

Introduction of Honda Driving Support System – Field Operation Test for Highway Infrastructure System (Smartway) –

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ABSTRACT

As an initiative of the Smartway project under the Ministry of Land, Infrastructure, Transport and Tourism, field operation tests have been conducted since May 2007 with the participation of private enterprises (nine automobile manufacturers and 17 electronics manufacturers) and other organizations. An advanced highway safety system was created that uses images and sound to enable safe, comfortable driving. Employing new on-board equipment for communications linking road and vehicles, the system was tested on the Metropolitan Expressway in Tokyo. Honda has been participating in the Smartway project with a view to practical application of information provision systems, as well as to verify the functionality of such systems and of the validity and acceptability of driver support.

A symposium was also held in October 2007 in order to generate widespread publicity inside and outside Japan for advanced ITS services on the Metropolitan Expressway. This Smartway 2007 Demonstration, performed as a joint public and private sector (with 30 private enterprises) program, provided people the opportunity to experience Smartway through test drives, presented exhibition displays, and the like. In questionnaires administered after the test drive, respondents gave favorable ratings for service effectiveness, indicating that Smartway holds promise for collision reduction impact.

1. Introduction

The Road Bureau of the Ministry of Land, Infrastructure, Transport and Tourism has been promoting Smartway, which integrates advanced ITS technology. In November 2004, the Smartway Project Advisory Committee established working groups. The National Institute for Land and Infrastructure Management (NILIM) and 23 private enterprises collaborated in summarizing the results of “Joint Research on Systems for Providing Advanced Road Services” in March 2006. The standards and specifications for roadside systems and on-board equipment were decided in March 2007.

The services that are to be realized in Smartway are the timely provision of Smart cruise information, the provision of regional guidance suited to location and needs, and smooth passage through all gates. These three services are to be realized by roadside systems and ITS on-board equipment. Field operation tests were conducted on the following driver safety support services: Providing information on obstacles ahead, merging assistance,

providing information on conditions ahead, information provision coordinated with digital road map data, and position information provision. These five support services were realized, and operation tests geared to full-scale operation have been underway since the end of 2007. Large-scale operation tests are planned to take place in Tokyo at the end of 2008. These will take place through the collaboration of the Cabinet Secretariat, the National Police Agency, the Ministry of Internal Affairs and Communications, the Ministry of Economy, Trade and Industry, the Ministry of Land, Infrastructure, Transport and Tourism, and private enterprises.

This paper reports the field operation test results obtained in Smartway and the details of Smartway 2007 demonstration.

2. Background

Japan has promoted various initiatives to develop Intelligent Transport Systems (ITS) and bring them to practical application. Such systems have spread rapidly,

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so that the number of VICS units has passed 18 million, while the number of vehicles equipped with ETC on-board equipment has surpassed 16 million.

In Fig. 1, the horizontal axis shows years, while the vertical axis shows shipment volume of navigation systems, VICS, and ETC units⁽¹⁾. The societal impact is starting to emerge, for example in the mitigation of congestion, the alleviation of environmental burdens, and the like. ITS is entering its second stage, in which it is expected to contribute to resolving societal issues and reforming society and people's lives.

Under these circumstances, the Smartway Project Advisory Committee submitted "ITS Enter the Second Stage" in August 2004⁽²⁾. This presents an organized summary of measures for the development of ITS as it enters its second stage.

The government announced the "New IT Reform Strategy" in January 2006⁽³⁾. This calls for the practical application of advanced highway safety systems utilizing vehicle-infrastructure cooperation in order to reduce traffic collision fatalities to 5000 or fewer, with the goal of making Japan's road traffic the safest in the world.

