Intelligent Transport Systems

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1) ITS Japan

1 Introduction

Intelligent transport systems (ITS) are being developed to help resolve various social issues caused by the modern transportation environment through the adoption of innovative technologies. Examples of these issues include traffic accidents, congestion, the increasing load placed on the environment by emissions, and so on. In recent years, information and communication technology has been utilized to connect vehicles with other elements of the traffic environment, such as roadside infrastructure, other vehicles, pedestrians, motorcycles, and so on. This concept is referred to as vehicle-infrastructure cooperation. As a result, the scope and possible roles of ITS have expanded further, opening the way to greater possible application. As a result, ITS may also have a future as fundamental technologies for building a more prosperous and active society, as well as simply for helping to resolve issues.

In 2012, public-private partnerships carried out verification tests related to the appropriateness and effective roles of ITS using various existing and new systems to help resolve issues standing in the way of practical adoption of vehicle-infrastructure and vehicle-vehicle cooperative systems. Based on the results of these tests, plans for adoption and nationwide rollouts from 2014 and beyond have been drawn up while carrying out pilot programs. Specifically, 22 representatives from the relevant government ministries and industry (i.e., institutions and ITS related vehicle and electronics manufacturers) formed an ITS promotion committee in December 2011. This committee met four times up to March 2013 with the aims of sharing information and strengthening collaboration on joint public-private activities related to driving safety support systems, promoting verification tests of vehicle-infrastructure and vehicle-vehicle cooperative systems to help resolve issues standing in the way of practical adoption, developing and popularizing onboard equipment and vehicles compatible with driving safety support systems, and so on. The committee promoted various activities in 2012 toward the aim of achieving the world's greenest and safest road traffic environment, under the slogan ITS Green Safety.

The collaboration between the government, academia, and private companies to develop and introduce ITS technologies in Japan has positioned Japan as a global leader in ITS technology and implementation. In Japan, Prime Minister Abe's second cabinet announced a new ITS strategy on May 24, 2013 [(1)]. This strategy declared Japan's intention to build an ideal society through the promotion of accessibility to publically held data (i.e., open data), the promotion of the use of big data (i.e., facilitating the distribution and use of certain personal data), achievement of the world's safest and most resilient society in the face of natural disasters, achievement of the world's safest, greenest, and economical road traffic environment, and so on.

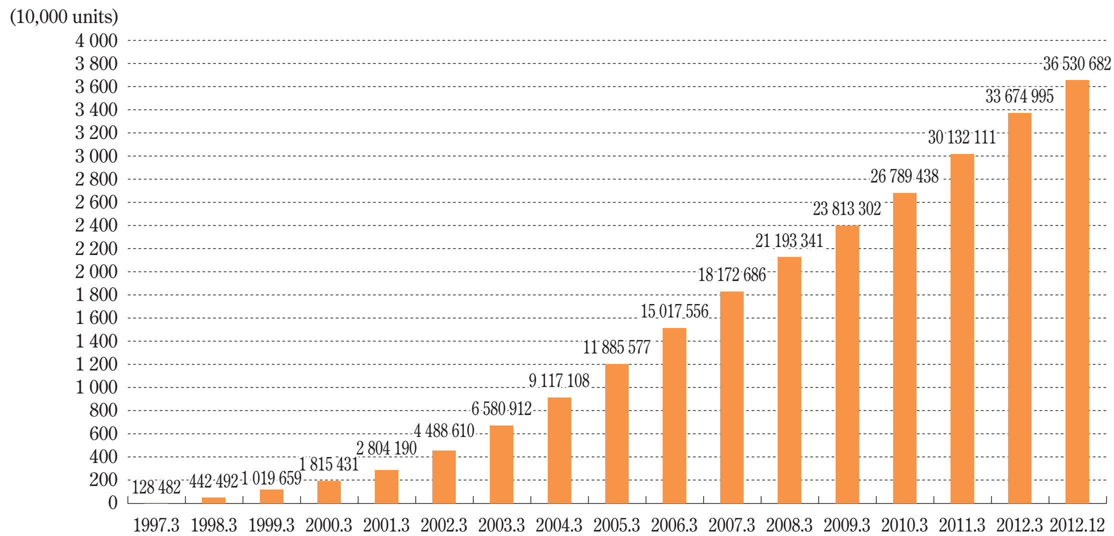
The utilization of big data and the building of a resilient society in the face of natural disasters are two of the main themes behind the 20th ITS World Congress to be held in Tokyo in 2013. Collaboration between public and private entities is expected to form one of the facets of Japan's growth strategy in the future.

