

Introduction of Honda ASV-3 (Motorcycles)

Kazumitsu KUSHIDA* Mutsumi KATAYAMA* Yojiro TSUTSUMI*
Kazuyuki MARUYAMA* Yutaka KAMATA* Yutaka MURATA*

ABSTRACT

As part of the Advanced Safety Vehicle Phase 3 (ASV-3) project proposed by the Road Transport Bureau of the Ministry of Land, Infrastructure and Transport, Honda has conducted research on predictive active safety technologies. Honda developed the ASV-3 motorcycle based on the concepts of assistance of “visibility” and “conspicuity.” The predictive safety technologies used in the Honda ASV-3 motorcycle consist of inter-vehicle communications technologies, observing sensor technologies and conspicuity enhancement technologies. The inter-vehicle communications system is useful in enhancing both visibility and conspicuity. It is based on research conducted following the development of the inter-vehicle communications system used in the Honda ASV-2. Observing sensor technologies help enhance visibility by using a front-monitoring system and a rear-view system. This enables warning signals to be provided that help prevent rider oversight and reduce blind spots. Conspicuity enhancement technologies help make it easier for the motorcycle to be seen. Specifically, the conspicuity of the motorcycle has been increased using the “FACE design,” which exploits the drivers’ innate ability to recognize the pattern of a human face thus increasing the rate of recognition of the vehicle, and the “LONG design,” which increases awareness of the vehicle’s speed and distance.

1. Introduction

The Advanced Safety Vehicle Phase 3 (ASV-3) project being conducted by the Road Transport Bureau of the Ministry of Land, Infrastructure and Transport was concluded in FY2005, in accordance with its five-year plan. The focus of Phase 3 was inter-vehicle communications technology. This was the core technology for research by the 14 Japanese automotive manufacturers involved in the project. Proving tests using real vehicles, followed by public demonstrations, were conducted at the Tomakomai winter test track of the Civil Engineering Research Institute of Hokkaido between July and October 2005.

As part of this project, Honda conducted further R&D on the

inter-vehicle communications technology developed for the Honda ASV-2. This not only involved the development of inter-vehicle communications technologies, but also focused on research related to driving support systems and the design of motorcycles based on accident analyses. This increases their conspicuity and enables drivers of other vehicles to see them more easily, thus preventing errors in judgment. The results of these studies were incorporated into the Honda ASV-3 motorcycle and passenger car. This was made public in September 2005 (Fig. 1).

This paper provides an overview of the inter-vehicle communications technologies, observing sensor technologies and conspicuity enhancement technologies that were used in the Honda ASV-3 motorcycle.

* Motorcycle R&D Center



Fig. 1 Honda ASV-3

2. Accident Analyses

Figure 2 shows a breakdown of ratios of fatal collisions involving motorcycles by type of collision⁽¹⁾.

Collisions involving a right-turning automobile with straight-going motorcycle at intersection, and collisions at crossing paths account for more than 60% of the accidents.

Figure 3 shows a breakdown of the collisions caused by automobiles⁽¹⁾. Accidents caused by oversights and misjudgments of approach speed account for 70% of the collisions between automobiles and motorcycles. These are lapses in judgment and awareness on the part of the automobile drivers. It can also be assumed that lack of prediction and anticipation skills and lapses in judgment by motorcycle riders also played a part.

It is therefore highly possible that information related to the position of other vehicles will help reduce misjudgments and lapses in awareness by both motorcycle riders and automobile drivers. This will enable some accidents to be prevented or the severity mitigated.