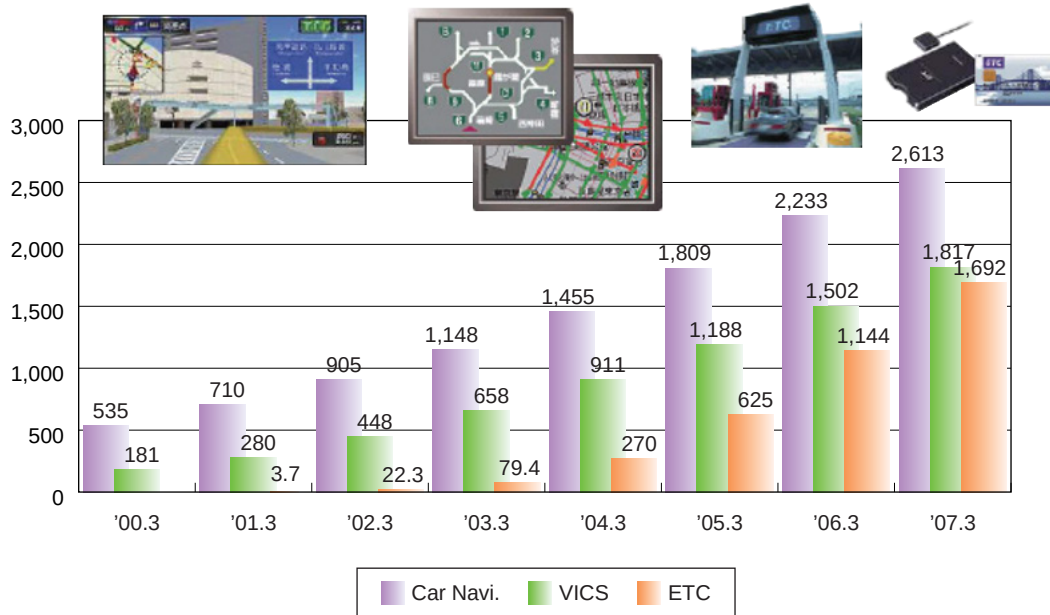


Fig. 1 Cumulative total numbers of navigation systems, VICS, and ETC units shipped

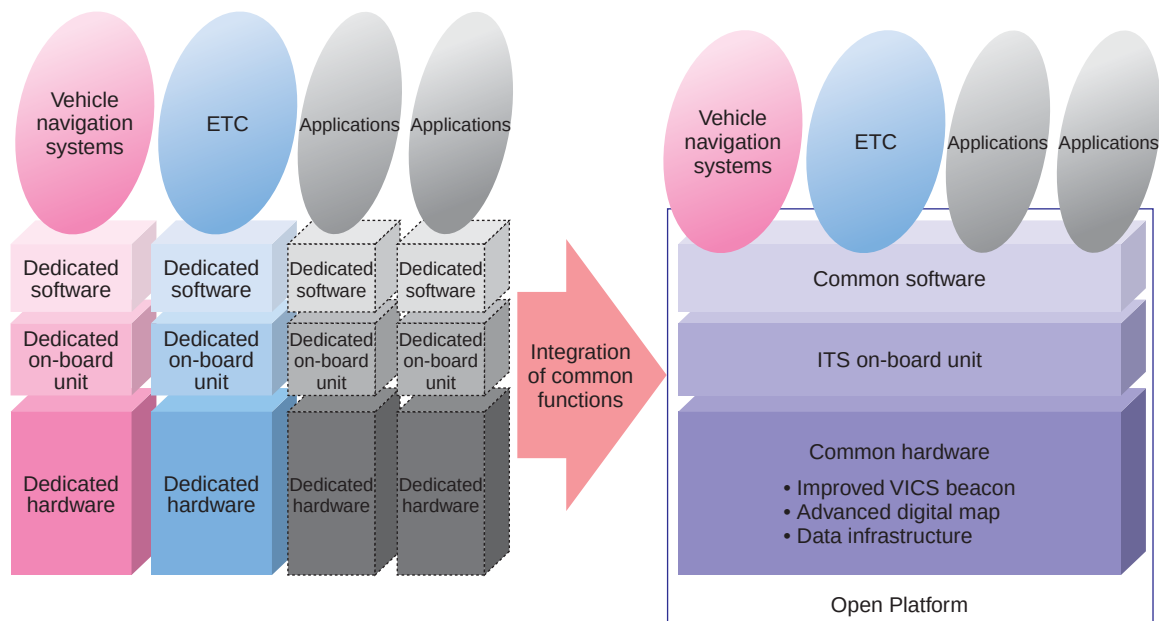


Fig. 2 Concept of platform

Measures to realize this goal have accordingly been promoted by the government and private sector in collaboration. Under such measures, a collaborative council with government and private sector members was formed early in 2006, and conducted an examination of those services and systems envisioned as effective, to include comparative examination of the characteristics of multiple media, as well as the substance of the corresponding operation tests. The result of this examination was the adoption of the concept of an open platform that would share dedicated hardware and software that had been performing their functions independently. Such a platform could mount multiple applications to realize system functionality. Figure 2 illustrates the concept of the platform for next-generation on-board equipment⁽¹⁾.