In addition, activities based on sophisticated driver support technologies, autonomous driving systems, and the like will be promoted over the next five years as specific ideas in ITS-related fields.

2 ITS Trends in Japan

2. 1. Vehicle Information and Communication System (VICS) [(2)]

VICS is an information and communication system that compiles and processes road traffic information (related to congestion, traffic restrictions, and the like) at the VICS Center. This information is then transmitted by radio wave and infrared beacons and FM multiplex



Source: Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

Fig. 1 Number of onboard VICS units.

broadcasting for display in three forms (text, simple graphics, and maps) on navigation systems and other onboard devices. VICS operates 24 hours a day, 365 days a year.

The number of vehicle navigation systems in Japan exceeded roughly 54 million units at the end of December 2012. Of these, approximately 36 million are compatible with real-time VICS road traffic information (services started in 1996). VICS provides travel times, congestion statuses, traffic restriction information, and the like in real-time to navigation systems to improve driver convenience. Appropriate route guidance from VICS is also effective in reducing CO_2 emissions and environmental load by smoothing traffic streams and improving fuel efficiency. As a result, VICS helped to reduce CO_2 emissions in 2010 by roughly 2.4 million tons (Fig. 1).

2. 2. Universal Traffic Management System(UTMS) [3]

The aim of UTMS is to help achieve a safe and comfortable traffic environment with a low environmental load. It achieves this by supplying real-time traffic information to drivers through sophisticated use of information communication technology, including two-way communication between individual vehicles and traffic management systems using infrared beacons. It also performs proactive management of traffic streams, including safe driving support, actions for emergencies, and the facilitation of more efficient movements of people and logistics. This helps to enhance the safety and smooth flow of road traffic and also alleviates traffic pollution.

The main functions and services of UTMS are as follows.

2. 2. 1. Advanced Mobile Information Systems (AMIS)

AMIS are systems that provide traffic information to onboard devices via infrared beacons in addition to traffic information signs, radio broadcasts, and the like. These systems aim to achieve natural dispersion of traffic streams, alleviate congestion, and so on. As of the end of 2012, all prefectures in Japan had adopted AMIS.

2. 2. 2. Fast Emergency Vehicle Preemption Systems (FAST)

These systems use infra-red beacons to detect emergency vehicles in areas where call outs are frequent, and control traffic signals to give priority to the emergency vehicles. The aim of FAST is to shorten the time required for emergency vehicles to reach an incident scene or medical facility and to help prevent traffic accidents involving emergency vehicles. As of the end of 2012, 15 prefectures had adopted FAST.

2. 2. 3. Public Transportation Priority Systems (PTPS)

PTPS control traffic signals to give priority to buses and other public transportation. The aim is to reduce journey times and increase user convenience, thereby encouraging people to switch from cars to public transportation. As of the end of 2012, 40 prefectures had adopted PTPS.

2. 2. 4. Infrastructure-vehicle (I2V) cooperative Driving Safety Support Systems (DSSS)

The National Police Agency (NPA) of Japan is promoting the adoption of DSSS. DSSS level I (information provision type) systems were adopted in Tokyo in 2006 and Saitama Prefecture in 2007. This type of level I system uses roadside equipment to detect possibly dangerous situations in the road traffic environment and supplies that information to drivers. In addition, large-scale verification tests were carried out of DSSS level I (judgment type) systems in 2008. These systems combine information from roadside equipment with information such as the position and speed of the driver's vehicle and judge the necessity of providing information to the driver via onboard devices. The purpose of this information is to alert the driver to possible danger via audio warnings or displays. In addition to helping to prevent accidents in locations where the roadside equipment is provided, these systems also help to improve overall driver behavior through a learning effect.

In 2010, Tokyo and Kanagawa Prefecture introduced several DSSS level II systems that use infrared beacons as communication devices at intersections that are particularly prone to accidents. These systems include traffic signal recognition enhancement, rear-end collision prevention, stop sign recognition enhancement systems and crossing collision prevention systems. Operation started from July 1, 2011. Analysis confirmed that these systems were effective at supporting safe driving by improving the safety awareness of drivers through information provision. In 2012, equipment was established for verification tests of lower cost DSSS. These are simplified systems that provide information to onboard devices continuously using radio waves and have no connection with traffic management centers.

2.2.5. Sophistication of traffic management systems using probe data

ITS are increasingly regarded as a possible effective means of smoothing traffic streams. Over four years from 2009, the NPA developed a sophisticated model project related to traffic management that uses probe data (i.e., driving history information recorded in onboard devices). The NPA has combined information from existing roadside sensors with probe data to develop technology that generates enhanced traffic information and traffic information capable of enhancing traffic signal controls. It has also utilized the generated information to improve equipment for achieving enhanced traffic signal controls. The effectiveness of this technology was verified in 2012.

