

Introduction of the Honda ASV-2 Experimental Vehicle with a Road-vehicle Communication System (Motorcycles)

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ABSTRACT

Joint proving tests of the Advanced Safety Vehicle (ASV) and Advanced Cruise-assist Highway Systems (AHS) were conducted by the Ministry of Land, Infrastructure and Transport (formerly the Ministry of Transport) for Smart Cruise systems. Thirteen domestic vehicle manufacturers participated in the tests on a proving test course set up at the National Institute for Land and Infrastructure Management of the Ministry of Land, Infrastructure and Transport. Seven services and eight test systems were tested. The objective of these systems is to receive information from the road infrastructure via Dedicated Short Range Communication (DSRC) concerning, for example, obstacles in the road ahead and the presence of oncoming vehicles; then, the systems provide warnings and information to motorcycle riders in order to reduce the occurrence of collisions. Honda provided a scooter, with an engine capacity of 250 cm³, loaded with a road-vehicle communication receiver to receive the road information from the Dedicated Short Range Communication system, an information control ECU, and a newly developed Human Machine Interface (HMI) for motorcycles. The tests were conducted to confirm the effectiveness of the road-vehicle communication system from the viewpoint of driver acceptance.

The proving tests yielded the following findings:

- (1) Information provided from the road infrastructure via DSRC for the purpose of enhancing active safety was confirmed to also be effective for motorcycles.
- (2) An HMI system that combined sound information with visual information was confirmed to be capable of providing information appropriately for each driving assistance service.

1. Introduction

Honda designed two types of autonomous Advanced Safety Vehicle (ASV) motorcycles and carried out research on them as part of the activities promoted for the Advanced Safety Vehicle Phase 2 (ASV-2) activities proposed by the Road Transport Bureau of the Ministry of Land, Infrastructure and Transport (formerly the Ministry of Transportation)⁽¹⁾. At the same time, work was underway on the Advanced Cruise-Assist Highway Systems (AHS) proposed by the Road Bureau of the Ministry of Land, Infrastructure and Transport (formerly the Ministry of Construction). As part of the ASV-2 project, 13 automobile and motorcycle manufacturers participated in joint proving

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tests held at the National Institute for Land and Infrastructure Management (previously the Public Works Research Institute of the former Ministry of Construction) of the Ministry of Land, Infrastructure and Transport. This article presents an overview of the proving tests and introduces an example of the results obtained.

2. Overview of Services

The purpose of these proving tests was to verify the seven services and eight systems intended to help prevent traffic accidents and to reduce damage from accidents that do occur.

The road infrastructure sensors detect information about

Table 1 Services of joint proving test

Principal user services	Honda's motorcycle participated
Forward obstacle collision prevention support system	Yes
Curve overshooting prevention support system	Yes
Crossing collision prevention advisory system - Approaching support	Yes
Crossing collision prevention advisory system - Acceleration support	Yes
Right turn collision prevention advisory system	Yes
Crossing pedestrian collision prevention advisory system	Yes
Lane departure prevention support system	Automobile only
Road surface information system for ACC etc.	No

obstacles, other vehicles, pedestrians, the road surface, and other such information in areas with poor visibility that an autonomous system cannot detect. The road-vehicle communication system transmits this information to the cruising vehicle, where it is used for driver information and warning, for vehicle control, and so on. The services that Honda motorcycles participated in are shown in Table 1.

The content of each service is described in "Introduction of the Honda ASV-2, an Advanced Cruise-assist Highway System Test Vehicle (Passenger Car)."⁽²⁾ It is difficult, for technical reasons, to create an autonomous system for a motorcycle that will prevent single vehicle accidents on curves. Therefore, Honda participated in testing of the Curve Overshooting Prevention Support System, which is anticipated to help reduce the number of this type of accident. An overview is presented in Fig. 1. In this system, information on the road surface condition, road shape, and so on is transmitted from DSRC antennas installed on the roadside.