The following causes of lapses on the part of automobile drivers can be suggested:

(1) Drivers misjudge the approach speed and the distance between

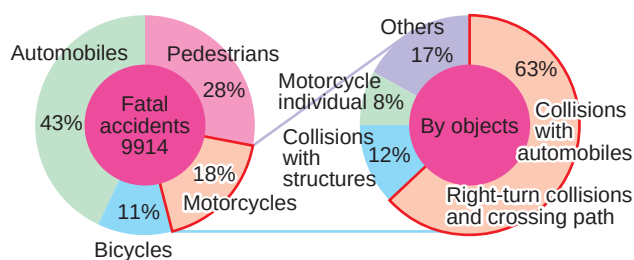


Fig. 2 Breakdown of motorcycle fatal accidents in Japan

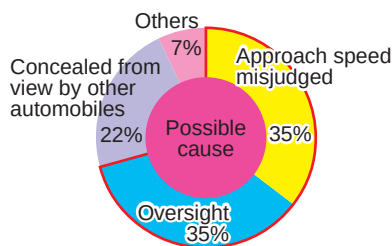


Fig. 3 Breakdown of accidents caused by automobiles

their vehicles and motorcycles because of the smaller motorcycle profile.

- (2) Drivers overlook the presence of motorcycles because their smaller profiles cause them to be hidden by other vehicles and surrounding objects.

Assisting automobile driver awareness by increasing the conspicuity of motorcycles could therefore be expected to help enable automobile drivers to more quickly identify a motorcycle in traffic and more appropriately judge distance and approach speed.

3. Features of the Honda ASV-3 Motorcycle

3.1. Concept

As accident analyses have indicated, assistance of “visibility” and “conspicuity” are essential in helping reduce the human error that causes accidents (Fig. 4). To enhance visibility, the Honda ASV-3 motorcycle is provided with a front-monitoring system and a rear-view system as well as an inter-vehicle communications system.

Crossing path collisions typically occur at intersections without traffic signals. When the motorcycle fails to come to a complete stop, driver oversight can easily occur. The Honda ASV-3 motorcycle uses a front-monitoring system with image recognition technology to assist the motorcycle rider when stopping at an intersection. This was developed with consideration to cost and ease of mounting on a motorcycle. Additionally, human error is further reduced by using an inter-vehicle communications system to reduce misjudgments of distance and speed of other vehicles approaching the intersection when the motorcycle starts again after stopping. Since there is a blind spot in a motorcycle's rear-view mirror, an increased awareness of the traffic situation behind the vehicle is also necessary during lane changes, etc. The Honda ASV-3 motorcycle is also provided with a rear-view system.

The inter-vehicle communications system is capable of sensing vehicles at long distances (around 50-200 m), but its accuracy in detecting position is low around 30 m. This system can be produced at a lower cost compared to observing sensor technology. The observing sensor technology displays a higher level of accuracy in detecting vehicle position. However, it can only detect vehicles at a range of around 100 m. The inter-vehicle communications system and observing sensor technology can therefore be considered highly compatible and can be used to supplement each other. In addition, sensor fusion is expected to provide a higher level of driver support.

To assist conspicuity, the Honda ASV-3 motorcycle is provided with an inter-vehicle communications system and technology for increased conspicuity. Analysis of accident statistics indicates that motorcycles can be easily overlooked. Their distance and speed

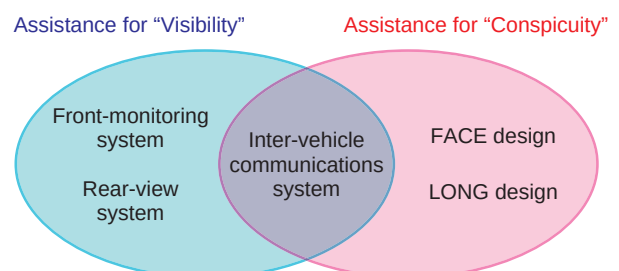


Fig. 4 Honda ASV-3 motorcycle concepts

can be easily misjudged by other vehicle drivers. This makes enhancements for increased conspicuity beneficial. The inter-vehicle communications system is also able to provide enhancement for conspicuity by transmitting its own information (position, speed, etc.) to other vehicles nearby. Motorcycles are also overlooked or have their distance and speed misjudged because they are smaller than automobiles. The Honda ASV-3 motorcycle further attempts to reduce human error by using the “FACE design” and the “LONG design.” These enhance conspicuity using the capacity for pattern recognition of the human face and characteristics of distance and speed recognition.

3.2. Technological Overview

Figure 5 shows the system layout when installed, and Fig. 6 shows the structure of the system.

3.2.1. Inter-vehicle communications system

(1) Communications system The inter-vehicle communications system provides an enhancement for both visibility and conspicuity.

