JAPAN'S APPROACH FOR ROAD SAFETY: OPEN PLATFORM FOR COOPERATIVE VEHICLE SAFETY

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ABSTRACT

As Japan has actively promoted the development and practical application of Intelligent Transport Systems (ITS), or systems that use the latest telecommunications technologies to link humans, roads, and vehicles, changes including alleviation of traffic congestion and reduction of the environmental burden have begun to emerge in society as a result of the rapid spread of car navigation systems, VICS (Vehicle Information and Communication System), and ETC(Electronic Toll Collection system). ITS is now entering the so-called second stage, in which it will contribute to positive changes in society and daily life by resolving various problems of society that have been difficult to solve in the past.

In August 2004, the Smartway Project Advisory Committee (chaired by Shoichiro Toyoda, honorary chairman of the Japan Federation of Economic Organizations) issued a proposal entitled "ITS Enters the Second Stage," presenting a set of measures for the development of ITS in its second stage.

In January 2006, IT Strategic Headquarters issued the New IT Reform Strategy, which calls for the realization of systems for assisting safe driving by infrastructure-vehicle cooperation, with the goal of reducing traffic accident fatalities to fewer than 5,000. In response, public and private organizations have been steadily pursuing these goals through collaborative efforts. Tests on public roads, using ITS on-board equipment based on an open platform, are planned in 2007.

This paper presents a conceptual description of ITS in Japan and describes the current situation of efforts to support safe driving.

1. CURRENT STATE OF ITS IN JAPAN

1.1 Background of the promotion of ITS

As motorization advanced rapidly beginning in the 1950s, it created a negative legacy including an increase in traffic accidents, traffic congestion, and environmental pollution.

At an early stage, efforts were begun to resolve these problems using IT. The Comprehensive Plan for Intelligent Transport Systems in Japan was formulated in 1996, presenting a plan for ITS development and deployment during the next ten years. ITS has continued to be emphasized in government policy, including the Basic Policy for Promotion of an Advanced Information and Telecommunications Network Society (1997, Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society); the e-Japan Priority Policy Program-2004 (June 2004, IT Strategic Headquarters); and the New IT Reform Strategy (January 2006, IT Strategic Headquarters).

1.2 The second stage of ITS in Japan

These efforts to promote the development and practical use of ITS in Japan have led to rapid popularization. Over 15 million VICS units have been shipped, and over 14 million ETC on-board units have been installed. In addition to greater convenience for users, this is resulting in positive effects for society, including reduced congestion and a lower environmental burden.

As a specific example, the introduction of ETC, which allows drivers to pay tolls without stopping their vehicles, has alleviated congestion at tollgates. In addition, VICS provides information on congestion, accidents, and other road traffic conditions to vehicles, where it is displayed on the screen of an on-board car navigation system. Based on this information, drivers can select alternate routes and avoid congested areas, thereby reducing the environmental burden.

