RECENT PROGRESS OF R&D ON THE NEXT-GENERATION ITS IN JAPAN

Setsuo Hirai, Yasuyuki Manabe
Intelligent Transport System Division, National Institute for Land and Infrastructure Management,
Ministry of Land, Infrastructure and Transport
1 Asahi, Tsukuba-shi, Ibaraki Prefecture, 305-0804
TEL：+81-29-864-4496　FAX：+81-29-864-0565
E-mail：hirai-s2xp@nilim.go.jp, manabe-y82ac@nilim.go.jp

1. Introduction

ITS R&D efforts for practical use in Japan have been aggressively made to solve issues of recurring traffic accidents, degraded natural environment, and traffic congestions. Number of on-board unit (OBU) for the Electronic Toll Collection system (ETC) services, which commenced operation in 2001, reached 12,000,000 units as of May 2006. Alleviation of congestions along tollgate sections indicates effectiveness of ETC.

ITS, which has steadily spread in Japan, is now an effective tool for solving social issues, including traffic congestions and environmental problems.

In August 2004, a proposal titled “ITS Enter the second stage” was prepared by the Smartway Project Advisory Committee. This proposal claimed that varied ITS services to be offered in the second stage should form part of social activities in communities, and contribute to solution of problems that the communities are encountering. Responding to the proposal, the National Institute for Land and Infrastructure Management (NILIM) conducted “Joint Research on systems to provide Next-Generation Road Services” which is research on technology for ITS On-Board Unit (OBU) and road side systems cooperatively with 23 private companies from February 25, 2005 until March 31, 2006, in order to create an in-car environment permitting the use of diverse services with a single OBU in 2007.

As part of the outcomes of the final achievements of the joint research, “Smartway Open Field Test Domo 2006” was held at the test course at NILIM in Tsukuba City from February 2006. This report describes the joint research and Demo2006.

2. Outline of the joint research

2-1. Basic concept of the joint research

Joint Research on systems to provide Next-Generation Road Services is intended to create an in-car environment where, in addition to existing services provided separately by ETC, VICS etc., drivers can use three new types of public services; “Information provision services along roadways”,

"Information connection services such as at roadside rest areas", and "Public parking lot settlement services" (Fig. 1)-with a single OBU. And in the future, it is sure to be used to provide a variety of private services including gas stations, private parking areas, drive through facilities and so on.