Honda began research on safer vehicle operation when they applied the wireless communication technology to transfer information between vehicles in 1990s. The results of this research were used in the inter-vehicle communications system fitted into the Honda ASV-2. This was made public in 2000⁽²⁾.

The study of system requirements progressed further for the Honda ASV-3, and the system configuration was established as follows:

(A) Communications requirements:

- Maximum distance: 500 m
- Maximum number of vehicles for inter-vehicle communications: 120
- Communication interval: 100 ms

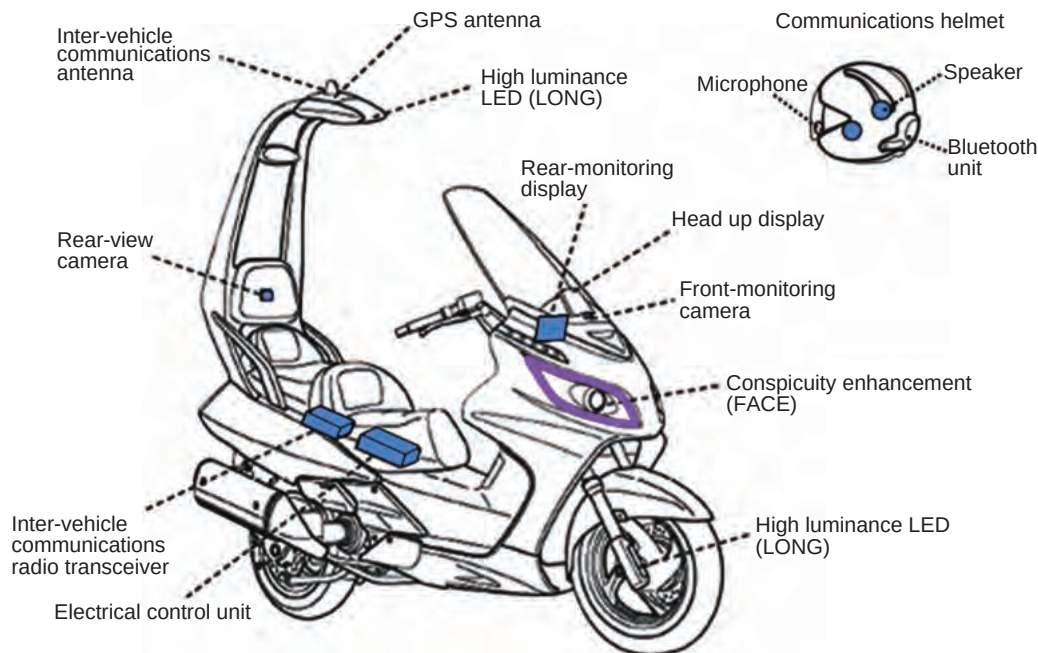


Fig. 5 System layout

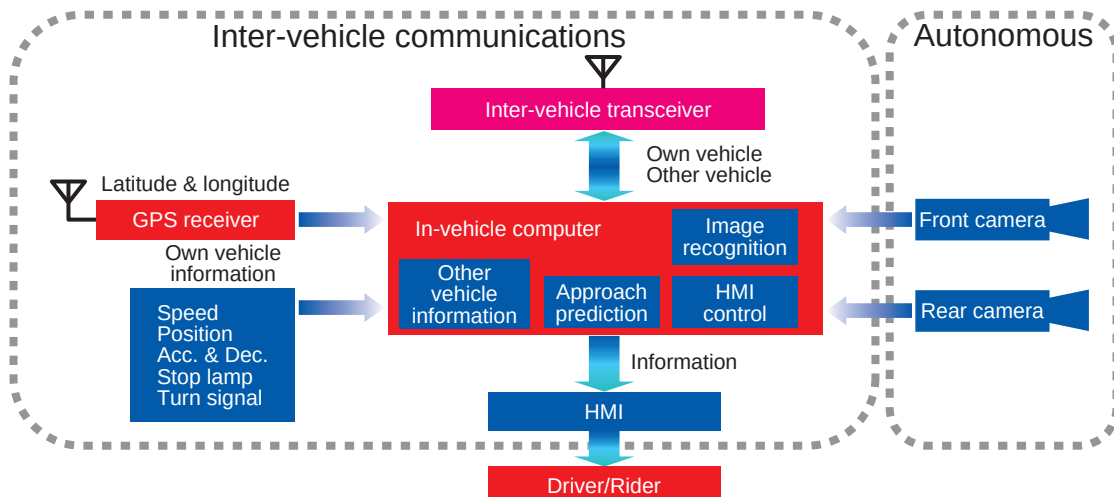


Fig. 6 Structure of inter-vehicle communications system and autonomous system

- (B) Wireless communications equipment:
 - Frequency: 5.8 GHz
 - Transmitting output: 10 dBm
- (C) System control
 - Control interval: 10 ms
- (D) GPS receiver
 - GPS data interval: 1 s
 - Estimation interval of subject vehicle's position: 100 ms

The information from the inter-vehicle communications radio transceiver, GPS receiver, front-monitoring camera and subject vehicle are inputted into the onboard control computer every 100 ms. The computer processes control timing and sequence of providing information to the rider, according to the synthetic situations of inputted information.

Because the communication interval is 100 ms while the GPS data interval is 1 s, the real position of the vehicle will have moved forward in the interval time under which the GPS data is updated. Assuming a vehicle speed of 90 km/h, the distance traveled in this time would be 25 m. Therefore, errors could occur in vehicle position of transmitted information. To correct these errors, the vehicle's longitude and latitude data are predicted every 100 ms from its wheel pulse and yaw rate.

(2) Head-Up Display (HUD) and Human-Machine Interface (HMI) providing acoustic information A method of providing information to the rider via an HUD using a system of zones to indicate the direction of danger has been developed. The merit of this method is that the rider can awake to indication of the HUD via peripheral vision, without having to focus on the image. The HUD also includes a speedometer area, enabling the rider to access the area with a comparatively small change in line of vision (Fig. 7).