3. Smartway Technology

3.1. System Configuration

The system for realization of next-generation road services is made up of roadside systems, ITS on-board equipment, and road-vehicle communications. The roadside systems and ITS on-board equipment have a shared functionality among them that is used by different services [a basic application program interface (API)].

Figure 3 shows the structure of the Smartway system⁽⁴⁾.

3.2. Shared Functionality

The common functions for realization of various ITS services include instruction and response functionality, memory access functionality, IC card access functionality, push-type information distribution functionality, ID communication functionality, basic instruction functionality, and shared security functionality. The system has the basic shared functionalities (basic API) that incorporate the same functions.

3.3. Roadside System Configuration

The roadside system is equipped with road-vehicle

communications functionality, basic API, and individual applications. It provides services to the ITS on-board equipment in coordination with external systems. The roadside system is equipped with the functions shown in Fig. 4(1), according to the services to be provided. These are the functions for generating the information to be provided, editing it, and storing it, as well as probe data processing functionality, transaction charge processing functionality, parking area gate operation functionality, and parking charge display functionality⁽⁵⁾. Of these, only the necessary functions are selectively installed. Figure 4(2) shows a photograph of the dedicated short range communication (DSRC) antenna.

3.4. ITS On-board Equipment Configuration

The ITS on-board equipment provides an external interface, basic API, road-vehicle communications, and other such functionality for providing services to the driver.

The road-vehicle communications functionality in the ITS on-board equipment is made up of the DSRC protocol, the extended link control protocol, and the application sub-layer (ASL), which is comprised of non-Internet protocol (non-IP) communications and Internet protocol (IP) communications. This system realizes road-vehicle communications within the roadside system communications zone.

The car navigation function serves as the point of contact between the ITS on-board equipment and the driver. It is equipped with display, Web, and other such functionality. Since it also serves as the point of contact with external equipment, it is further equipped with the capability to acquire and uplink information from car navigation or other such systems.

Figure 5 shows the configuration of the ITS on-board equipment⁽⁵⁾.

3.5. Information Provision Content

The content of services provided in Smartway was as shown below.

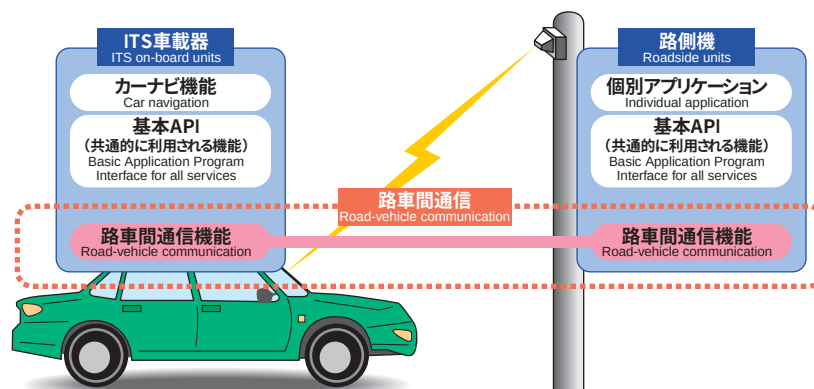
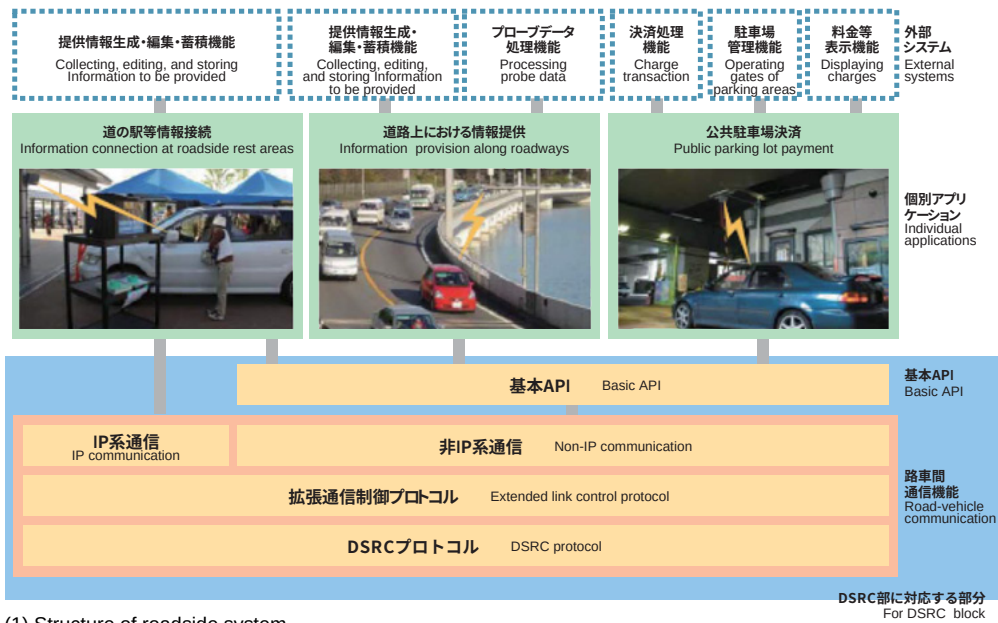