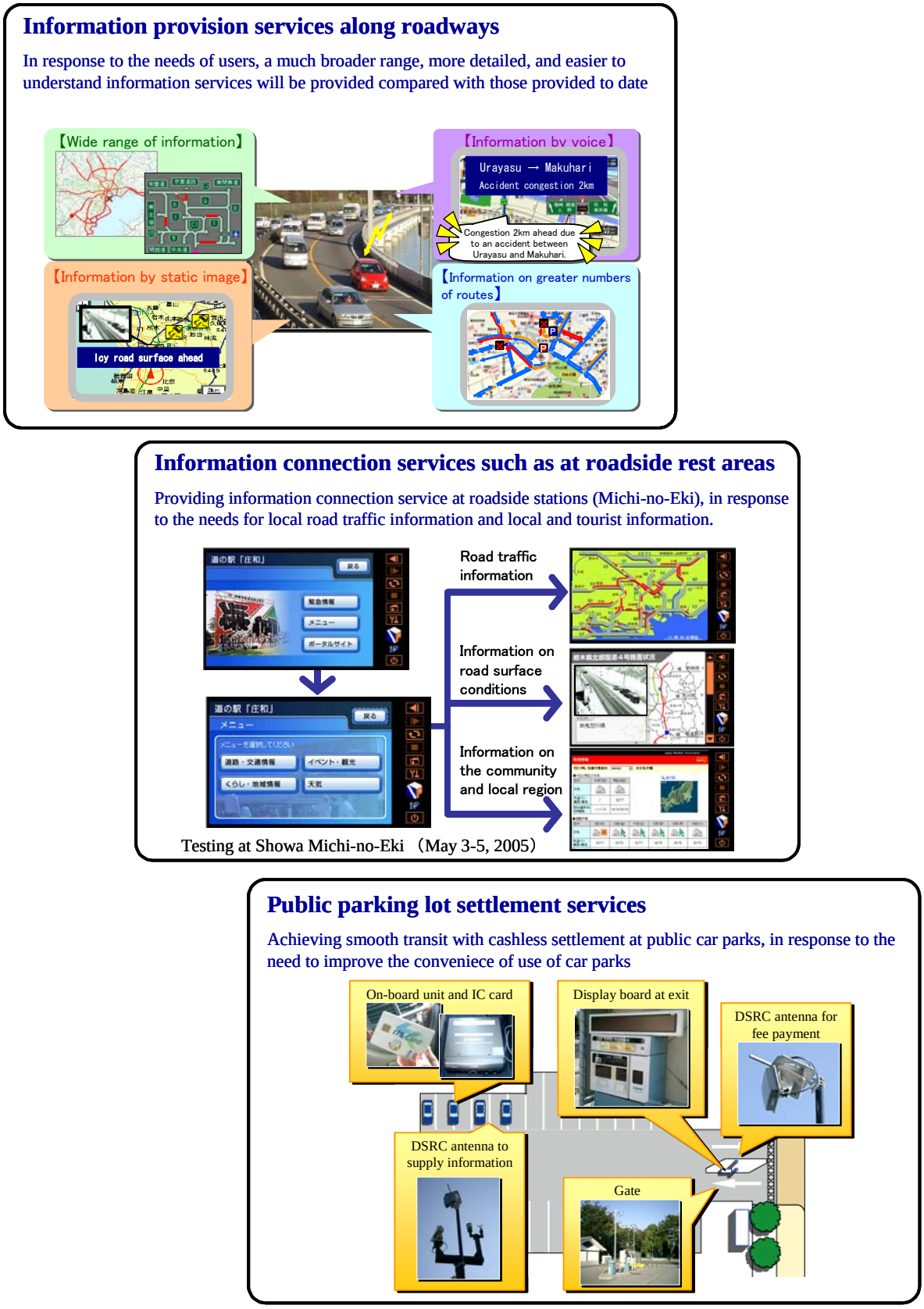

Figure 1. Next Generation Road Services (Three Public Services)

2-2. Research items in the joint research

To achieve the above goals, the joint research has been carried out by studying and harmonizing both the services and methods of achieving them (Fig. 2).

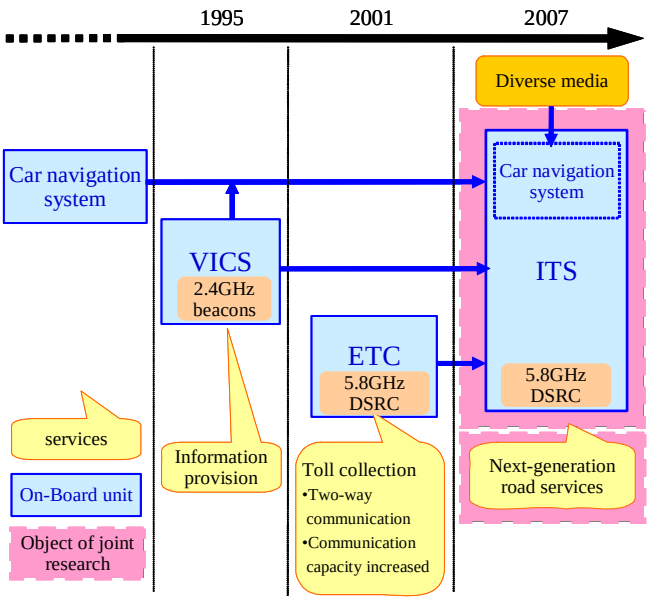

Figure 2. Object of the Joint Research

(1) Specific study of the services

The specific contents of the three services and innovations necessary to establish them were studied.

1) Information provision services along roadways

VICS, using 5.8GHz-DSRC to handle broad-band telecommunications, a wide range of information is provided than was previously possible. Timely information by voice provides comprehensible information and warning to drivers, including senior citizens. Still pictures of the road surface taken with roadside cameras are used to provide information that is far more easily understood than before. Probe data up-linked from vehicles will be used to provide information about more road links than the present.

2) Information connection services at roadside rest areas etc.

Information that increases safety and reduces worry—information about traffic in the district for example—is provided in response to requests from drivers in cars parked at roadside rest areas, service areas and parking areas. And it provides information easily understood about the local region and tourist information etc.