The communications helmet used in the system enables acoustic information to be provided to the rider at the same time. The communications helmet is fitted with a speaker and a microphone. This also enables the rider and a passenger to talk. The onboard computer is preprogrammed with a variety of acoustic data that can be presented to the rider as required, depending on the situation. Bluetooth wireless technology is used to transmit data between the onboard computer and the communications helmet (Fig. 8).

3.2.2. Observing sensor technology

The external monitoring system is made up of a front-monitoring system and a rear-view system to enhance visibility.

(1) Front observation assistance Analysis of images from the front-monitoring camera shown in Fig. 9 enables the system to recognize an intersection ahead; information of the presence of an intersection can therefore be provided as a rider approaches the intersection.



Fig. 7 Head up display



Fig. 8 Communications helmet

As Fig. 10 shows, image analysis isolates the stop sign, stop line and "stop" painted on the road from the image data provided by the front-monitoring camera. If the rider does not apply the brakes, or slow down to less than a predetermined speed, information that the vehicle is approaching an intersection will be indicated on the HUD with acoustic information to encourage the rider to stop.

(2) Rear-view assistance As shown in Fig. 11, the ASV-3 motorcycle is equipped with a rear-view camera. Figures 12 and 13 show the type of images from the rear of the motorcycle that are displayed on the LCD at the bottom of the HUD.

Conventional motorcycle rear-view mirrors are sometimes partially obscured by the rider's body. This makes it difficult for the rider to check directly behind the vehicle during lane changes, etc. Positioning the rear-view mirrors even further out enables a wider range of monitoring around the rear of the vehicle than prior art. This helps reduce the blind spot (Fig. 14).