Fig. 3 Structure of Smartway system

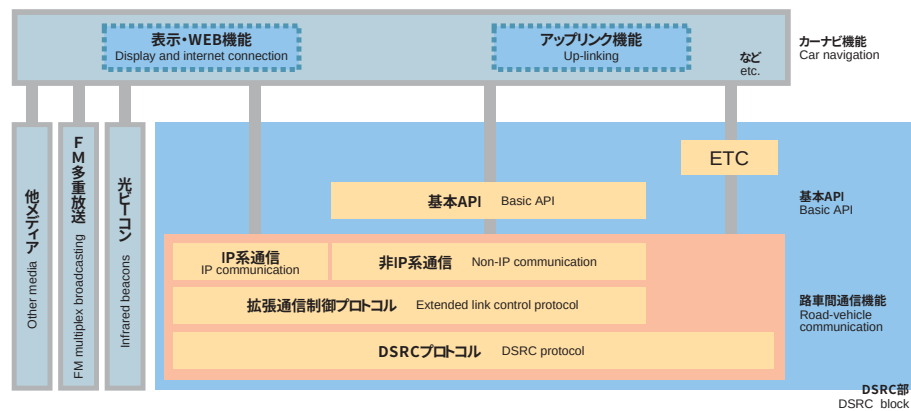


(1) Structure of roadside system



(2) DSRC antenna

Fig. 4 Roadside system



(1) Structure of ITS on-board unit



(2) ITS on-board unit

Fig. 5 ITS on-board system

(a) Providing information on obstacles ahead

This service uses roadside sensors to detect congestion and stationary vehicles ahead on curves with reduced visibility. It alerts drivers who are heading toward such curves by providing them with information by screen display or voice announcements (Caution! Congestion ahead) before they enter the curve.

Figure 6 shows a conceptual image of the service for providing information on obstacles ahead⁽⁶⁾.

(b) Merging assistance

This service uses vehicle detectors to detect the presence of merging vehicles. It alerts drivers by providing them with information about the presence of other moving vehicles by screen display or voice announcements (Caution! Merging from the left ahead) before reaching the merging section.

Figure 7 shows a conceptual image of the merging assistance service⁽⁶⁾.

(c) Providing information on conditions ahead

This service alerts drivers using screen display and



Fig. 6 Providing information on obstacles ahead



Fig. 7 Merging assistance

voice announcements to provide information on road conditions at tunnels and other locations subject to frequent congestion, in order to enhance drivers' sense of security, provide drivers with an extra margin of reassurance, and assist them with route selection.

Figure 8 shows a conceptual image of the service for providing information on conditions ahead⁽⁶⁾.

(d) Providing information on conditions ahead (highway radio)

This service uses voice announcements to provide information about congestion and other such road traffic conditions according to the driving location and direction of movement.

(e) Information provision coordinated with digital road map data

This service uses the digital map database that is built into the car navigation system to alert drivers through



Fig. 8 Providing information on conditions ahead (still image information)



Fig. 9 Providing information with digital road map data

screen display and voice announcements (Caution! Rear-end collisions happen often) about the presence of high-collision curves and other such locations according to the vehicle speed.

Figure 9 shows a conceptual image of the service for providing information with digital road map data⁽⁶⁾.

(f) Providing location information (electronic signs)

This service provides information to support



Fig. 10 Providing information with digital position data



Fig. 11 Internet connection



Fig. 12 Parking lot cashless payment

positional determination by the car navigation system where on-ramps, and the like, overlap with the main route itself on the map, and provides simple road sign information.