3) Public parking lot settlement services

Allows cars to smoothly enter and leave public parking areas by performing cashless fee payments. The use of existing ETC OBU that is now widely installed is supplemented by the use of ITS OBU and a single IC card type general purpose credit card. This method will permit flexible services including parking fee discounts, a point system, or support for handicapped people according to the use of adjoining facilities.

(2) Study of conditions essential for common functions

The System for providing next-generation road services consists of roadside systems, ITS OBU, and road-vehicle communication (Fig. 3). The road-vehicle communication functions and other commonly used functions necessary to realize the three services were studied as shown below (Fig. 4).

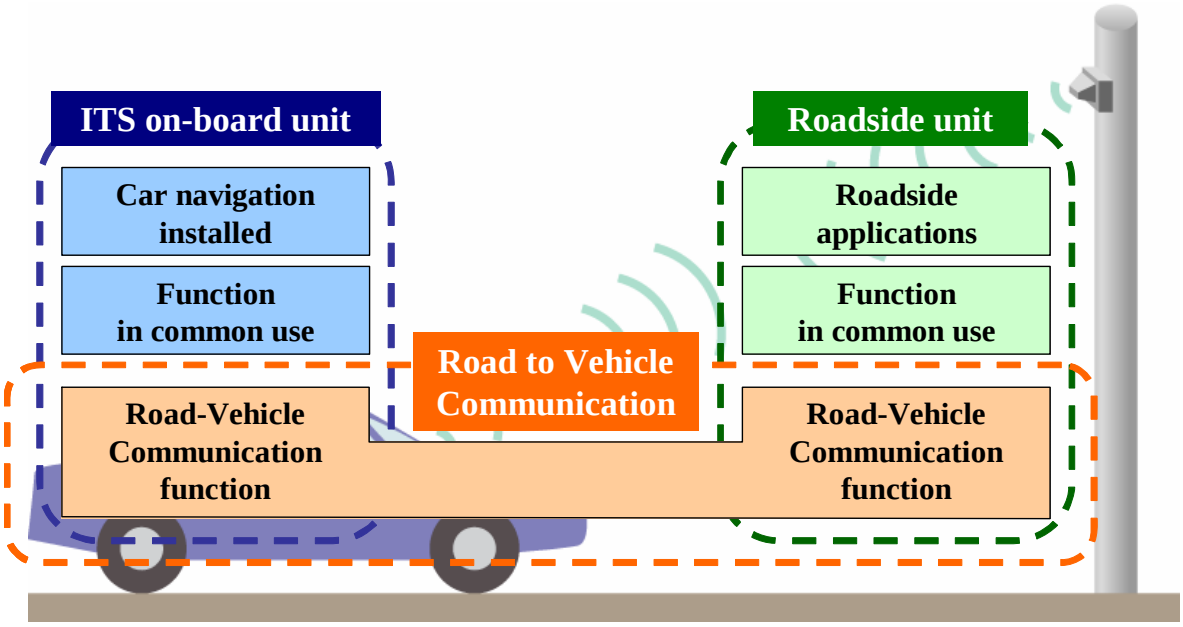

Figure 3. Configuration of the System that is the Object of the Joint Research

1) Command response function

Commands are transmitted to OBU from the roadside and the OBU responds

2) Memory access function

Information is read in from roadside system to OBU memory and read out of OBU memory

3) Card access function

Fee payment information is transmitted to and received from IC cards

4) Push-type information distribution function

Provides diverse information in packages from a roadside system to OBU

5) ID communication function

A roadside system identifies an OBU and the OBU responds

6) Basic instruction function

A roadside system transmits instructions to OBU

7) Common security function

Ensures the reliability and safety of applications by providing three functions: mutual validation, data validation, and encoding

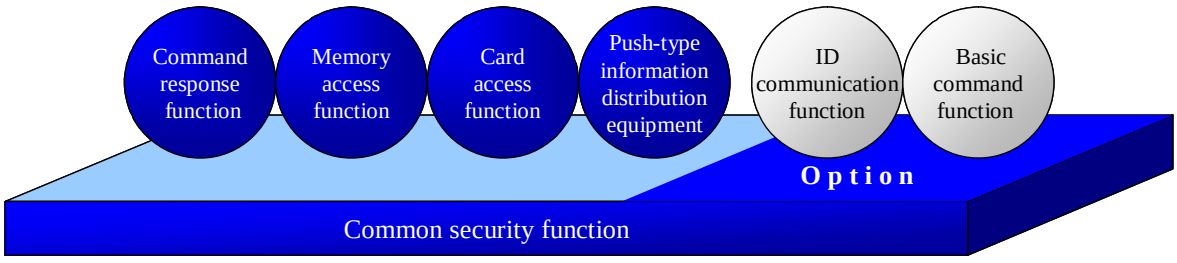

Figure 4. Functions Commonly Used by the next-generation road Services

(3) Study of common functions of the roadside system

It has been decided that the roadside system will provide necessary services by combining a variety of applications linked to outside systems (Table 1).