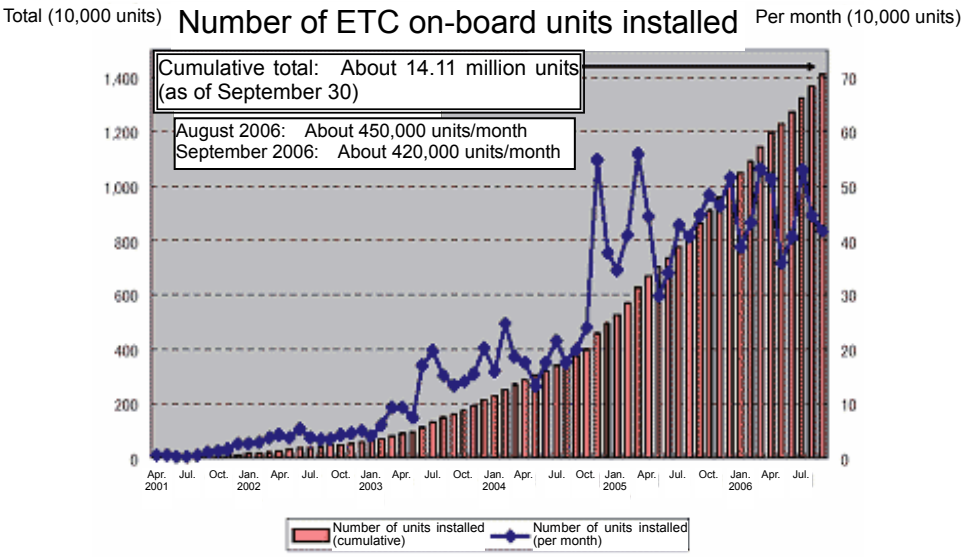

Figure 1 - Number of ETC on-board units installed

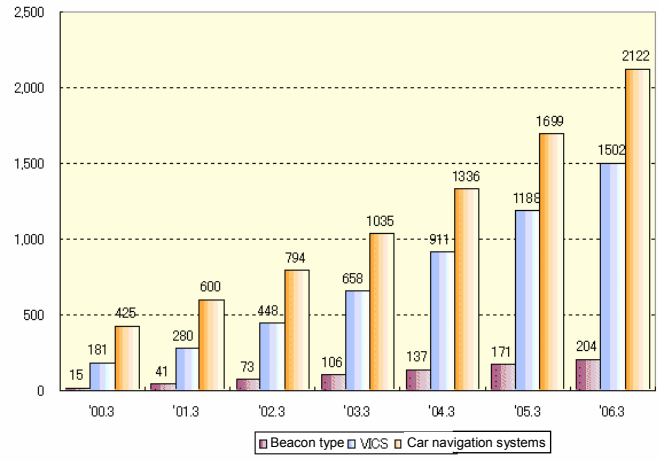

Figure 2 - Numbers of car navigation systems and VICS units shipped

With the goal of reducing traffic accidents, measures to improve safety and peace of mind are also being steadily advanced. In addition to single-vehicle safety systems such as rear-end collision warning system which are already in practical use, trial operation will begin in 2007 for services to support safe driving through road-vehicle cooperation.

ITS in Japan is now entering the second stage, in which it will contribute to positive changes in society and daily life by resolving various problems of society that have been difficult to solve in the past.

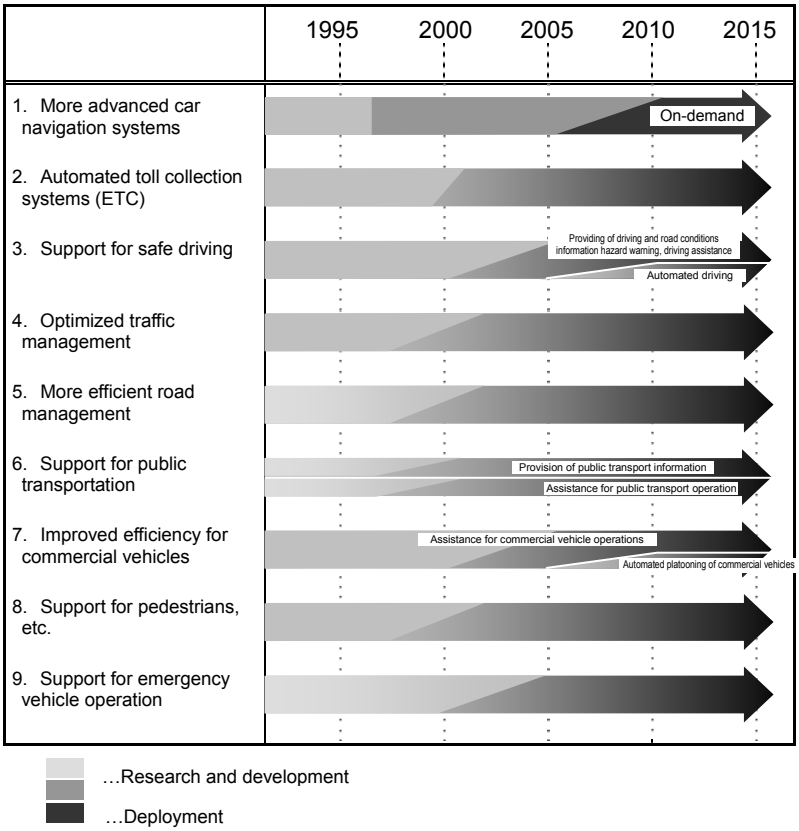

Figure 3 - Planned development and deployment of ITS

2. SMARTWAY: THE INTEGRATED SYSTEMS SOLUTION

2.1 Goals of Smartway

The goals of Smartway are to improve the quality of mobility and transportation in order to realize a society of smart mobility by means of the following four goals: reversing the negative legacy of motor vehicles including accidents, environmental burden, and congestion; ensuring the mobility of the elderly and disabled so that they can get around with peace of mind; developing affluent communities and lifestyles by promoting the use of expressways and public transportation in order to improve community vitality and bring a sense of affluence; and improving the business climate by ensuring the seamless flow of information and improving the efficiency of distribution.