Figure 10 shows a conceptual image of the service for positional information provision⁽⁶⁾.

(g) Internet connectivity

This service provides an Internet connection environment for vehicles parked in service areas, parking areas, and other designated areas.

Figure 11 shows a conceptual image of the Internet connectivity service⁽⁷⁾.

(h) Parking lot cashless payment

This service enables vehicles to enter and leave parking areas smoothly and without any need to use cash by charging parking fees to a credit card.

Figure 12 shows a conceptual image of the parking lot cashless payment service⁽⁷⁾.

4. Field Operation Tests

4.1. Overview of Testing

From May 14 to June 8, 2007, field tests were conducted on the Metropolitan Expressway using a total of 60 test vehicles equipped with prototype on-board equipment and manufactured by each participating company. Public road test routes were set on sections of Route 4 Shinjuku Line, Route 5 Ikebukuro Line, and Inner Circular Line. Test subjects were provided with services at 18 points and then asked to respond to questionnaires. Verification of system functionality, which combines the roadside system, vehicle, and communications functions, was performed in the tests, and the service effectiveness and acceptability were verified separately by each participating company.

Field operation test results using Honda test vehicle will be described in section 4.2., and overall test results from participating companies in section 4.3.

Figure 13 shows the test routes and the point at which services were provided during the field operation tests.

- (a) Number of test days: 19 days
- (b) Operating hours: 172.5 hours
- (c) Test subjects: 55 subjects (cumulative)
- (d) Driving distance: 7 000 km
- (e) Offered services: Information provision on obstacles ahead, information provision on conditions ahead, merging assistance, information provision coordinated with digital road map data
- (f) Evaluation data: Data on vehicle behavior during service provision and collected test subject questionnaire data
- (g) Test vehicle: ODYSSEY

Figure 14 shows a scene of information provision during the field operation tests.

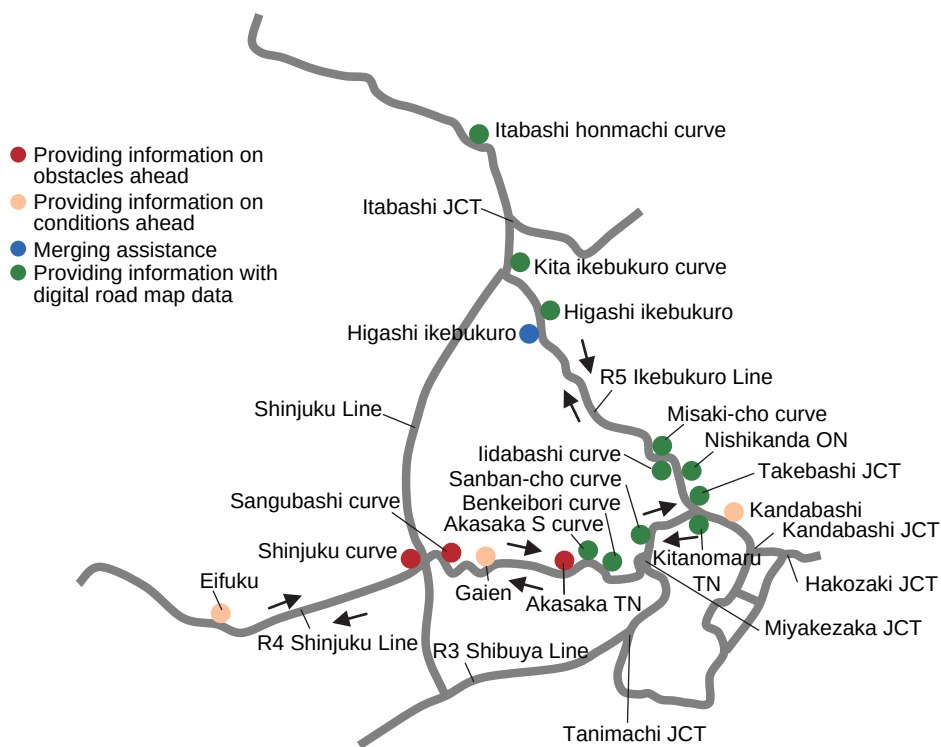


Fig. 13 Service test locations



(1) Providing information with digital road map data



(2) Providing information on obstacles ahead



(3) Providing information on conditions ahead



(4) Merging assistance

Fig. 14 Scenes of information being provided

Table 1 Changes that occur in drivers when information is provided

Changes in Drivers	Description	Findings
Changes in Awareness	• Warning prompted focus of awareness to shift to object, attention directed to safe side.	L
	• Few negative responses such as “startled and confused” or “troublesome”	L
Changes in Action	• Warning did not cause instant action, but line of vision moved in direction of object phenomenon.	L
	• Almost zero negative responses such as suddenly applied brakes	L