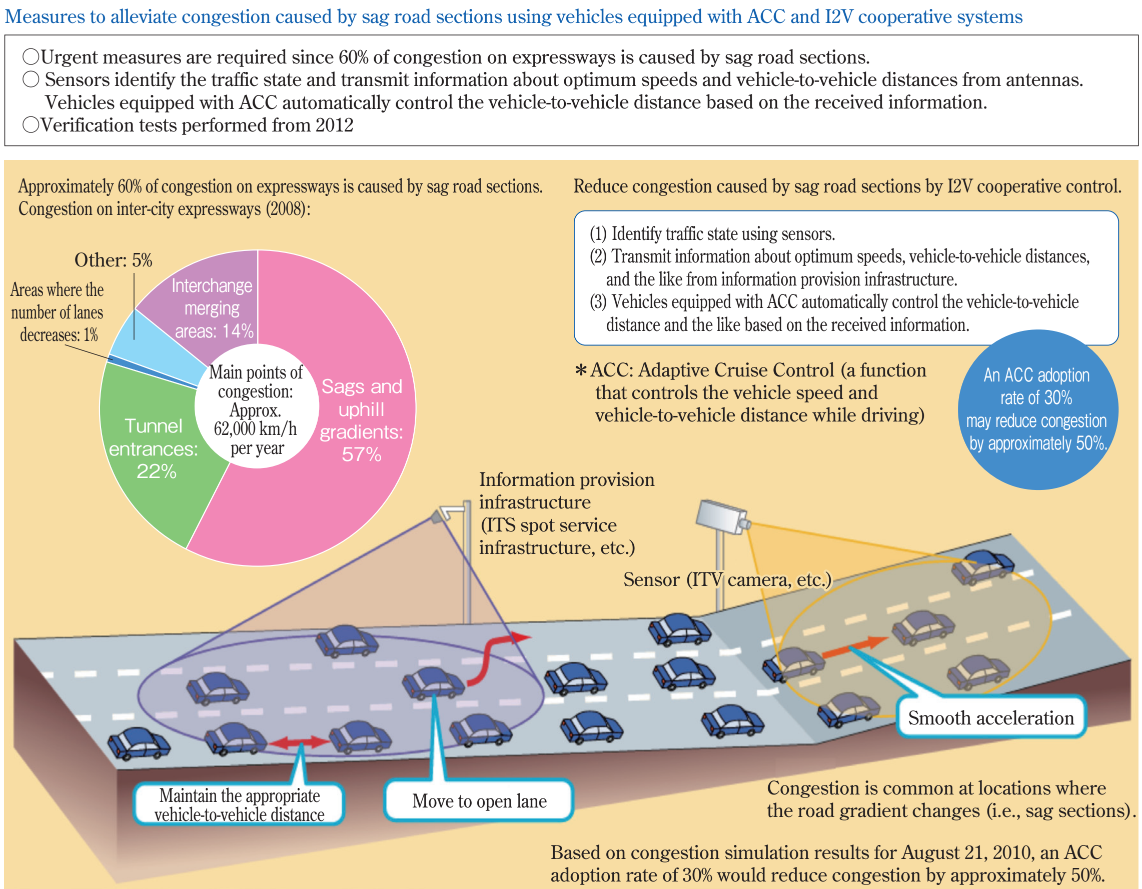
2.3. Smartway Project [4][5]

The aim of the Smartway Project is to enhance traffic safety and to develop measures for improving congestion and the environment. In this project, a Smartway is defined as a next-generation road that uses ITS technology to link people, vehicles, and roads by information. Japan is working to achieve Smartways by researching and developing ways of providing next-generation services via I2V coordination through public-private partnerships. As part of the Smartway Project, the adoption of next-generation ITS services (called spot services) has been promoted in recent years. Various ITS spot services started throughout the country in August 2011, mainly through spot service infrastructure installed on expressways. However, the project is also examining the feasibility of extending ITS spot services from expressways to general roads. At the end of 2011, services started in 20 key locations in the Kanto and Chubu regions as part of measures to respond to natural disasters such as heavy rainfalls.

The Japanese National Institute for Land and Infrastructure Management (NLIM) and automakers have started a joint research project with the aim of developing new services to help alleviate congestion caused by sag road sections, which is responsible for roughly 60% of congestion on inter-city expressways in Japan. These services use vehicles equipped with adaptive cruise control (ACC) systems, which are capable of controlling vehicle speed and vehicle-to-vehicle distance, and information provided from ITS spot services and the like. This approach alleviates congestion by helping to prevent excessive increases in vehicle-to-vehicle distances and reductions in speed in sag road sections (Fig. 2).