In order to achieve these four goals, steady efforts to promote Smartway will be needed.

2.2 Providing a variety of services with a single ITS on-board unit

In the deployment of varied ITS services, taking the approach of developing each service separately and independently would result in inconvenience for users and a slower pace of progress. Therefore, instead of the separate realization of each individual service, it is important to build an infrastructure (platform) that can be used in common for a variety of services, based on an appropriate division of roles among interested parties.

In Japan, ETC as the road-to-vehicle communication platform (5.8 GHz DSRC) and car navigation systems as the driver interface (with display, audio, etc.) have become quite widespread. These elements will be further developed to form a platform for the realization of varied services from an ITS on-board unit.

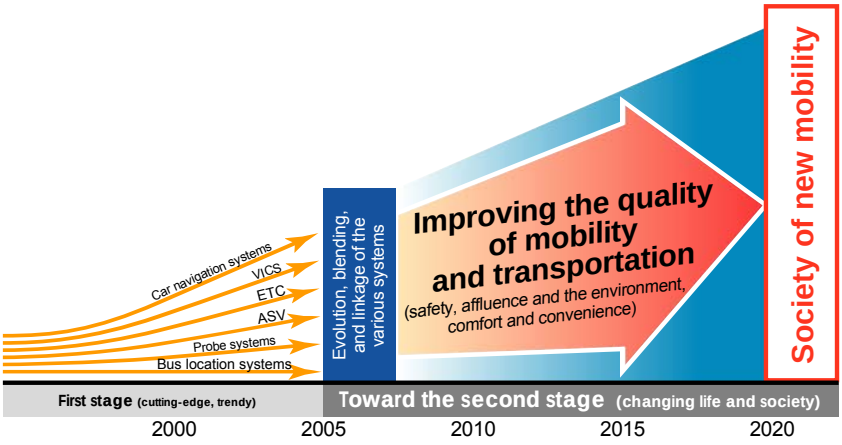

Figure 4 – SMARTWAY : Society of new mobility

2.3 Promoting the realization of ITS services in 2007

The necessary infrastructure for public services will be built and the manufacturing of ITS on-board units by the private sector will be promoted, toward the realization of ITS services in 2007 as recommended in the proposal. It is also important to deploy services for public facilities at an early stage, promote enhancement of the service environment, encourage the widespread adoption of ITS on-board units, and support the deployment of private services.

The desirable directions for each area of services are described below.

(1) Timely driving support information

The aim with regard to timely driving support information is to improve safety and peace of mind through services that use audio announcements and images to supply moving vehicles with easily understandable information on obstacles in the road ahead, unusual conditions ahead, weather conditions, and road surface conditions.

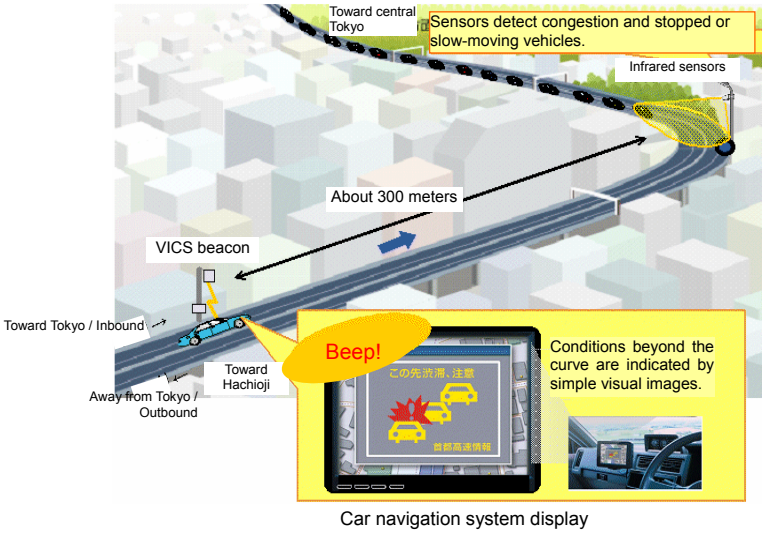

Figure 5 - Illustration of timely driving support information

(2) Regional guides according to location and needs

The aim with regard to regional guides is to provide added convenience for road users through services that supply road traffic information, regional information, tourist information, etc. in response to requests from users in vehicles, according to their locations and needs. Consideration will also be given to ensuring that this common infrastructure can also be used by local governments and private businesses to provide various services.