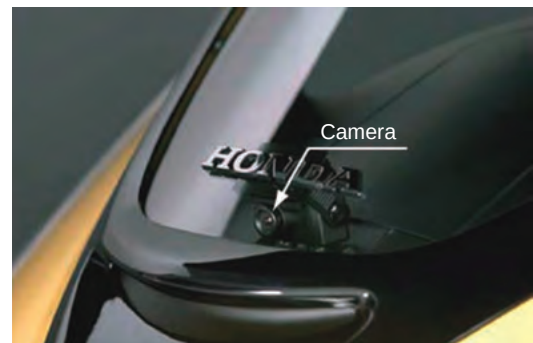


Fig. 9 Front-monitoring camera

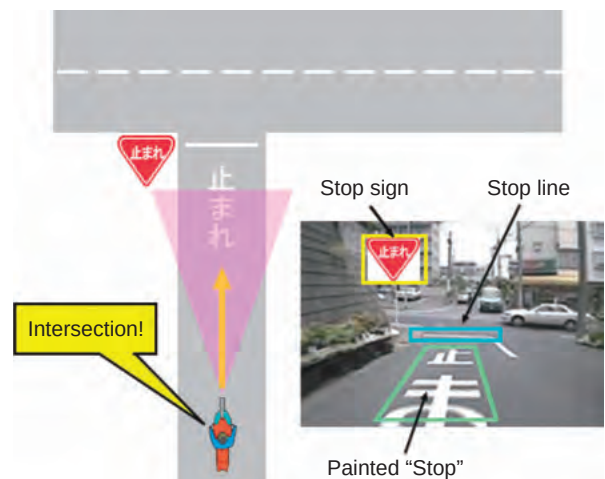


Fig. 10 Intersection approach support



Fig. 11 Rear view camera



Fig. 12 Example of HUD image: 1



Fig. 13 Example of HUD image: 2

3.2.3. Conspicuity enhancement technology

This technology is used to increase the ease with which other drivers are able to recognize motorcycles.

(1) FACE (Facial Attention to help Conspicuity Enhancement) design Increasing the conspicuity of motorcycles is effective in helping prevent them from being overlooked by the drivers of other vehicles.

Neurological research has indicated the existence of neurons that respond more quickly to specific patterns; in 1981, the discovery of “face neurons” was reported⁽³⁾.

The fact is well known that awareness of motorcycles is delayed, because motorcycles are small and can be hidden by trucks and/or passenger cars in a mixed traffic environment. Research has therefore been conducted on a design of the front of motorcycles (FACE design) that exploits the ability to recognize faces that is innate to humans. This further enhances the conspicuity of motorcycles in mixed traffic environments. Specifically, this

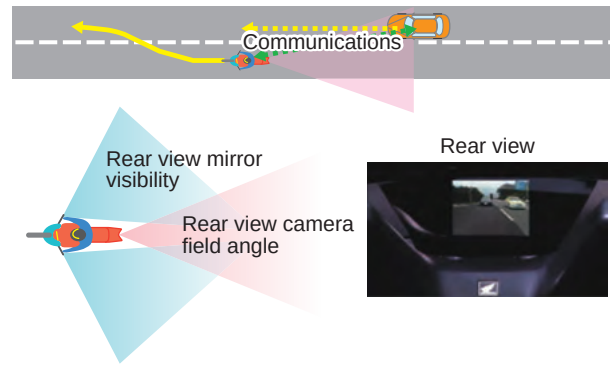


Fig. 14 Rear view support

involves a lighting design on the front of a motorcycle that resembles a human face. The design genuinely suggests a face during the day and at night⁽⁴⁾.

Images of mixed traffic of the type shown in Fig. 15 were formulated using an image simulator. These images were used in tests to determine whether test subjects could identify the motorcycle when shown the images for a short period. The results of these tests showed that subjects were approximately twice as likely to recognize a motorcycle with front design elements resembling a face than a conventional motorcycle (Fig. 16).

Functional Magnetic Resonance Imaging (fMRI) measurements of the brain function (Fig. 17) when shown an image of a real human face and a motorcycle with design elements suggesting a face are very similar. This indicates that the design causes activity in part of the brain that is extremely sensitive to the “face” pattern (Fig. 18).