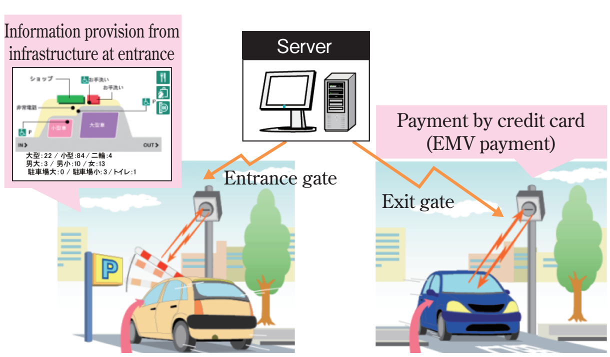
In 2012, to confirm the congestion alleviation effect of these measures to prevent excessive increases in vehicle-to-vehicle distances and reductions in speed in sag road sections, tests were performed on public roads through encouraging driver behavior that helps to smooth traffic flows by aiming to achieve a constant vehicle-to-vehicle distance and the like, and the addition of vehicles equipped with ACC into traffic streams before the occurrence of congestion. These tests investigated the effects of the test vehicles on the surrounding traffic flows and the like.

The use of ITS spot service information also allows the introduction of cashless payment services for car parks and drive-through facilities (Fig. 3). To facilitate



Source: Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

Fig. 2 Measures to alleviate congestion caused by sag road sections.



Source: Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

Fig. 3 Illustration of cashless payment service.

the introduction of cashless payment services, NLIM carried out a joint project with five private companies from November 2009 to March 2013. In 2010 and 2011, this project researched and developed the various devices required for payment, roadside infrastructure, onboard devices, and the like and performed a verification test at the Hibiya Parking Lot managed by the East Nippon Expressway Company in Hibiya (part of Chiyoda Ward in Tokyo). As part of the test, the project studied payment rules and system processes from the standpoint of shortening the payment process time, which was identified as an issue of the system. Based on the results of the test, improved equipment was introduced and re-tested at the Hibiya Parking Lot to evaluate the system technology and reliability.

2. 4. Electric Toll Collection (ETC) system [6]

ETC is a system that enables non-stop automatic collection of tolls. It uses wireless communication between systems provided in booths at toll roads and onboard vehicle terminals to exchange the necessary information for payment without the vehicle having to stop at the gate.

ETC has gained widespread acceptance since its full-scale introduction from March 2001. As of the end of December 2012, more than approximately 40 million onboard units had been set up. 24 nationwide expressway and public road management companies use a single nationwide ETC system. Each day, approximately 6.4 mil-

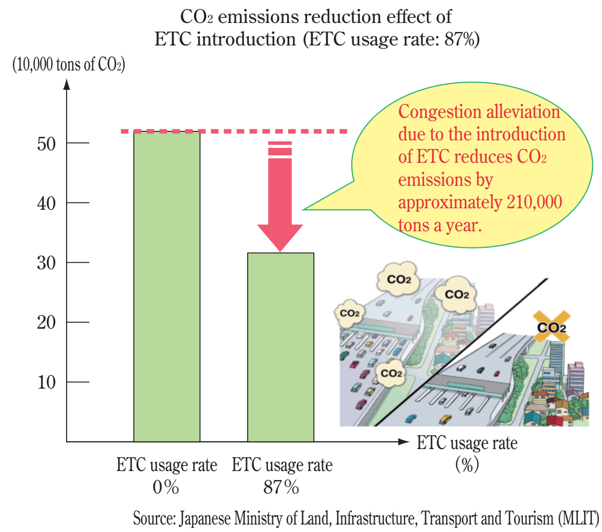


Fig. 4 ETC usage rates and CO_2 emissions reduction.

lion vehicles utilize ETC services, a rate of roughly 87%. ETC has virtually eliminated congestion at toll booths, which accounted for about 30% of expressway congestion throughout Japan. Consequently, ETC also helps to lower environmental load by reducing CO_2 emissions by approximately 210,000 tons per year due to the lower congestion (Fig. 4).

2. 5. Advanced Safety Vehicle (ASV) Project [7]

Since 1991, the Road Bureau of MLIT has promoted the development and popularization of ASVs equipped with leading-edge DSSS technology through collaboration between industry, academia, and the government. The 5th ASV promotion plan began in 2011. This plan aims to encourage the development of dramatically more sophisticated DSSS capable of autonomous detection and DSSS that use next-generation communication technology, as an extension of those systems that have already been implemented. The plan is also promoting preparations for demonstrations to be carried out at the ITS World Congress Tokyo 2013.