Table1. Applications

Service		Application name
Information provision services along roadways	Information provision	Safe driving support information provision
		Caution/warning information provision
		Multi-purpose information provision
		Long text read out information provision
		Congestion/travel time information provision
		Parking area information provision
	Information gathering	Vehicle ID information collection
		Time and position information collection
		Location speed, direction, acceleration, angular velocity information collection
		Weather information, vehicle behavior information collection
		Driving information collection
Information connection services such as at roadside rest areas		Provision of information to vehicles entering the parking area
		Provision of various kinds of information
Public parking lot settlement services		Fee collection
		Parking area exit control
		Facility information provision

(4) Study of ITS OBU functions

ITS OBU functions were divided between the DSRC unit and the car navigation unit to study OBU functions that will be used by the three services and to specify requirements for the ITS OBU as shown below.

1) Information provision services along roadways etc. adopt the QPSK modulation mode with large communication capacity as the 5.8GHz – DSRC modulation method.
2) Services for cars when they are cruising or traveling slowly are provided using a push type information distribution application and services for stopped cars are provided using either push type information distribution applications or IP connections.
3) Considering the protection of private information, a method that does not accumulate data around the start point and a function that can stop uplinking when a user wishes are included.

4) It is necessary to confirm the user's intention to pay fees with a credit card (there will be no restriction on the intention confirmation method).
5) DSRC-SPF is recommended as the standard security installed in ITS OBU.

(5) System operation check

In order to contribute to the reliable and smooth provision of next-generation road services, a method of performing interconnection testing to test the mutual connectivity of ITS OBU in an indoor environment in advance has been devised. A prototype of the system was prepared and tested at the NILIM test course to make sure it operated properly.

3. Outline of Smartway Open Field Test Demo 2006

3-1 Outline of Demo2006

The Smartway Open Field Test Domo 2006 was held to publicize the outcomes of the joint research to develop the next-generation road services provision system that is explained above (Table 2).The test and demonstration were done by setting up three kinds of courses (test drive courses A ~ C) on the 6km test course at the NILIM and test runs were done using 10 demonstration cars (Figure 5).

Table2. Outline of the Open Field Test

Dates of the trial	February 22 (Wed.) – 24 (Fri.), 2006
Place	National Institute for Land and Infrastructure Management, the Ministry of Land, Infrastructure and Transport (Tsukuba City in Ibaraki Prefecture)
Sponsors	the National Institute for Land and Infrastructure Management, the Ministry of Land, Infrastructure and Transport
	Twenty-three private companies
Participants	Approximately 1,000 people in 3 days