(3) Smooth passage through all types of gates

The aim with regard to smooth passage through all types of gates is a versatile system for cashless payments. Consideration will also be given to ensuring that local governments and private businesses can also use the common infrastructure to provide various services.

Parking fee payment

Figure 6 - Smooth passage through all types of gates

2.4 Scenario for the spread of ITS on-board units

The popularization of ITS on-board units will be an important issue in the supply of ITS services in 2007 and beyond. Since ETC, car navigation systems, and VICS are already widespread in Japan, it is expected that a smooth transition to ITS on-board units can be realized by studying popularization policies that give consideration to users of ETC only as well as users of existing systems.

3. ADVANCED SAFETY VEHICLE (ASV)

The project for advance of the vehicle safety is promoted. Advanced safety vehicle (ASV) are vehicle equipped with driving assistance system for safety using advanced technologies. The ASV project, closer cooperation industry, academics, and government, aims to promote the development, introduction and popularization of ASV technologies.

During the first phase (1991-1995) of ASV project, technological possibilities were studied. During the second phase (1996-2000), ASV design principles were formulated and road-to-vehicle communication systems were studied for introduction. During the third phase (2001-2005), inter-vehicle communication systems were studied for introduction. Several technologies, including lane keeping assistance system, adaptive cruise control (ACC), and damage mitigation braking system, are already available commercially. At present, the forth phase (2006-2010) are to implement promoting introduction of communication-technology-base system and full-scale popularization of ASV.

4. RESEARCH AND DEVELOPMENT: SMARTWAY 2007

4.1 Joint public-private research

A working group (chaired by Hironao Kawashima, professor at Keio University, Faculty of Science and Engineering) was established under the Smartway Project Advisory Committee to study specific measures with the goal of promoting realization of the proposal. This included intensive study through joint public-private research regarding the ITS services which are to be launched in 2007.

Joint public-private research was conducted from February 2005 to March 2006 on the subject of systems to provide next-generation road services. The working group consisted of the National Institute for Land and Infrastructure Management (NILIM) of the Ministry of Land, Infrastructure and Transport and 23 private firms selected through public recruiting. It studied the functions required of roadside units in order to realize new road services, the functions of on-board units, and other aspects; and prepared technical materials that will be needed to formulate common standards and specifications for practical application.

Figure 7 - Smartway Demo 2006

Table 1 - Companies participating in joint public-private research

Area of business	Name of company	Area of business	Name of company
Automobile manufacturers	Toyota Motor Corp.	Navigation system manufacturers	Aisin AW Co., Ltd.
	Nissan Motor Co., Ltd.		Clarion Co., Ltd.
Electronics manufacturers	Oki Electric Industry Co., Ltd.		Kenwood Corp.
	Sumitomo Electric Industries, Ltd.		Xanavi Informatics Corp.
	Toshiba Corp.		Denso Corp.
	NEC Corp.		Pioneer Corp.
	Japan Radio Co., Ltd.		Fujitsu Ten Ltd.
	Hitachi, Ltd.	Other	NTT DoCoMo, Inc.
	Fujitsu Ltd.		Tokico Technology Ltd.
	Matsushita Electric Industrial Co., Ltd.		Park 24 Co., Ltd.
	Mitsubishi Heavy Industries, Ltd.		Fujitsu Laboratories Ltd.
	Mitsubishi Electric Corp.		

(1) Subjects studied in joint research

This joint research was focused on the use of a single on-board unit to provide varied services, including services that have been provided separately in the past, such as car navigation, VICS, and ETC, as well as next-generation road services consisting of information provision services along roadways, information connection services at roadside rest areas, and Public parking lot payment services.

(2) Configuration of the system studied in joint research

The system which will be used to provide next-generation road services consists of roadside units, ITS on-board units, and road-vehicle communications. Functions for shared use by the services will form the basic application programming interface (API) of the roadside units and ITS on-board units.