To ensure that the front of the Honda ASV-3 motorcycle suggests a face at a glance, the projector headlamps are shaped like pupils;

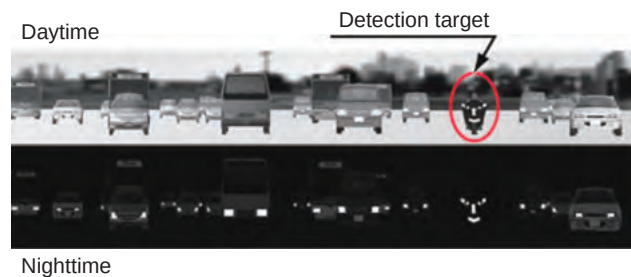


Fig. 15 Mixed traffic by image simulator

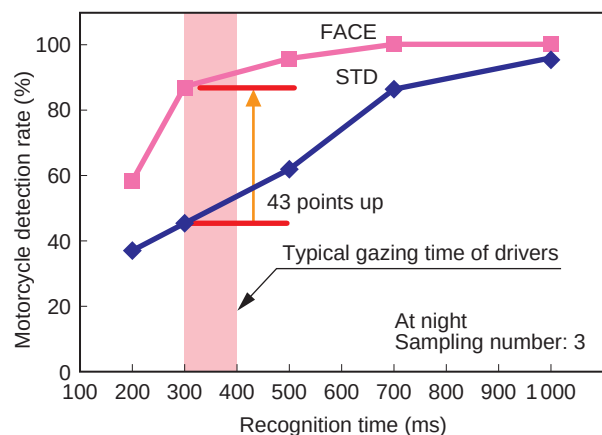


Fig. 16 Results of probability-of-detection experiment at night

the outline of the “eyes” and their “whites” also glow when the lights are on. This further reinforces the image of eyes, especially at night (Figs. 19 and 20).

(2) Longitudinal Oriented Normative time-Gap compensate (LONG) design Driver misjudgment of the distance and speed of oncoming motorcycles has been shown to be one of the main causes of accidents involving a right-turn collision or a crossing paths collision (Fig. 3).

To enhance distance awareness, lights have been positioned low on the body of the motorcycle to emphasize the point at which the vehicle contacts the road. At the same time, to increase awareness of the motorcycle’s speed, lights have been positioned high on the body to emphasize the size of the body, making it easier for drivers to judge exact speed (Fig. 21)⁽⁵⁾.

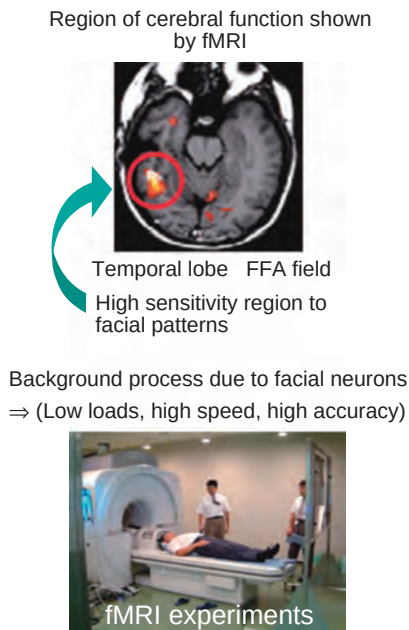


Fig. 17 Brain function analysis using fMRI

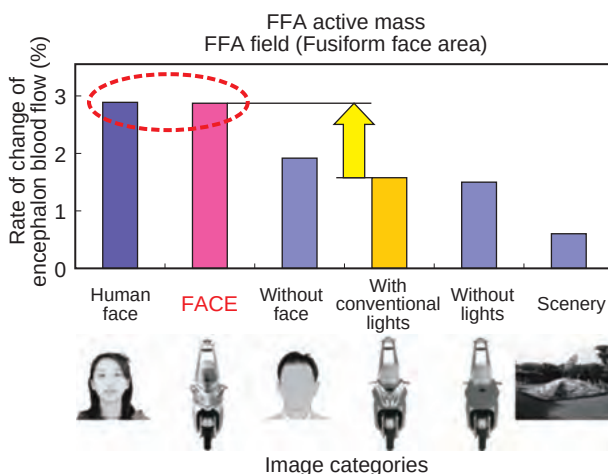


Fig. 18 Assessment of face-recognition using fMRI

A motorcycle equipped with lights following the LONG design (LONG) produces an almost identical awareness of the distance as for a normal passenger vehicle (CAR). This represents an enhancement of approximately 10% compared with a standard motorcycle (STD) (Fig. 22). In addition, LONG displays an enhancement of 20% over STD in speed awareness. The results of measurements of distances at which speed differentials could be discriminated for a standard stimulus (60 km/h) showed that a more accurate discrimination was possible for a greater distance for LONG than for STD (Fig. 23).