Table 2 Selected opinions

Service	Description	Findings
Providing information on obstacles ahead	Information is of low reliability.	L
Providing information on conditions ahead (still image)	Cannot tell what location the information refers to.	L
	Was too occupied with driving to look at screen.	L
	Screen display time too short	L
	Need voice announcement or sound explanation of screen image.	L
	Cannot tell what is intended by screen image.	L
Providing information on conditions ahead (voice announcement)	Too much information provided	M
	Provision timing is too slow.	S
	Cannot tell at all where information refers to.	L
	Manner of speech is difficult to understand because it is unnatural.	L
Information provision coordinated with digital road map data	Provision timing is too slow.	L
	Depending on vehicle speed, provision timing seems off.	S
	Depending on road traffic conditions, provision timing seems off.	L
	Function overlaps with function of commercial car navigation system.	L
General	Difficult to distinguish from existing VICS service.	L
	Warning tones all sound the same so differences are hard to distinguish.	S
	When you get used to it, you stop paying attention.	L
	Coming on top of VICS information, the system information becomes overload.	L
	It should be possible to select the amount of information.	M
Human Machine Interface (HMI)	HMI screen designs are inconsistent.	L
	Understanding the information necessitates time and knowledge.	L
	Voice announcements are too long.	L
	The language is ambiguous so the meaning is unclear.	M
	The road infrastructure side and Smartway services overlap sometimes.	L
	Functions should be narrowed down to just those that can be handled by the vehicle.	L

4.2. Test Results Using Honda Test Vehicle

The questionnaire results with respect to changes in drivers' awareness and action are shown below.

The results show the number of responses by three grades (L: large number; M: medium number; S: small number).

Table 1 indicates changes that occur in the drivers when information is provided.

Large numbers of subjects responded positively to all the items related to changes in awareness and action.

Table 2 shows selected opinions.

Large numbers of subjects responded positively to the majority of questionnaire items. However, a few responded negatively to the items regarding provision timing and quality of information.

4.3. Overall Test Results

Figure 15 shows questionnaire results of the necessity of each service⁽⁸⁾.

The majority of responses regarding the service for providing information on obstacles ahead and that for merging assistance were positive, indicating the services were felt to be necessary. Meanwhile, no clear results were obtained from the questionnaires regarding the necessity of information provision on conditions ahead and information provision coordinated with digital road map data.

Figure 16 shows overall questionnaire results of the effectiveness of the services in Smartway⁽⁸⁾.

Positive response indicating the services were useful or relatively useful amounted to 63% of the total.

4.4. Discussion

The Metropolitan Expressway is a demanding environment in terms of road shape and traffic conditions. With many sharp curves located throughout it, the

expressway frequently experiences congestion in areas with low visibility (after curves, at tunnel entrances) and other conditions likely to result in collisions. The test subjects felt that these services were necessary to deal with the rapidly changing traffic environment. They were hopeful that the services could help reduce the risk of collisions, and thought that the effectiveness of Smartway was promising. The test results show that provision of services directs driver attention to the objects of those services, and give reason to expect services will be effective.

As to acceptability, the affirmative responses received from test subjects vary by whether the content of the service is considered necessary or not. It will be necessary in the future to consider the amount of information provided, the quality of information, the provision timing, and other factors from the driver perspective in order to develop still better driver safety support.