The ASV Project is continuing to function as a support system for ASV technology backed by the project (such as collision damage mitigation brakes, devices to alert the driver to unstable driving behavior, electronic stability control (ESC), and the like).

2. 6. Probe data

Probe data consists of information collected by individual vehicles (for example, positional and speed information) using wireless communication technology. This data is then used to support traffic management and drivers. In this case, vehicles are used as sensors to collect information about the traffic environment.

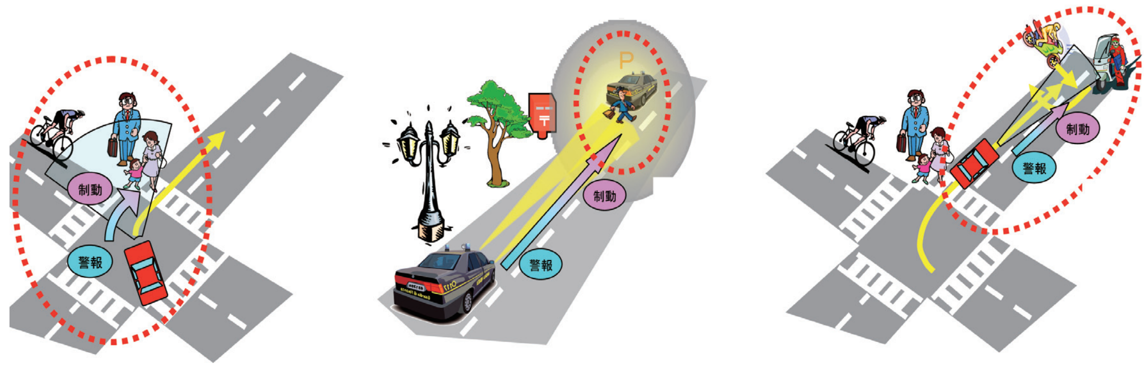
In addition to providing information about congestion using conventional VICS data, navigation systems have also been developed by automakers and specialist navigation system manufacturers to use probe data. Services that transmit traffic information about all roads, excluding narrow urban streets, as well as roads compatible with VICS have also been launched.

From the standpoint of the effective utilization of collected probe data, various activities are under way to share and use individual items of data. The mutual utilization of probe data helps to increase the volume of accessible traffic information, thereby enabling the provision of even more refined services. Therefore, it is likely that activities to share probe data through public-private partnerships will be promoted in the future.

Traffic stream smoothing measures using ITS include the development of the model sophisticated traffic management project by the NPA over four years from 2009 using probe data (i.e., driving history data recorded by onboard devices). As described above, the NPA combined information from existing roadside sensors with probe data to develop technology that generates enhanced traffic information and traffic information capable of enhancing traffic signal controls. It has also utilized the generated information to improve equipment for achieving enhanced traffic signal controls. The effectiveness of this technology was verified in 2012.

The Japanese Ministry of Internal Affairs and Communications (MIC) is carrying out investigations and studies toward sharing and enhancing the sophistication of data contents and communication methods of systems for collecting and transmitting probe data. The aim is to achieve efficient collection and transmission of traffic information for alleviating congestion. Issues were identified in field tests and the like performed in 2012. Studies of sophisticated uses for information and communication technology (ICT) toward achieving a low-carbon society included field tests and the like to identify issues related to the collection of probe data from smart phones that have spread rapidly throughout Japan in recent years in addition to vehicles. Other studies have examined the effect of measures in reducing environmental load.

In 2012, the Japanese Ministry of Economy, Trade and Industry (METI), carried out investigations and research related to new services and the like that are capable of developing an environment for mutual use of probe



Detection of pedestrians and the like when turning left or right at an intersection

Detection of pedestrians and the like during high speed driving

Detection of high-speed motorcycles and the like

Source: MIC

Fig. 5 Illustration of high-resolution 79 GHz band radar use.

data after the establishment of technology for collecting and sharing data gathered and transmitted by individual automakers. These new services aim to achieve this goal by enhancing the scope and sophistication of data through concentrating and sharing various types of probe data, as well as expanding the number of data collection vehicles and data types. Specifically, verification tests were carried out to confirm the social effect of probe data systems by collecting and sharing probe data from telematics services and commercial and private vehicles. METI also carried out activities to identify technical and non-technical issues preventing the establishment of social probe data systems, including data collected regularly from vehicles, and to study potential solutions.

Furthermore, MLIT is also investigating and studying items such as the collection of probe data to provide logistics support services by identifying the locations of logistics vehicles using ITS spot services, as well as the collection of probe data detailing actual driving times in certain areas for road administration purposes.