Fig. 19 FACE design for Honda ASV-3



Fig. 20 Comparison of FACE design (daytime and nighttime comparison)

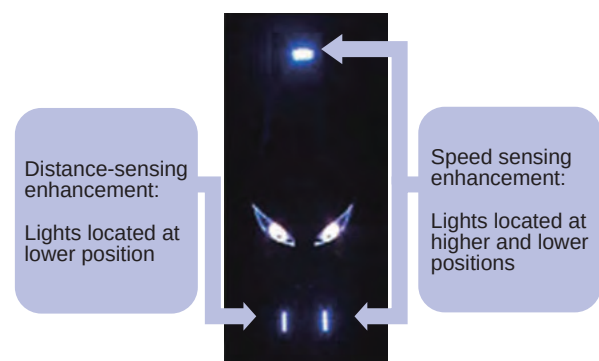


Fig. 21 LONG design lamp arrangement

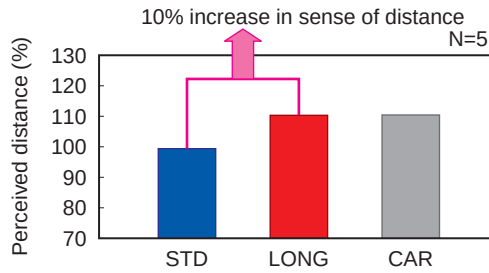


Fig. 22 LONG effect (sense of distance)

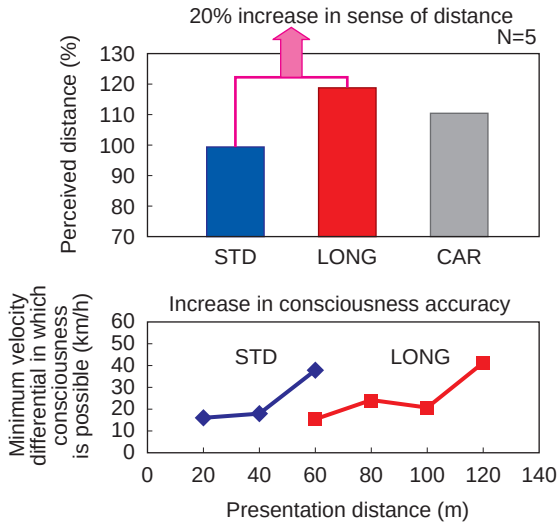


Fig. 23 LONG effect (sense of speed)

4. Proving Tests of Inter-Vehicle Communications System

4.1. Overview

In phase 3 of ASV by MLIT, proving tests of driving support systems using inter-vehicle communications were conducted jointly by 14 domestic automotive manufacturers at the Tomakomai winter test track of the Civil Engineering Research Institute of Hokkaido.

These tests focused on seven total accident types: four types of accidents for which oversight was considered the major cause (crossing paths collisions, right-turn collisions, head-on collisions and pedestrian collisions); and three types of accidents that cause serious damage, generating a significant social need for mitigation (rear-end collisions, left-turn collisions and lane change collisions).

Table 1 shows the categories in which the respective manufacturers were involved. Honda's tests, for the Honda ASV-3 motorcycle and passenger car, covered all seven accident types.

4.2. Results of Proving Tests and Considerations

The driving support system used in the Honda ASV-3 motorcycle does not use digital maps for car navigation systems; the application has been designed to encourage direct visual perception and thus increase awareness.

Tests related to motorcycle accident scenarios involving right-turn collisions and crossing path collisions indicate the inter-vehicle communications system was effective in supporting the ability to judge the possibility of a collision. This stimulates visual awareness in riders.