- Name of service: Curve Overshooting Prevention Support System
- Purpose: Reduce the number of accidents in which vehicles enter curves without sufficiently reducing speed
- Functions: The system receives information about the curve shape and road surface condition for the road ahead from the road infrastructure via DSRC. Based on that information and the vehicle situation, it furnishes information to prompt caution and, when it is possible that deceleration will not take place in time, it warns the rider.
- Target road: Expressways, ordinary roads
- Caution level: Information, warning

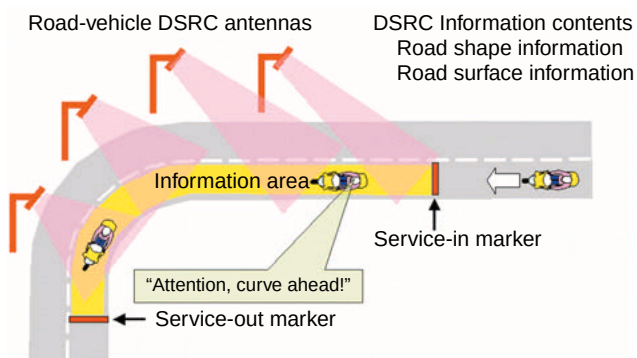


Fig. 1 Outline of curve overshooting prevention support system

3. Proving Test System

The Human Machine Interface (HMI) and the on-board equipment mounted on the experimental vehicle with road-vehicle communication system is explained below.

3.1 On-board Communication Equipment

Foresight scooters with a displacement of 250 cm³ were used for the tests. Fig. 2 shows an external view of the Honda ASV-2 vehicle No. 6.

The on-board equipment included sensors to capture vehicle condition signals (for throttle, speed, brakes, turn indicators), an information control Electronic Control Unit (ECU) for communication control and HMI control processing, a wireless voice transmitter to send voice information to the communication helmet, a DSRC receiver and antenna for road-vehicle communication, a DSRC receiver and sensor for the Service-in marker, and so on (Fig. 3).

The DSRC antenna (Fig. 4) was built into the front fairing on the upper part of the headlight unit. It was attached at an elevation angle of approximately 10 degrees.

The proving tests for each support service required



Fig. 2 Honda ASV-2 vehicle No.6

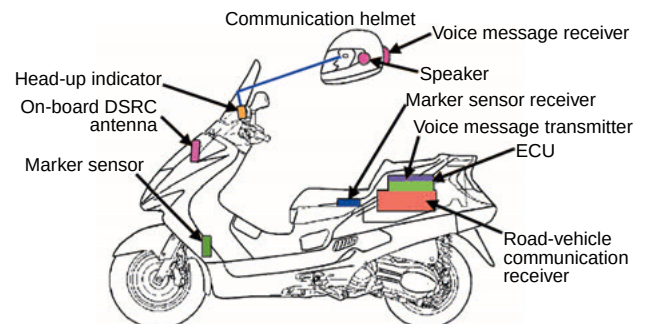


Fig. 3 Outline of prototype motorcycle system



Fig. 4 DSRC antenna

changing control parameters, revising algorithms, and conducting prompt data analysis within a limited test time. Consequently, the equipment was configured for operation in a seamless environment. To meet the requirement for real-time control of applications, the information control ECU configuration included a notebook computer (Toshiba Dynabook SS3380) and a signal processing controller. Microsoft Windows 2000^R was used in order to realize a 50 ms sampling time for vehicle condition and sequence control every 100 ms. Fig. 5 presents a block diagram of the on-board system.