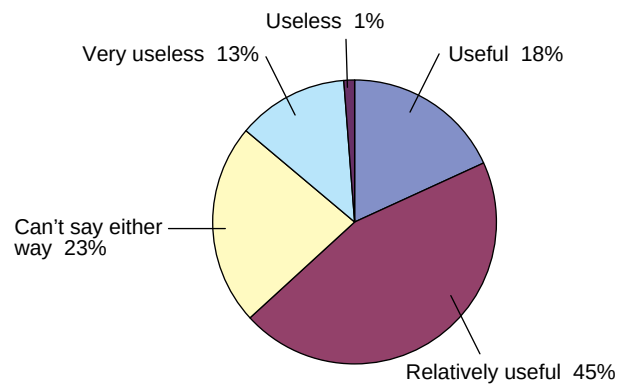


Fig. 16 Overall assessment of effectiveness

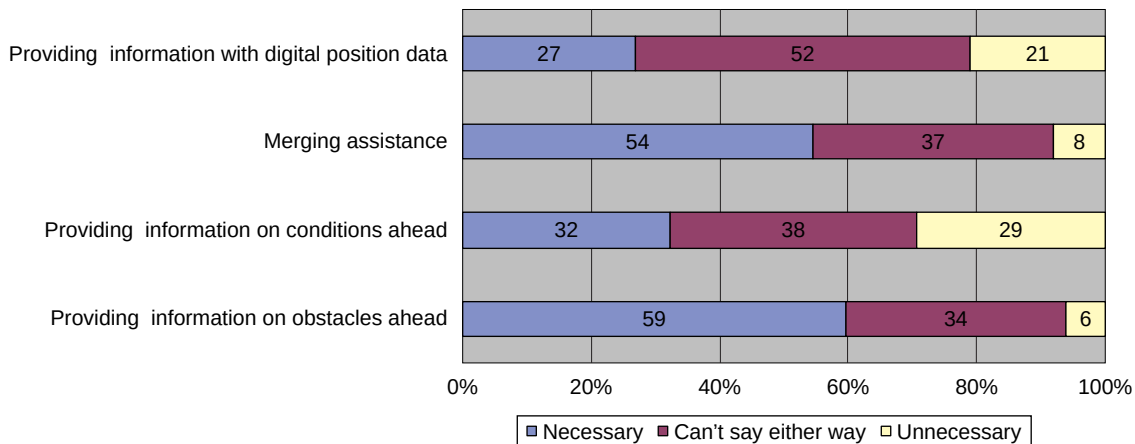


Fig. 15 Assessment of necessity of each services

5. Smartway 2007 Demonstration

5.1. Overview of Demonstration

The prototype ITS on-board equipment systems, developed by the various participating companies, were installed into demonstration vehicles. Visitors were offered test drives to experience ITS services on the Metropolitan Expressway, as well as in the Kajibashi Parking Area, where a roadside system was set up. The event also included symposiums and an exhibition.

A total of approximately 1 650 people attended the event. These included 50 people from other countries, and people from 35 media news organizations. Test drives were experienced by approximately 670 of the visitors.

- (a) Dates: October 14–17, 2007
- (b) Venue: Tokyo International Forum, Metropolitan Expressway (Route 4 Shinjuku Line, Route 5 Ikebukuro Line, Inner Circular Route)
- (c) Content: Opening ceremony, inauguration of test rides, symposiums, keynote address, panel discussions, test drives (scenes of the test drives are shown in Fig. 17 and the test drive course is shown in Fig. 13), exhibitions, vehicle displays, and the like.
- (d) Participants: ITS-concerned parties from Japan and other countries, Japanese government ministries and agencies concerned, expressway companies, experts and specialists, related organizations, media news organizations, Smartway 2007 demonstration participating companies, and other such related organizations.

5.2. Test Drive Content

The roadside system used for the test drive employed equipment that had been licensed as utility stations. The on-board equipment consisted of prototypes for use in Smartway 2007. The on-board equipment included both ITS on-board equipment for use with car navigation systems, which provide information by screen image and voice announcement in coordination with a car navigation system, and stand-alone ITS on-board equipment, envisioned for use in heavy duty vehicles, light motor vehicles, and other vehicles not equipped with car navigation systems, that provides information only by voice announcement. Test drives were performed. Eight types of services, which are to be provided in Smartway, were evaluated.