In tests of accident scenarios involving head-on, rear-end and left-turn collisions, insufficient accuracy in lane information caused the effectiveness of the system to be limited to the level of support of providing information on the presence of other vehicles. However, a driving support system using inter-vehicle communications can be expected to be effective in helping reduce the number of left-turn collisions by notifying vehicle drivers to the presence of motorcycles.

5. Conclusion

This paper has mentioned the inter-vehicle communications system, observing sensor technology and conspicuity enhancement technology used in the Honda ASV-3 motorcycle. The basic concept behind these safety technologies is assistance for enhanced visibility and conspicuity. The aim is to help reduce and possibly prevent accidents by reducing human errors that can cause them. The effectiveness of the inter-vehicle communications system and observing sensor technology was verified in proving tests conducted

Table 1 Domestic car maker participation in operation support system verification experiment

○: Participated

Accident type		Right turn	Crossing path	Pedestrian	Head-on	Rear end	Left turn	Lane change
Honda	(Motorcycles)	○	○		○	○	○	
Honda	(Passenger cars)		○	○		○		○
Isuzu	(Trucks)		○			○	○	
Suzuki and Kawasaki	(Motorcycles)	○	○				○	
Suzuki	(Passenger cars)	○	○				○	
Daihatsu	(Passenger cars)		○			○		
Toyota	(Passenger cars)	○	○		○	○		
Nissan	(Passenger cars)	○	○			○	○	○
Nissan Diesel	(Trucks)					○	○	
Hino	(Trucks)	○				○		
Fuji Heavy Industries	(Passenger cars)	○	○		○	○		○
Mazda	(Passenger cars)	○	○	○	○	○	○	○
Mitsubishi	(Passenger cars)		○			○		
Mitsubishi Fuso	(Trucks)					○	○	
Yamaha	(Motorcycles)	○	○	○		○		○

jointly by 14 domestic automotive manufacturers. Conspicuity enhancement using the “FACE design” and the “LONG design” were shown in simulator tests to increase the ratio of recognition and awareness of speed and distance. Research is ongoing on the practical application of these designs.

6. Afterword

The IT New Reform Strategy⁽⁶⁾ announced by the Cabinet Office on January 18, 2006, specified a government target for the reduction of traffic accident fatalities. The target is below 5 000 persons annually by the end of 2012. From 2006, the public and private sectors will begin R&D collaboration that includes large-scale tests on systems to link infrastructure (inter-vehicle communications, vehicle-to-road communications, road-to-vehicle communications) with national diffusion of the systems. The target for practical use is early 2010.

References

- (1) Institute for Traffic Accident Research and Data Analysis, Japan: Koutsujiko Toukei Nenpou 1998 (in Japanese)
- (2) Yamamoto, K., Kushida, K., Iijima, S., Yamagawa, T., Kodaira, S.: Introduction of HONDA ASV-2 (Motorcycle), HONDA R&D Technical Review, Vol. 12, No. 2, p. 9-16
- (3) Bruce, C., Desimone, R., Gross, C. G.: Visual properties of neurons in a polysensory area in superior temporal sulcus of the macaque, *Journal of Neurophysiology*, 46, p. 369-384 (1981)
- (4) Sugawara, T., Matsumoto, Y., Kimura, M., Kushida, K., Murata, Y.: Enhancement of Motorcycle Conspicuity Using Brain Activities Induced by the Facial Image Stimuli, 2005 JSAE Annual Congress Proceedings, No. 50-5 (2005)
- (5) Maruyama, K., Tsutsumi, Y., Kushida, K.: A Study of a New Lighting System for Better Conspicuity of a Motorcycle, 2005 JSAE Annual Congress Proceedings, No. 94-05 (2005)
- (6) IT Strategic Headquarters: IT Shin Kaikaku Senryaku, p. 19 (2006) (in Japanese), http://www.kantei.go.jp/foreign/koizumipphoto/2006/01/19it_e.html

■ Authors ■



Kazumitsu KUSHIDA



Mutsumi KATAYAMA



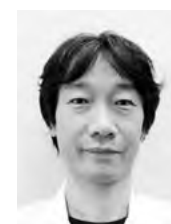
Yojiro TSUTSUMI



Kazuyuki MARUYAMA



Yutaka KAMATA



Yutaka MURATA