3.2 Human Machine Interface (HMI) Configuration

The HMI occupies a crucial position in safe driving support systems. However, HMI technology for motorcycles has not yet been established, and various methods are presently being explored. The performance and functions required are similar to those for automobiles, but the means for achieving them are limited by the differences in, for example, vehicle body design, audible sound range due to helmet use, driving posture, forms of steering control using steering and shifting body weight, vibration and defensive driving. The visual function, in particular, involves not only careful monitoring of the road ahead, but also of the subject motorcycle's behavior by means of the roll and yaw angles. Therefore, an HMI that is configured to change the rider's line of sight in order to receive information may end up having an effect significantly different from that originally intended. Taking these factors into consideration, the HMI concept for the present system was designed for the following:

- Active utilization of peripheral vision
- Information quantity should be kept to the required minimum in order to restrain eye movement
- Voice announcement as the principal means for presenting information

Information status is displayed visually, and the specific content of information is provided by voice announcement. Using the characteristics of visual and aural perception in this way allowed development of an HMI that can sustain the state of concentrated attention to the outside world.

3.2.1 Head-Up Indicator (HUI)

The HUI set into the upper face of the instrument panel uses a row of seven high-intensity LEDs to form a transverse band (Fig. 6).

It is important when making use of peripheral vision to provide the minimum quantity of information and to give it more than a certain fixed area of luminosity in order to prevent fixation of the rider's gaze.

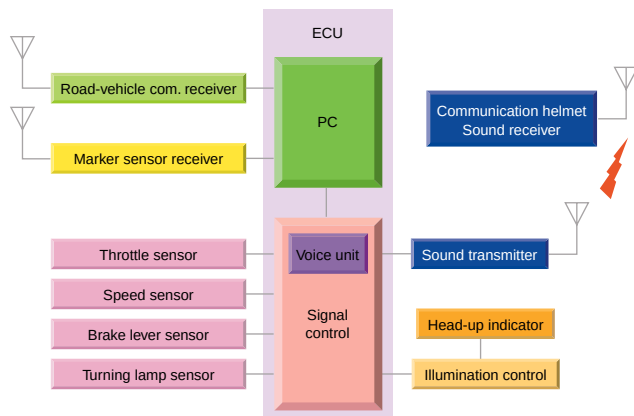


Fig. 5 On-board system block diagram



Fig. 6 Head-up indicator

The HUI illuminates an amber light that is reflected from the inside of the windscreen, where it creates a virtual image that is easily detected in the rider's peripheral vision. This location was also selected because it would not interfere with driving at night.

Information of the three kinds shown below is presented by the combination of LEDs that are turned on or off. This is intended to allow easy recognition of the current status of information provision.

- Service area
- Information to prompt caution
- Warning

It was decided to assign the seven LEDs to the three states of two left and right LEDs illuminated, central five LEDs illuminated, and central five LEDs blinking. Fig. 7 shows the HUI operating status and information content.

3.2.2 Communication helmet

Information provided by voice has the drawback that it cannot be understood without hearing the phrase to the very end. However, attention was paid to the selection of the wording, the length of the phrases, the use of distinct expressions, sound quality that enhances audibility, and so on. Thus, this method was found to be appropriate for accurately conveying information content.

A thin speaker is placed inside the helmet at the position of the outer ear. The system has several types of voice information recorded in advance, and the information control ECU activates these messages as necessary. Phrases were composed to convey voice information within three seconds. Table 2 shows examples of these voice messages.

High-quality wireless voice information is provided by the information control ECU using a voice transmitter with a built-in communication module and the communication helmet (Fig. 8).

4. Proving Test Results and Discussion

Analysis of motorcycle accident statistics shows that the greatest number of accidents involve automobiles, and the largest number of those are accidents involving vehicles turning right across traffic (a right turn as in Japan), and crossing accidents (accidents that occur at intersections)⁽³⁾. This article will use representative examples of test results to explain the Right Turn Collision Prevention Advisory System and the Crossing Collision Prevention Advisory System, which are intended to reduce the number of such

Service-in	Information	Warning
Pop up LED image on both sides during service area	Pop up LED image in the center	Blinking LED image in the center