(3) Study of common functionality requirements

The following six basic common functions (basic API) and common security functions were determined as the common functions to be provided for the realization of various ITS services, and requirements were studied for each function.

a. Instruction/response functions

Functions for responding by means of input at the on-board unit (buttons, etc.) when the on-board unit receives instruction data notifications from a roadside unit.

b. Memory access functions

Functions in which the roadside unit can write to and read from the memory of the on-board unit.

c. IC card access functions

Functions for sending payment information to and from an IC card.

d. Push-type data delivery functions

Functions for packaging various types of information and sending it from the roadside unit to the on-board unit.

e. ID communication functions

Functions in which the roadside unit can identify the on-board unit, and the on-board unit can respond.

f. Basic instruction functions

Functions for the roadside unit to send basic instruction data notifications to the on-board unit.

g. Common security functions

The three functions of mutual authentication, data authentication, and encryption, in order to ensure reliability and safety in applications.

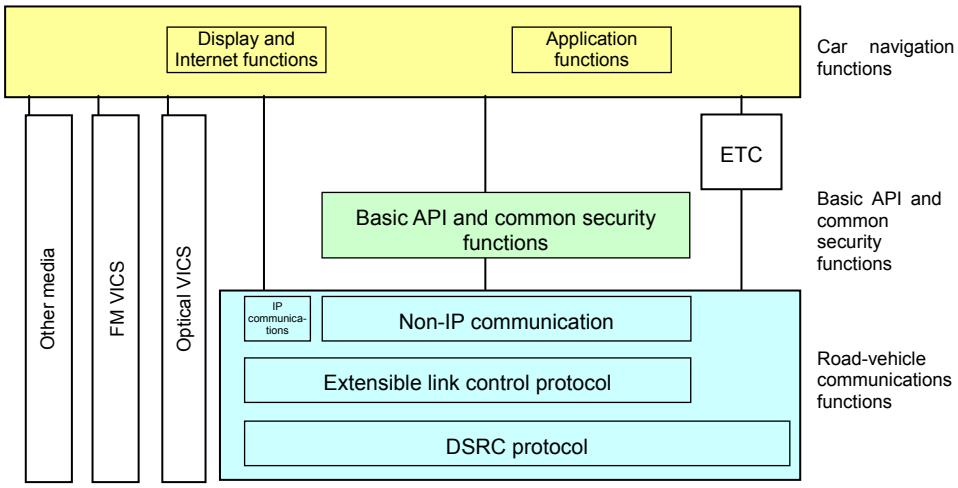

Figure 8 - ITS on-board unit configuration

(4) Roadside system configuration

The roadside system is equipped with road-to-vehicle communication functions, basic API and common security functions, and individual applications; and it provides services to ITS on-board units in coordination with external systems. From among the functions in the figure below (functions to generate, compile, and store provided information, probe data processing functions, payment processing functions, parking management functions, and functions for the display of fees, etc.), the roadside system will include selective implementation of only those functions which are necessary for the services provided.

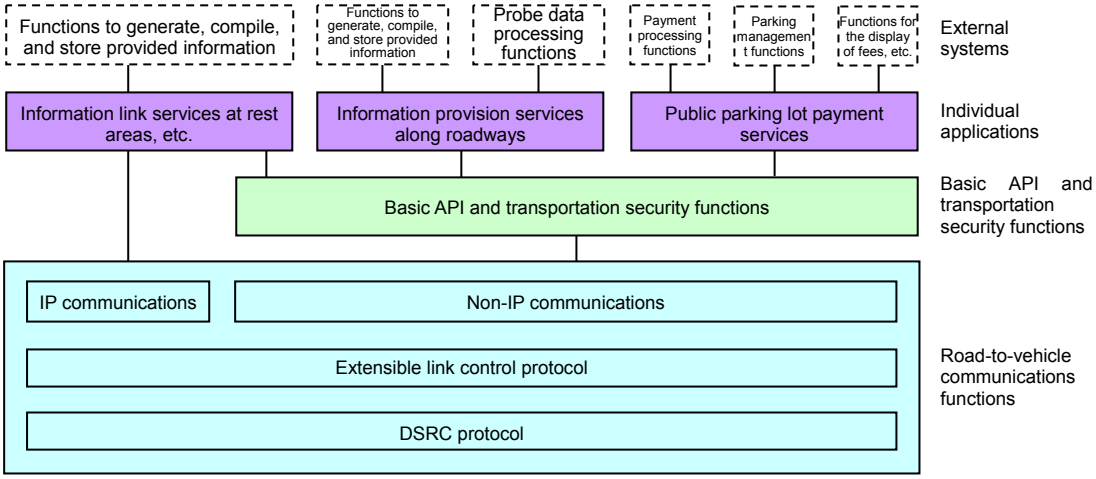

Figure 9 - Roadside system configuration

(5) ITS on-board unit configuration

The ITS on-board unit provides services to the driver by means of an external interface, basic API, road-to-vehicle communication functions, and so on.