2.7. Other

With respect to the use of wireless systems, MIC is responsible for allocating the use of new frequencies and forming policies for related technical standards, considering the usage situation of radio waves and interference with other wireless systems. In the field of ITS, MIC is studying the technical standards required for new frequency allocation and system introduction to enable the introduction of new systems and the enhancement of existing system sophistication. It has already allocated frequencies and formulated technical standards for VICS, ETC, ITS spot systems, and the like, and worked to promote the popularization of these systems. In 2012, MIC studied communication control protocols and the like for vehicle-vehicle and I2V communication, as well as for harmonious vehicle-pedestrian (V2P) communication and infrastructure-infrastructure communication. These studies aimed to further enhance the sophistication of DSSS using the 700 MHz frequency band to help achieve a safe road traffic environment. It also acted with respect to 79 GHz band radar systems, which have higher resolution than existing radar systems. After receiving partial reports from the Information and Communications Bureau in April 2012, it set up a framework by issuing revised ordinances and the like in December. In addition, a prototype high-resolution 79 GHz band radar was manufactured and tested at intersections and in the rain to verify its effectiveness in the real-world (Fig. 5).

As part of its project to develop energy-saving ITS technologies, METI carried out the activities described below over a planned five year period from 2008. The purpose of these activities is to encourage the implementation of highly effective ITS technologies for saving energy and countering global warming to support the efforts of the transportation sector in developing measures related to energy and the global environment. Measures to save energy and counter global warming include the reduction of CO_2 emissions from vehicles by reducing wasteful fuel consumption due to repeated acceleration and idling in stopped traffic caused by congestion. Therefore, METI is aiming to alleviate congestion by smoothing traffic streams through the active introduction of ITS.

Platoon driving is an energy saving measure that uses ITS technology to drive multiple vehicles (usually trucks)

Source: Japan Automobile Research Institute (JARI)

Fig. 6 Autonomous platoon driving system.

together with an extremely close vehicle-to-vehicle distance, thereby reducing drag particularly when driving on an expressway. Consequently, METI is developing basic technology to achieve platoon driving, as well as autonomous driving technology with built-in environmentally friendly controls for urban roads. In 2012, the final year of the project, it succeeded in holding a demonstration test of platoon driving that satisfied its ultimate targets of a four-vehicle platoon with each vehicle separated by four meters and a speed of 80 km/h. In addition, to promote the adoption of the first technology developed by the project, METI collaborated with four Japanese truck manufacturers to produce a test vehicle equipped with cooperative adaptive cruise control (CACC). This vehicle was then subjected to verification tests (Fig. 6) [8].

As part of efforts to develop methods and technology to quantitatively evaluate the CO_2 reduction effect of ITS, METI is also working on creating and improving evaluation tools. These efforts were concluded in 2012. After discussions with researchers in the U.S. and Europe about evaluation tools and verification methods, agreement was reached about the targeted ITS policies, reference models, and the like. The details were summarized and published in a joint international report called the Guidelines for Assessing the Effects of ITS on CO_2 Emissions - International Joint Report -. In addition, METI also carried out case studies in Kashiwa and Toyota as model ITS cities to examine specific application cases toward the early implementation of the results of ITS projects. These cities were used to confirm the effectiveness of tools by evaluating the CO_2 reduction effect of environmentally friendly driving support and route information.

Other projects include efforts by MLIT to encourage bus use by improving convenience. The aim of MLIT is to create transportation networks that maintain an optimum balance between the use of private cars and public transportation. In this way, it wants to enhance the safety of vehicle traffic in cities through comprehensive measures that emphasize both safety and traffic smoothing in vehicle transportation projects. Specifically, MLIT is aiming to support collaboration with local authorities for the adoption of advanced systems introduced by road transportation operators such as bus location systems, ticket systems using IC cards, PTPS, and the like (for example, PTPS is a collaborative project with the NPA).

In the aftermath of the Great East Japan Earthquake in March 2011, vehicle data from private companies (probe data) was concentrated together and information about roads traveled over the previous 24 hours was released on the internet. Since some roads might be closed even if used by vehicles, this map was also overlaid with road closure information obtained by the Geospatial Information Authority of Japan (GSI). In this way, collaboration between private and public entities helped to enhance the accuracy of the information posted on the internet.