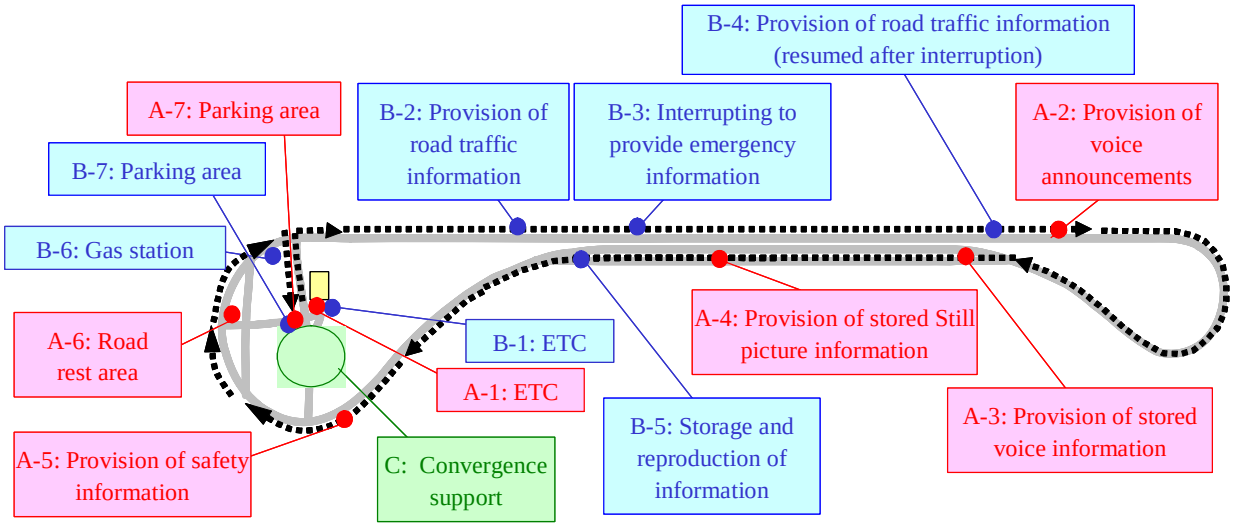

Figure 5. Details of Service Provided on Three Courses (A-C)

Each demonstration car was equipped with an ITS OBU prototype (equipped with the common functions studied by the joint research). While the demonstration cars traveled on the course, information transmitted by the DSRC antenna installed on the roadside was received by the OBU and this information was provided by presenting it either on a screen display or as voice information.

3-2. Details of the event and points

(1) Test drive course A

1) Information provision services along roadways

i) Provision of road traffic information using still pictures and voice information (instantly reproduced)

The DSRC antenna on the roadside transmits road traffic information about congestion etc. in the form of voice information and still pictures that are then reproduced instantly by the voice information function and still picture display function that are installed in the OBU (Fig. 5: A-2).

The use of voice information and still pictures permits the provision of easily understood information to drivers of all kinds including the elderly, women, etc.

ii) Provision of information that attracts drivers' attention to dangerous locations (stored and reproduced)

An OBU that has received warnings of poor visibility in a tunnel or information about closed lanes beyond the tunnel exit from a DSRC antenna stores the information without instantly reproducing it then, linked to the car navigation system, it finally reproduces it as voice information or as a still picture just before the car reaches the location of the phenomenon (Fig. 5: A-3, A-4, Photo1).

Photo 1. Providing Information by Storing then Reproducing Still Pictures (Warning of a Closed Lane Beyond a Tunnel Exit)

The existing VICS could only provide warnings of phenomena to cars directly under its antennas, but it is possible to provide information to drivers at appropriate locations just before the car reaches the phenomenon using the new functions. Because up to three phenomena can be stored in the OBU, a single DSRC antenna can be used efficiently.

iii) Provision of safe driving support information on curves with poor visibility

A car parked on a curve with poor visibility is detected by a sensor and a warning is provided in real time in the form of a graphic display and voice announcement to a driver about to enter the curve (Fig. 5: A-5, Photo 2).

Photo 2. Providing Safe Driving Support Information

This system is equipped with functions that can use highly reliable communications in the narrow range that is a characteristic of DSRC to support safe driving by also supplying the OBU with information that stipulates the time when information is displayed after it is received. This service permits measures to deal with drivers' human errors (delayed awareness of the event) that account for 75% of accidents. Of course, such information provision effectively prevents dangerous behavior that cause potentially dangerous minor incidents, a benefit that makes drivers feel safer.

2) Information connection services such as at roadside rest areas etc.

While a car is stopped at a road rest area, this service connects it to the internet through a DSRC and provides it with road traffic information about nearby roads, regional and tourist information, real time still pictures of a parking area at the destination, and moving picture contents on demand (Fig. 5: A-6, Photo 3).

Photo 3. Information Connection Service at Road Rest Areas Etc

By enabling the OBU to connect to the internet, it lets a driver perform real time information searches, reserve parking spaces, etc., and download music. In addition, links to car navigation functions allow the driver to register the facility that was the object of the search as the destination in the car navigation system.

3) Public parking area fee payment service

This service provides graphic and voice guidance to parking spaces for disabled drivers

Photo 4. Public Parking Area Fee Payment Services

to cars as they pass through a parking area gate equipped with ETC communication technology (Fig. 5: A-7, Photo 4).

In addition to existing ETC functions, it is equipped with an IC card type general purpose credit card function that is counted on to be applied to the payment of fees in various other fields such as privately operated parking areas and gas stations, etc.