The ITS on-board unit's road-vehicle communication functions, which handle road-to-vehicle communications within the communications zone of the roadside system, consist of a DSRC protocol, an extensible link control protocol, and an application sub-layer (ASL) composed of non-IP communications and IP communications.

The basic API and common security functions generally consist of the basic API and common security functions as mentioned above.

The car navigation functions, which play the role of a contact point between the ITS on-board unit and the driver, include display and Internet functions. Since these functions also support contact with external equipment, functions for uploading data collected by car navigation systems, etc. are included.

4.2 New IT reform strategy

In January 2006, IT Strategic Headquarters (headed by Prime Minister Junichiro Koizumi) issued the New IT Reform Strategy, aimed at the pursuit of structural reform regarding IT in Japan. With regard to ITS, this strategy calls for the realization of systems for assisting safe driving by infrastructure-vehicle cooperation in order to realize the world's safest road traffic environment, with the goal of reducing traffic fatalities to 5,000 or below.

Toward the realization of systems for assisting safe driving for prevention of traffic accidents as a means to achieve this goal, it was decided that a liaison committee with both public and private involvement would be established in early 2006 to study directions for effective services and systems, including comparative study of the characteristics of various media, and to consider the matters to be included in proving tests. Decisions were also made to

conduct a large-scale proving test of systems for assisting safe driving with public-private cooperation on public roads in certain regions by fiscal 2008, with steps to ensure coordination with regional transportation; to verify directions for effective services and systems; to obtain a quantitative evaluation of the level of contribution to accident reduction with the aim of nationwide deployment of systems for assisting safe driving, primarily at frequent accident locations, beginning in fiscal 2010; and to promote the widespread adoption of on-board units that support this system.

In response to the New IT Reform Strategy, a public-private liaison committee has been established to promote the development and practical application of systems for assisting safe driving and so on, based on unified public and private aims. It is studying future directions for systems for assisting safe driving and so on, unified standards and systems related to systems for assisting safe driving, and the specific content and approaches for proving tests related to systems for assisting safe driving.

4.3 Smartway2007

After the ITS World Conference which will be held in Beijing from October 10 to 13, 2007, Smartway 2007 will be held in Japan from October 14 to 17 on the Tokyo Metropolitan Expressway to demonstrate trial operation of the latest ITS services, in accordance with the New IT Reform Strategy.

Routes of the Tokyo Metropolitan Expressway that have particularly high accident rates were selected for use in testing, and the system was introduced at locations where accidents occur frequently. In addition to on-board units that are linked to car navigation systems and use both audio and images to provide information (ITS on-board units integrated with car navigation systems), the test included on-board units that provide information using audio alone (independent ITS on-board units) in order to provide safety information to trucks and other vehicles that are not equipped with car navigation systems.

The following nine ITS services are planned for trial operation.

(1) Providing information on obstacles in the road ahead

Roadside sensors are used to detect stopped vehicles or congestion beyond a curve with poor visibility, and drivers entering the curve are alerted by images or audio announcements. The test will verify the effectiveness of this service in enhancing safety and evaluate driver acceptance. The service will be provided with images only at 2.4 GHz, and with images plus audio or audio only at 5.8 GHz DSRC.

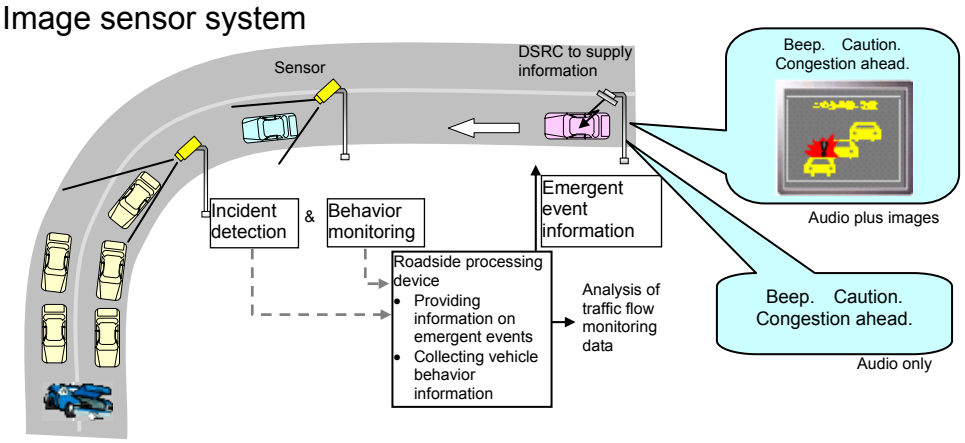

Figure 10 - Illustration of providing information on obstacles in the road ahead

(2) Providing information on conditions ahead

Drivers will be visually informed of road conditions ahead. The test will verify route selection and acceptance by drivers. Camera images of tunnels and locations of frequent congestion will be provided as still images using 5.8 GHz DSRC. In addition, the content of nearby information signs will be provided in audio form.