This information helped recovery and rescue efforts after the earthquake, such as movement in the affected areas, transportation of emergency supplies to the Tohoku region, and the like. Opinions about this activity obtained from the national and local governments, private companies, and experts included requests for the inclusion of heavy-duty vehicle data, rapid map creation after a natural disaster, and more frequent data communication. In 2012, a structure was established incorporating studies to enhance the system to create information specifications that follow the needs of the users, practical operational systems, and arrangements for bearing costs. The details of information obtainable from private companies, uniform specifications for information cycles and the like, and the necessary costs for system operation and upkeep, and other factors were organized.

3 ITS Trends outside Japan

3. 1. Asia/Pacific

The 12th ITS Asia-Pacific Forum was held in April 2012 in Kuala Lumpur, Malaysia. The meetings and exhibitions attracted 809 participants from 22 countries. The theme of the forum was the fundamental innovation and enhancement of traffic information in each country.

Reports and discussions were held related to traffic information in the participating countries and regions.

3.2. U.S. [9]

The Connected Vehicle Research project is a national government-led project that has been under way for a number of years. This project aims to utilize communication between vehicles (V2V) and between vehicles and other mobile devices to study services for safety and the environment. The project is coming to a head and the major milestone of a Safety Pilot Project will be reached in 2013. After making a Regulatory Decision about V2V, the project will then aim to achieve practical implementation.

3.3. Europe [10]

In July 2010, the EU Road Safety Policy (2011–2020) was adopted with the new target of halving traffic accident fatalities within ten years. The research and development phase of the policy was driven by projects such as Cooperative Vehicle-Infrastructure Systems (CVIS), SAFESPOT, Co-operative Systems for Intelligent Road Safety (COOPERS), and the like. This phase has been superseded by the field operational test (FOT) phase through projects such as DRIVE C2X, euroFOT, the Strategic Platform for Intelligent Traffic Systems (SPITS), and so on. The M453 directive has accelerated standardization, helping to build an environment for practical system adoption. The 19th ITS World Congress was held in Vienna, Austria, in October 2012 under the theme of "Smarter on the way." The meetings and exhibitions attracted 10,000 participants from 91 countries. The congress adopted the three action plans of Austria as its main topics: connecting seamlessly, serving customers, and encouraging sustainability. The participants enjoyed active discussions and exchanged information, centering on exports from industry, governments, and academia.

3.4. International cooperation and standardization

As part of efforts by METI toward standardization, Japan is playing an active role on the main and subcommittees of ITS/TC 204. Various proposals from Japan, such as for vehicle-to-vehicle distance control systems and navigation system message sets have been approved for conversion from draft to full international standards. Japan is also playing a leading role in the standardization of collision mitigation braking systems and lane-keeping assistance systems. In 2012, these reached virtually the final phase of the international standardization process. New proposals by Japan included basic requirements for alert systems.

The NPA is also promoting international standardization activities at ISO/TC 204 in partnership with the UTMS Society of Japan. Standards related to centrally determined route guidance (CDRG: ISO/TR 17384) and emergency vehicle priority control (PRESTO: ISO 22951) have already been issued.

MIC is also actively making proposals based on the situation of frequency allocation in Japan as part of Working Party (WP) 5A (land mobile services) and 5B (radio-determination services) of Study Group 5 (SG5) of the Radio-communication Sector of the International Telecommunication Union (ITU-R). In December 2011, the Japanese Radio Regulatory Council agreed to the allocation of the 700 MHz band for ITS in Japan. Prompted by the formulation of standard 109 from the Association of Radio Industries and Businesses (ARIB STD-109) in February 2012, MIC proposed a revision to the ITU-R M.2228 report to reflect the latest information at a meeting of WP 5A in May 2012. In addition, as part of its efforts related to high-resolution 79 GHz band radar systems, MIC initiated a revision process to add the new high-resolution 79 GHz band radar information to recommendations related to data communication of automotive radars using 76 GHz and other bands, which are regarded as low-power automotive radars. This information was approved as the ITU-R M.1452-2 recommendation in May 2012 [11].

Based on the results of public-private research and the like related to ITS spot services, MLIT is also proposing systems to implement various services by selecting and combining onboard basic application program interfaces (API) from technologies for communicating map data between information centers and vehicle navigation systems and roadside infrastructure applications. It is currently following the procedures toward adoption as an international standard.

These activities are an extremely significant part of Japan's policy of global collaboration. This is regarded as a highly effective way of promoting various ITS technologies in the Asia-Pacific countries as well as simply Japan, the U.S., and Europe.