Fig. 7 Head-up indicator status

Table 2 Voice message examples

Services	Voice messages	Upper: Caution
		Lower: Warning
Forward obstacle collision prevention support system	Attention, obstacle 100 meters ahead	
	Stop!	
Curve overshooting prevention support system	Curve ahead	
Crossing collision prevention advisory system-Approaching support	Crossing 60m ahead	
	Stop!	
Crossing collision prevention advisory system-Accelerating support	Attention, vehicle from the right	
	Stop!	
Right turn collision prevention advisory system	Attention, approaching vehicle ahead	
	Stop!	
Crossing pedestrian collision prevention advisory system	Pedestrian at the right hand side	
	Stop!	



Fig. 8 Communication helmet

accidents, and the Curve Overshooting Prevention Support System, which is intended to reduce the number of accidents occurring on curves, which make up the largest number of single-vehicle accidents involving motorcycles. The effectiveness of these systems will be discussed from the perspective of driver acceptance.

All the proving tests were conducted on the proving test course of the National Institute for Land and Infrastructure Management of the Ministry of Land, Infrastructure and Transport. This proving test course was equipped with the test conditions and road environments envisioned for the various support services. For details regarding the test environment, please see "Introduction of the Honda ASV-2, an Advanced Cruise-assist Highway System Test Vehicle (Passenger Car)" in the Honda R&D Technical Review, Vol.13, No.2⁽²⁾.

4.1 Right Turn Collision Prevention Advisory System

The test was conducted at an intersection equipped with a traffic signal and a dedicated right-turn lane. Fig. 9 shows an overview of the Right Turn Collision Prevention Advisory System for vehicles turning right across traffic. During the test, the HMI operated by turning on the LEDs on the two ends of the HUI to notify the rider of entry into the service zone at the point when the subject motorcycle approaching the intersection passed the Service-in marker. The vehicle receives information from the road infrastructure via DSRC concerning oncoming vehicles that are approaching the intersection. When there is a possibility that the subject motorcycle and an oncoming vehicle will collide or have a near miss, the central LED in the HUI is turned on, and a voice announcement conveys information to prompt caution with the message, "Approaching vehicle ahead."

The test was conducted under two sets of conditions. In one, the status of the approaching vehicle can be seen from the subject motorcycle, while in the other, the view is

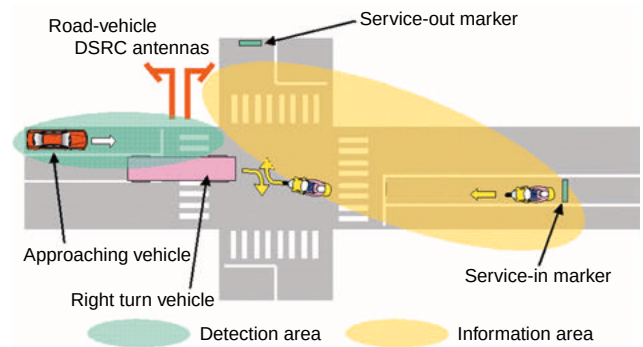


Fig. 9 Outline of right turn collision prevention advisory system

blocked by a large truck that is stopped in the right turn lane on the opposite side of the road.

The test results suggest that the rider can be prompted to caution regarding oncoming vehicles passing through the intersection and collisions can be prevented by setting the information timing to allow an appropriate time margin. Motorcycle rider evaluation comments also indicated that driver acceptance was significant. Some riders rated the system as effective, stating that it gave a strong sense of security when the view of the opposing lane from the subject motorcycle is blocked by a large vehicle stopped in the right turn lane on the opposite side of the road, making it difficult to see an oncoming approaching vehicle. Table 3 shows the results of driver acceptance evaluation.

Riders A and B are both test riders for Honda. The evaluation standards were set at the five levels of Excellent, Good, Fair, Poor, and Very poor.

4.2 Crossing Collision Prevention Advisory System

– Applied When A Vehicle Is Approaching

The test location was a small intersection with a single lane for each direction and no traffic signal. Fig. 10 shows an overview of the Crossing Collision Prevention Advisory System.