(2) Test drive course B

1) Information Provision services along roadways (interruption by emergency announcements)

This service interrupts the reproduction of road traffic information by still pictures and voice information (approx. 50 seconds), to provide emergency information such as road surface icing warning as still picture or as voice information. After the emergency announcement, the temporarily halted reproduction of road traffic information is resumed (Fig. 5: B-2,3,4, Photo 5).

Photo 5. Interrupt to Provide Emergency Information (Still Pictures)

2) Gas station fee payment service

At a simulated gas station where the test cars stopped on the test course, the type of fuel and the quantity of fuel obtained were confirmed by the OBU and after refueling was completed, the system performed cashless payments (Fig. 5: B-6, Photo 6). An important feature of this next generation road service is its ability to combine the cashless payment function with an internet connection so it can be used for a variety of private sector purposes. The expansion of the private market is counted on to spread the use of the OBU and lower the cost of the roadside systems.

Photo 6. Gas Station Payment Services

(3) Test drive course C

1) Merging support service

This service provides information to alert drivers as they approach merging lane locations to prevent and reduce accidents (Fig. 6). Specifically, a car was actually driven on a road that was assumed to be a high speed trunk road, road – vehicle communication was used to provide

information about its speed etc. to the merging car through a roadside system, and information was provided by the OBU on the merging car to alert its driver, only when the system predicted the danger of a collision between the merging car and the car on the high speed trunk road.

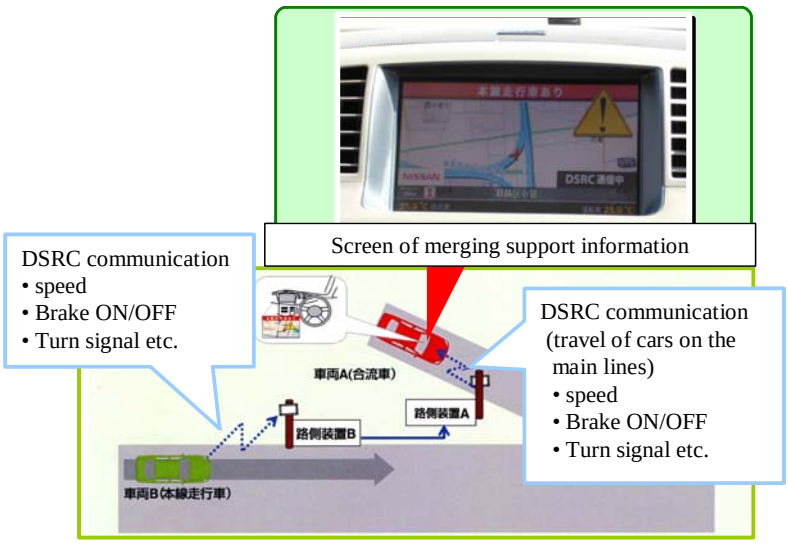

Figure 6. Merging support service

3-3 Opinions of participants in Smartway Open Field Test Demo 2006

A questionnaire survey conducted in conjunction with the Demo 2006 obtained evaluations of each service from approximately 640 participants. It revealed that generally good evaluations of all the services were obtained, with more than 90% of them rating the safety information and driving support service extremely highly as “an attractive service.” And their free opinions included many positive evaluations of the next generation road service provision system including, “It is extremely convenient to be able to use a variety of services with a single ITS OBU.” and “I am counting on the rapid introduction of the services.”

4. Conclusions

The Open field test held to complete the next-generation road service provision system has confirmed that a system based on DSRC, which is utilized for the ETC system has achieved a technical level suitable for its practical introduction.

This new system will be capable of using a single ITS OBU to provide services now provided separately by car navigation systems, VICS, ETC, etc.; a capability that will presumably lower the cost of the OBU. And because the applications of this service include safe driving support, it is expected to make a big contribution to the achievement of “the world’s safest road transportation” that is a goal of the IT Revolution Strategy enacted in January of this year. And the applications that connect cars to the internet and that can collect fees using general purpose credit cards can also be used by private companies, so they are expected to be applied to provide a variety of private services.

Our goal is to start operation of the next-generation road service provision system in 2007. To achieve this, we will finalize designs and specifications cooperatively with concerned organizations based on the outcomes of this joint research, and encourage installation of roadside systems and production of ITS OBU with corroborative testing of the IT Revolution Strategy.