Finally, the 20th ITS World Congress will be held in Tokyo in October 2013. Under the theme of "Open ITS to the Next," this is an excellent opportunity to demonstrate Japan's strengths that have attracted attention around the world in Europe, the U.S., and the Asia-

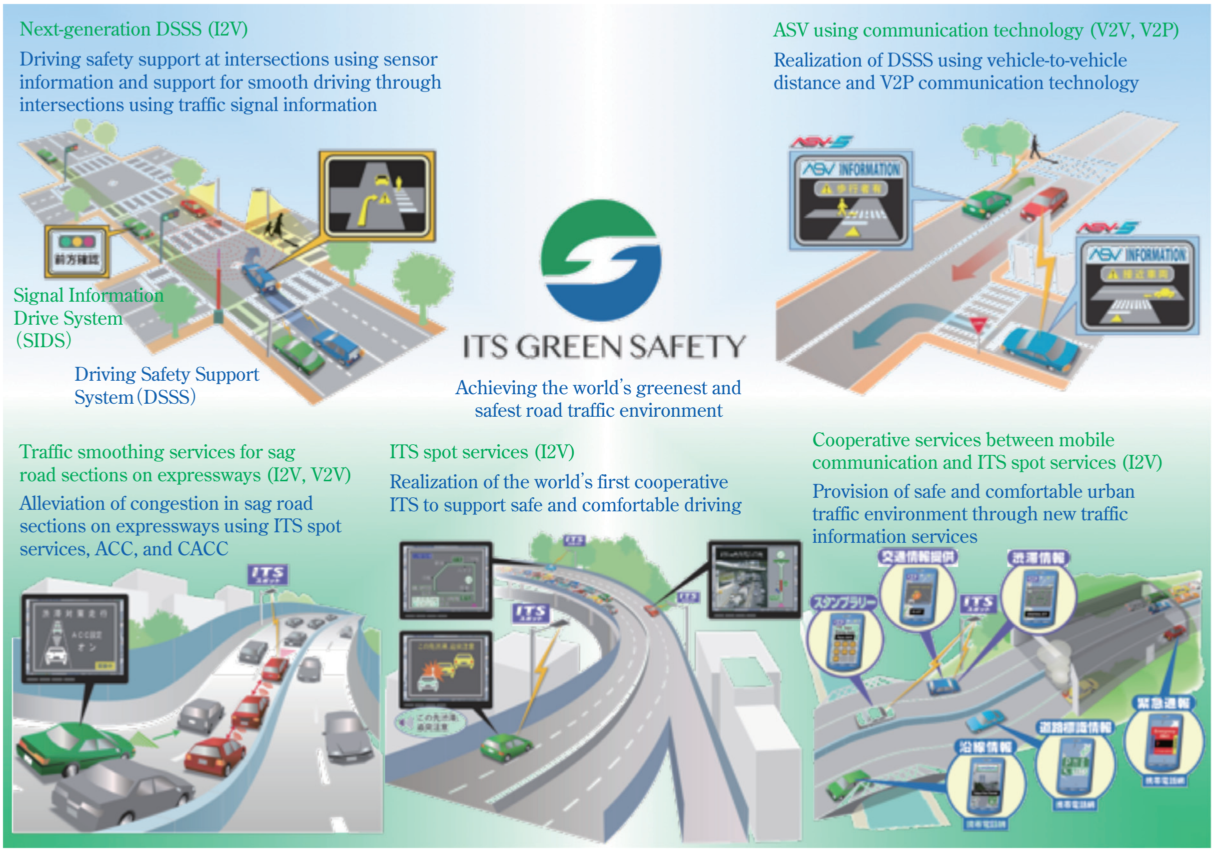


Fig. 7 World-leading cooperative ITS service showcase created by private-public collaboration in Japan.

Outline of ITS World Congress Tokyo 2013

Timing: October 14 (Monday) to 18 (Friday), 2013
Venue: Tokyo International Forum (opening ceremony on October 14)
Tokyo Big Sight (sessions (meetings), exhibitions, closing ceremony, and the like from October 15 to 18)
Open to the general public: October 17 and 18 (two days)
Theme: Open ITS to the Next
Registered meeting participants: 4,000   General participants: more than 8,000
Participating countries: More than 60   Exhibition booths: 700
Papers: 1,000   Sessions: 250

Logo

Tokyo International Forum

Tokyo Big Sight

Source: The Japan Organizing Committee of ITS World Congress Tokyo 2013

Fig. 8 Outline of ITS World Congress Tokyo 2013.

Pacific region. Specifically, this congress gives Japan the chance to present the collaborative public-private activities in various regions around Japan described above and the results of verification tests that are only feasible in a megacity like Tokyo. Representative examples are shown in the ITS Green Safety Showcase (Fig. 7). There are also several global collaborative projects to be discussed during the world congress. Starting these projects depends on the further development of ITS technology and Japan's experts are looking forward to working with their counterparts from around the world (Fig. 8) [12].

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