The test determined whether the timing was appropriate for information notifying the rider of the need to make a

Table 3 Driver acceptance evaluation

Evaluation point of view		Rider A	Rider B
Safety	Visible condition without large vehicle	Fair	Fair
	Invisible condition with large vehicle	Excellent	Good
Rider's acceptance	Helpfulness	Good	Good
	Marketable	Good	Good

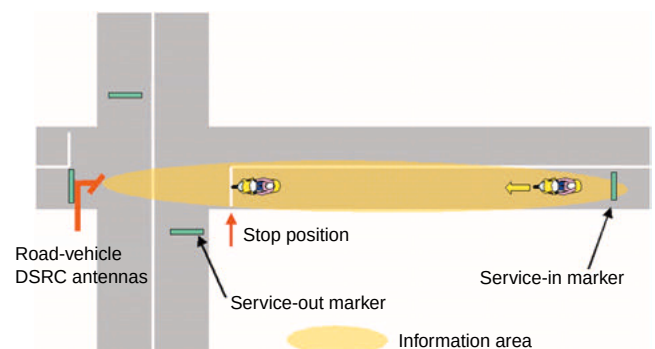


Fig. 10 Outline of crossing collision prevention advisory system - approaching service

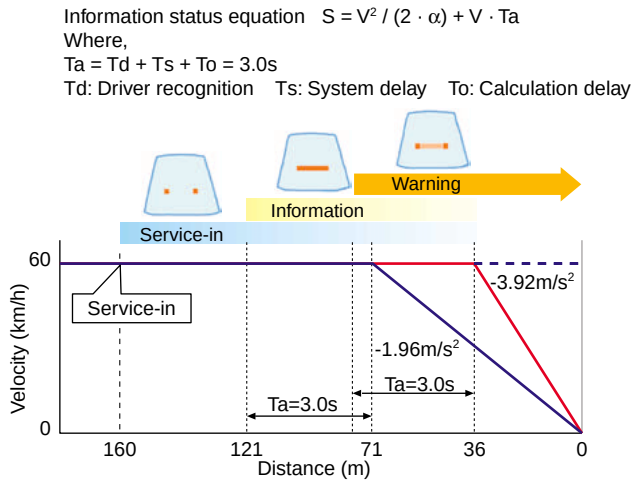


Fig. 11 Information status for crossing collision prevention advisory system - approaching service

complete stop when the subject vehicle is approaching a small intersection at a fixed speed on the non-right-of-way road. The effectiveness of the system was examined by comparing these results with the same setup without any information being provided. An example of information provision timing employed on the test course will be explained here. When the test vehicle passes the Service-in marker, the LEDs on both ends of the HUI light up to indicate that the vehicle has entered the information area. At this point, the vehicle receives data from the Service-in marker buried in the road surface concerning the distance (fixed value) to the intersection. The subject vehicle calculates its position in this area from the cumulative distance traveled. Then, as shown as an example in Fig. 11, the central LEDs in the HUI light up when the vehicle arrives at a point where, regardless of its speed, it will be able to stop at the stop line with a deceleration of 1.96 m/s^2 and a rider response time of 3 seconds. At this time, the rider is given information to prompt caution by means of the voice message, "Attention, crossing ahead".

If the vehicle does not decelerate but further approaches the intersection, the system issues a warning to prompt it to stop. The central LEDs in the HUI blink and the voice message "Stop" is issued when the vehicle arrives at the point where it can stop with a deceleration of 3.92 m/s^2 and a rider response time of 3 seconds.