5.3. Evaluation of Test Rides

A brief questionnaire survey was conducted after the test drive and 511 responses were received (approximately



Fig. 17 Scene of test drive experience

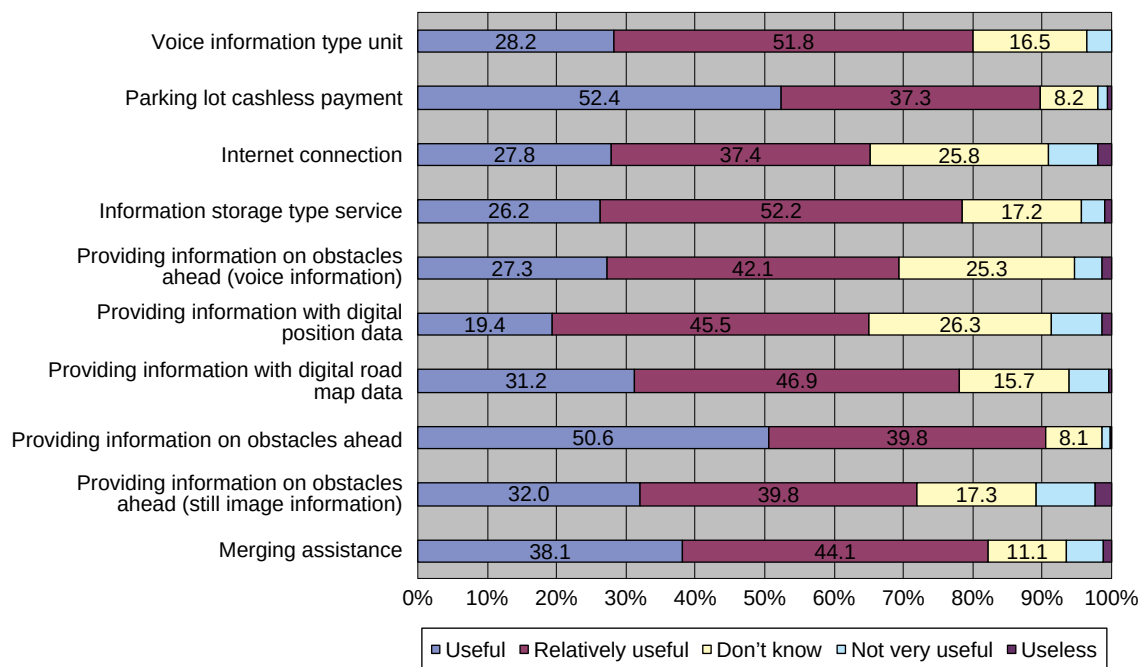


Fig. 18 Partial assessment of experienced service

83% of visitors who took test rides) over a four-day period. Responses that the subjects would like to buy or trade up their unit, indicating a willingness to purchase, were received from approximately 60% of respondents. Evaluations of merging assistance, providing information on obstacles ahead, and parking lot cashless payment were particularly positive (Fig. 18). Responses indicating a positive evaluation of the experienced services, finding them either useful or relatively useful, were received from approximately 90% of the respondents (Fig. 19).

The main reasons cited for finding the information provision service attractive were the use of voice announcements and the provision of information only when circumstances make it necessary⁽⁹⁾.

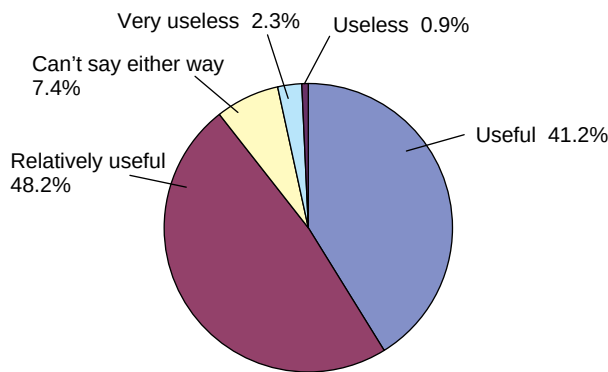


Fig. 19 Overall assessment of experienced service (domestic participant including Honda, excluding foreign invited guest)

6. Conclusions

Field operation tests conducted on public roads have successfully verified the functionality of Smartway project systems. The resulting findings were reflected in the Smartway 2007 Demonstration, where large numbers of visitors experienced test drives. They felt the promise of these services and the resulting efficiency in reducing collisions. The development of safety driving support systems with a high level of value and finish will be of great importance in determining the future configuration of Smartway services. As nationwide Smartway deployment proceeds, we anticipate major advances in the timing and content of information provision, as well as in the level of infrastructure development, including installation location. It will be necessary to continue making incremental enhancements to sustain system development.

Future Smartway development plans call for operation testing that is scheduled to take place in the Aichi, Hanshin, and Hiroshima regions in 2008. Measures have also been initiated to conduct specific studies for prioritization of Smartway deployment at high-collision locations.

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