(3) Providing audio information

5.8 GHz DSRC will be used to send audio information (TTS system, etc.) on congestion and other road traffic conditions. Several patterns have been prepared for audio delivery time, and driver acceptance for information supply by audio only will be confirmed.

(4) Support for merging

The presence of vehicles approaching the merge point is detected from the roadside. Through road-to-vehicle communications, understandable information on the presence of approaching vehicles is provided to drivers just before the merge point.

Drivers will be alerted by information in the form of audio plus images or audio only, which will be supplied using 5.8 GHz DSRC.

Initially, information will be supplied only to drivers on the main route. Later, information will also be supplied to merging vehicles. Subsequently, information to support cooperation will be supplied both to vehicles on the main route and to merging vehicles.

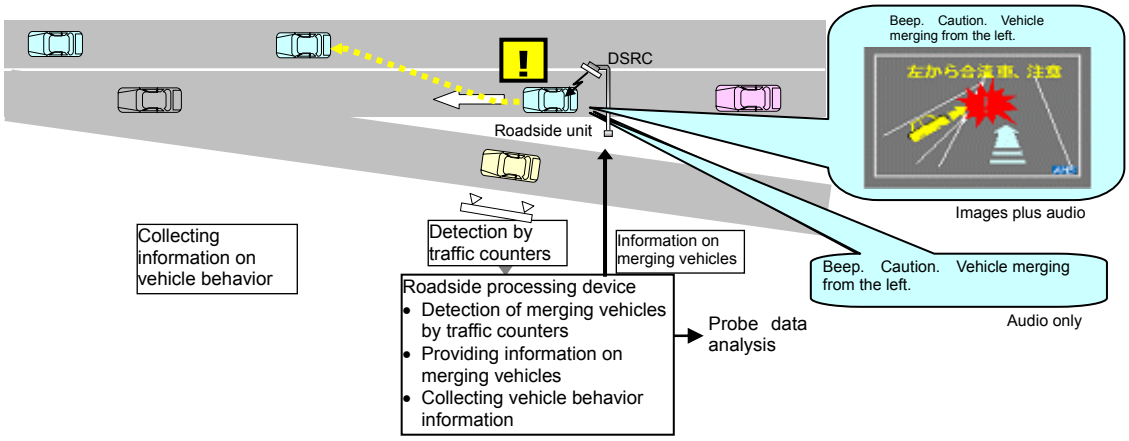

Figure 11 - Illustration of support for merging

(5) Information supply (IP data link)

Vehicles parked at service areas, parking areas, and the like will be provided with Internet connectivity using 5.8 GHz DSRC, wireless LAN, etc., and driver acceptance will be verified. Information on stores and so on will be provided by audio announcements at the entrances to service areas, parking areas, etc.

(6) Study of various communications media

The situation regarding communications, including public wireless LAN, will be verified. Based on the findings, study will be given to the use of these communications services in services such as a simple bus location service, with an eye to deployment outside urban areas. In the future, vehicles that upload data will be provided with information on travel time to each link ahead and information on unusual conditions. Vehicles that do not upload data will receive only the conventional types of information.

(7) Alerts regarding speed when entering curves, and information on locations with frequent accidents

Depending on the situation of the moving vehicle, alerts are provided to a vehicle entering a curve, based on the internal map databases of car navigation systems including data on the curvatures and gradients of road curves. In addition, information will be provided on locations with frequent accidents.

(8) Smart parking

A service that allows the use of an ETC on-board unit to pay parking fees will be provided to vehicles equipped with an ETC on-board unit, using the ETC user vehicle number. It is anticipated that this service will be provided at rest areas on the main line of the Tokyo Metropolitan Expressway. The possibility of discounting expressway tolls for parking area users will be studied.