Typical examples of measurement data are shown in Fig. 12. The test series was set up so that the intersection location could be perceived 100 m or more in advance. Consequently, no conclusions were reached with regard to

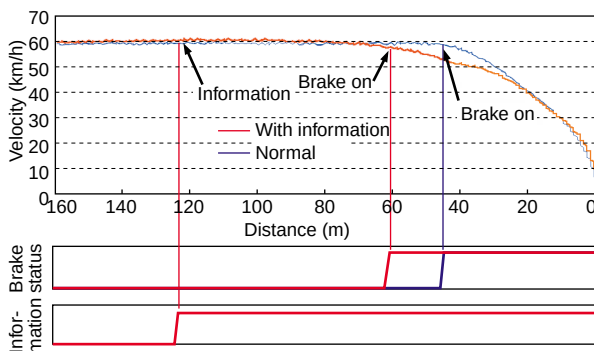


Fig. 12 Example of actual measured data - crossing-collision prevention advisory system (approaching service)

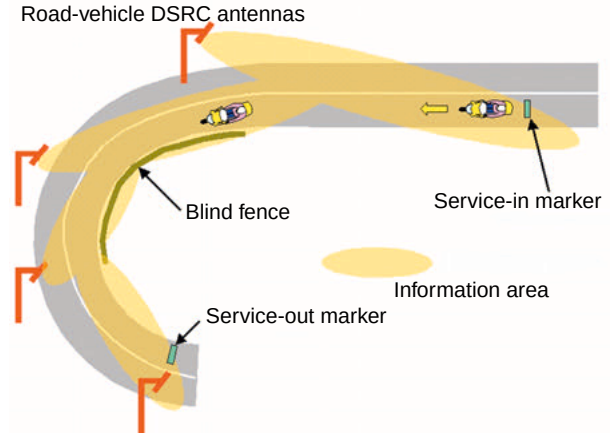


Fig. 13 Outline of curve overshooting prevention support system

driver acceptance or effectiveness of the service. As the data show, however, comparison of the test with and without information provision makes it clear that the point where deceleration begins comes earlier.

Therefore, it is thought that the service will be effective under conditions when the intersection location cannot be seen until the motorcycle is immediately before it, and when the rider has failed to notice the intersection due to oversight or absentmindedness.

4.3 Curve Overshooting Prevention Support System

The test location was a course set up to represent an ordinary road and an expressway. Fig. 13 shows an overview of the Curve Overshooting Prevention Support System.

The tests were conducted to provide information when the subject vehicle entered the curve at a set speed that exceeded the safe speed for the curve. The rider was presented with the information that there was a curve ahead and was urged to decelerate to a safe speed.

An example of the information timing employed on the test course will be explained here. When the test vehicle passes the Service-in marker, the LEDs on both ends of the HUI light up to indicate that the vehicle has entered the service area. At this point, the vehicle receives data from the Service-in marker buried in the road surface concerning the distance (fixed value) to the beginning of the curve. The subject vehicle calculates its position in this area from the cumulative distance traveled. Then, as shown in Fig. 14, the central LEDs in the HUI light up when the vehicle arrives at a point where, regardless of its speed, it will be able to slow down with a deceleration of 1.96 m/s^2 and a rider response time of 3 seconds. At this time, the rider is given information to prompt caution by means of the voice message, "Curve ahead."

Representative examples of measurement data simulating an ordinary road are shown in Fig. 15. The ordinary road test course (V1: set service-in speed of 70 km/h ; V2: safe curve speed of 40 km/h) is made up of a compound curve with two curvatures, the sharp curve (radius of 80 m) that is the target of this service, and before it a gentle curve (radius of 200 m). A fence is installed on the inside of the sharp curve to create an environment of poor visibility. As shown by the example in Fig. 14, when no information was provided, the test subject entered the gentle curve and predicted that the same curvature would be maintained. It is apparent that the sudden encounter with the sharp curve, however, caused the subject to decelerate rapidly. On the other hand, when information was provided,

