7	100	0	0	86	71	29	0	0	57	14	86	0		29	14	29	57	0	86	0	0	57	71	0	0	71	29	0	14	0	0	14			
	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.	1	91	15	24	60	79	61	34	3	1	23	78	55	5		0	4	36	40	1	69	0	18	35	49	19	1	58	32	0	18	3	1	4			
			2	95	15	20	65	84	69	30	1	0	14	86	53	6		0	7	33	47	0	80	0	13	32	56	13	0	72	26	0	24	2	0	3			
			X	14	100	0	0	96	93	7	0	0	7	79	71	7		0	7	64	93	0	93	0	0	50	64	14	0	79	43	0	7	7	0	0			

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