(9) Information supply (electronic signs)

Information will be provided to support location identification at locations such as ramp entrances where car navigation systems tend to mistakenly identify a vehicle's position. In addition, simple sign information will be provided. Simple and inexpensive communications antennas will be used.

With these operational trials, we are working toward full-scale implementation and nationwide deployment in 2008 and beyond, based on the goal of achieving the world's safest road transportation. Please come to Japan for Smartway 2007.

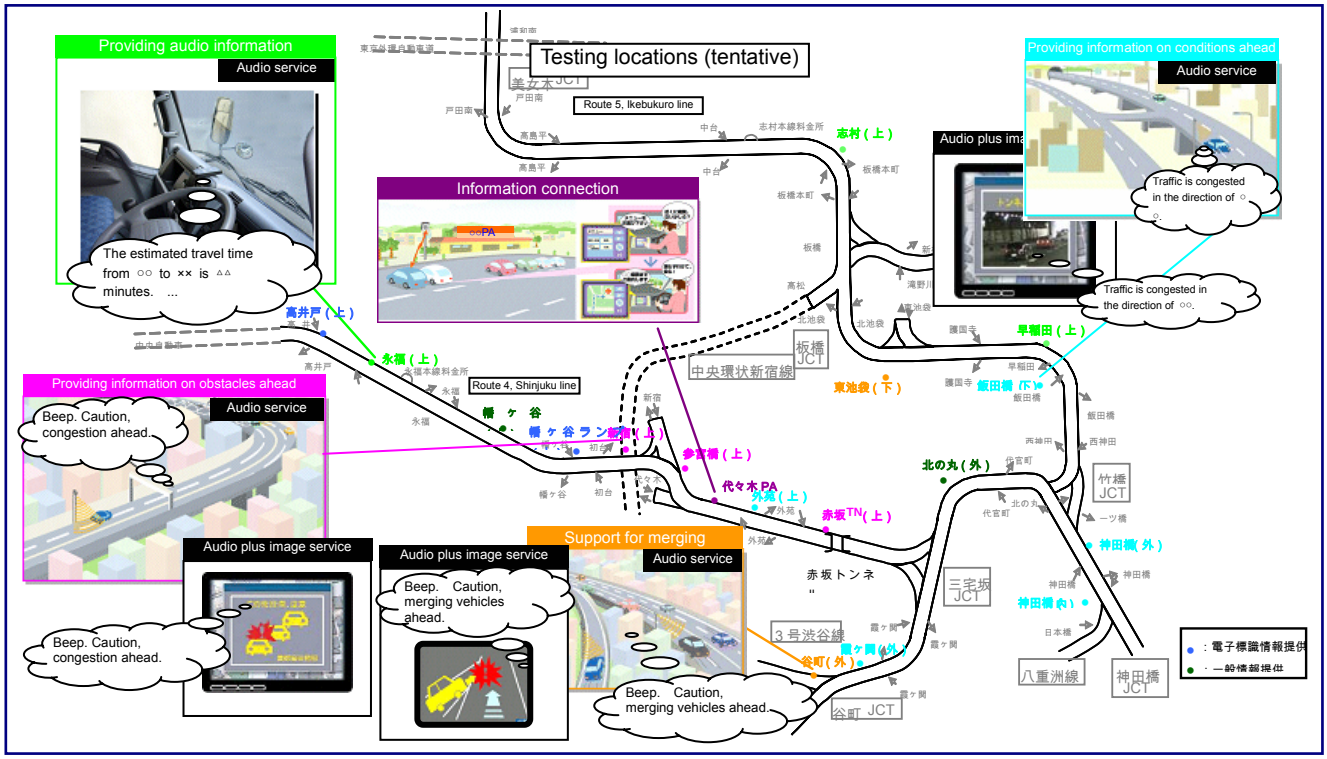

Figure 12 –Smartway2007 Testing locations (tentative)

REFERENCE DOCUMENTS

1. ITS HP of Road Bureau, Ministry of Land, Infrastructure and Transport
   URL: http://www.mlit.go.jp/road/ITS/
2. Smartway Project Advisory Committee (Japanese)
   URL: http://www.mlit.go.jp/road/ITS/j-html/
3. IT Strategic Headquarters
   URL: http://www.kantei.go.jp/foreign/policy/it/index_e.html
4. Final report of the joint public-private research program (Japanese)
   URL: http://www.nilim.go.jp/japanese/its/1top/kyouken/index.html
5. Advanced Safety Vehicle
   URL: http://www.mlit.go.jp/jidosha/anzen/asv/index_e.html