Information status equation $S = (V1-V2)^2 / (2 \cdot \alpha) + V \cdot Ta$

Where,

V1: Initial velocity V2: Target velocity

Ta = Td + Ts + To = 3.0s

Td: Driver recognition Ts: System delay To: Calculation delay

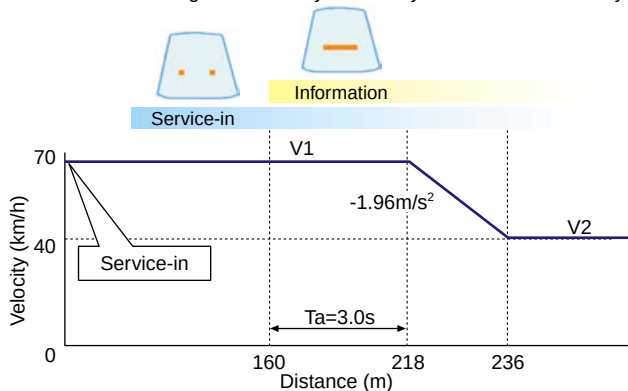


Fig. 14 Information status for curve overshooting prevention support system

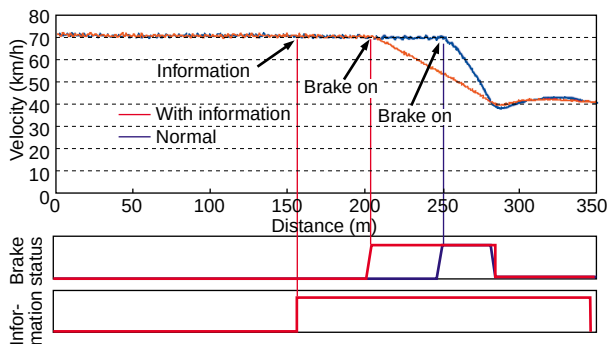


Fig. 15 Example of actual measured data- curve overshooting prevention support system -

it is evident that the subject decelerates with greater leeway.

On the expressway test course, however, the curve conditions were fully visible from a distance. The curve radius (148 m) was also larger. Consequently, there was only a slight difference between the initial speed and the target speed, and the deceleration could be accomplished by throttle operations. As a result, a significant difference between when the information was provided, and when it was not could not be found.

It will be necessary to conduct systematic tests in the future to determine rider acceptance and system effectiveness. The safe speed for a curve also varies with the type of vehicle and rider skills, and it is further thought to fluctuate with respect to the road design speed. Therefore, it is considered necessary to conduct a full study not only of safe speed but also of information timing and deceleration.

4.4 Issues for the Future

A variety of different disturbances and external factors are expected to affect operation in an actual traffic environment. Thus, it will be necessary to validate the overall effective function of the system under these types of conditions as well. At the same time, further effort will also be required to realize an HMI for the motorcycle that is effective and causes no discomfort from the perspective of driver acceptance. The creation of methods for evaluating the continuous flow that is composed of the accurate communication of information, correct judgement by the rider, and inducement of proper action, will also be an important issue.

5. Conclusion

It was confirmed that Smart Cruise systems with road-vehicle communication are capable of supporting driving for active safety in motorcycles as well as other vehicles. However, the proving tests were limited to facilities at the National Institute for Land and Infrastructure Management. It is considered necessary, therefore, to confirm the effectiveness of these systems in more realistic environments in order to work toward their practical application.

The HMI developed here was geared to the driving characteristics of the motorcycle. The HUI that makes use of peripheral vision can display three types of information, while the communication helmet can provide eleven types of information through voice messages. It was confirmed that an HMI combining voice and visual information constitutes a means of providing information that is capable of supporting various rider assistance services in the ways demonstrated in these proving tests.

6. Afterword

Starting in fiscal 2001, ASV, phase 3 proposed by the Ministry of Land, Infrastructure and Transport began as a five-year project. Honda is participating in this project along with other Japanese automobile manufacturers. In order to achieve practical application, it will be necessary to create a new framework that fuses together autonomous system and the road-vehicle infrastructure cooperation system.

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