

Development of Inter-Vehicle Communication Type Driving Support System in the ASV-3 Project

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Abstract

As measures to reduce traffic accidents are being promoted using the technologies of second-stage Intelligent Transport Systems (ITS), the development of cooperative driving support systems using wireless communication technologies has been gaining momentum in Japan and abroad. Mitsubishi Motors Corporation (MMC) participated in the 3rd phase Advanced Safety Vehicle (ASV-3) project, which was led by the Ministry of Land, Infrastructure and Transport (MLIT) with the objective of "Developing new technologies"; we took part in the verification test of the inter-vehicle communication (IVC) type driving support system for preventing collisions through vehicle-to-vehicle communication. The test revealed issues to be addressed concerning the technology for recognizing surrounding vehicles by obtaining their location information via wireless communication.

Key words: Preventive Safety, Intelligent Transport Systems (ITS)

1. Introduction

Each day, the media reports another string of traffic accidents. Fatalities are on the decline, but road accidents continue to occur at the same rate and with the same devastating effect. In response, accident prevention efforts are being made in conventional areas such as road design, traffic regulations, driver education and vehicle safety, and moreover, progress is being made in promoting measures that utilize second-stage ITS. The New IT Reform Strategy⁽¹⁾, formulated in January 2006 by the IT Strategic Headquarters of the Japanese government, sets forth a policy to promote the practical application of vehicle-to-infrastructure cooperative driving safety support systems which use IT to help reduce traffic accidents. Data from roadside sensors and position information from surrounding vehicles is used to supplement the recognition function of the driving support system, which is not possible with the conventional autonomous-detection type system. In this paper, we attempt to classify the existing driving support systems and describe the history of related R&D in Japan and abroad. We also outline a verification test, part of the MLIT-led Phase 3 ASV Project in which we participated, of the inter-vehicle communication type driving support system utilizing wireless communication technology. MMC is also developing autonomous-detection type driving support systems. An example of such efforts is presented in the article "GRANDIS ASV-3 – Unlikely to Strike, or Be Struck by, Another Vehicle –" in this issue of Mitsubishi Motors Technical Review.

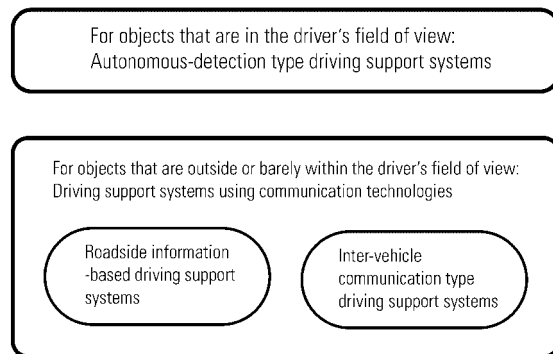


Fig. 1 Positioning of the systems developed in the ASV project

2. Classification of driving support systems

Drivers drive their vehicles in the three sequential steps of "recognition", "decision" and "action". Driving support systems are designed to help reduce the work load by taking over some of the driver's tasks while assisting in driving performance. "Recognition" refers to the detecting step of the situation around the vehicle, so the system must be capable of detecting conditions around the vehicle. For this purpose, two types of systems are required: one that is designed to cover those areas that the driver can see, namely, a system using onboard sensors; the other designed to cover those areas that the driver cannot see or can hardly see. In the ASV project, these systems are positioned as shown in Fig. 1⁽²⁾.

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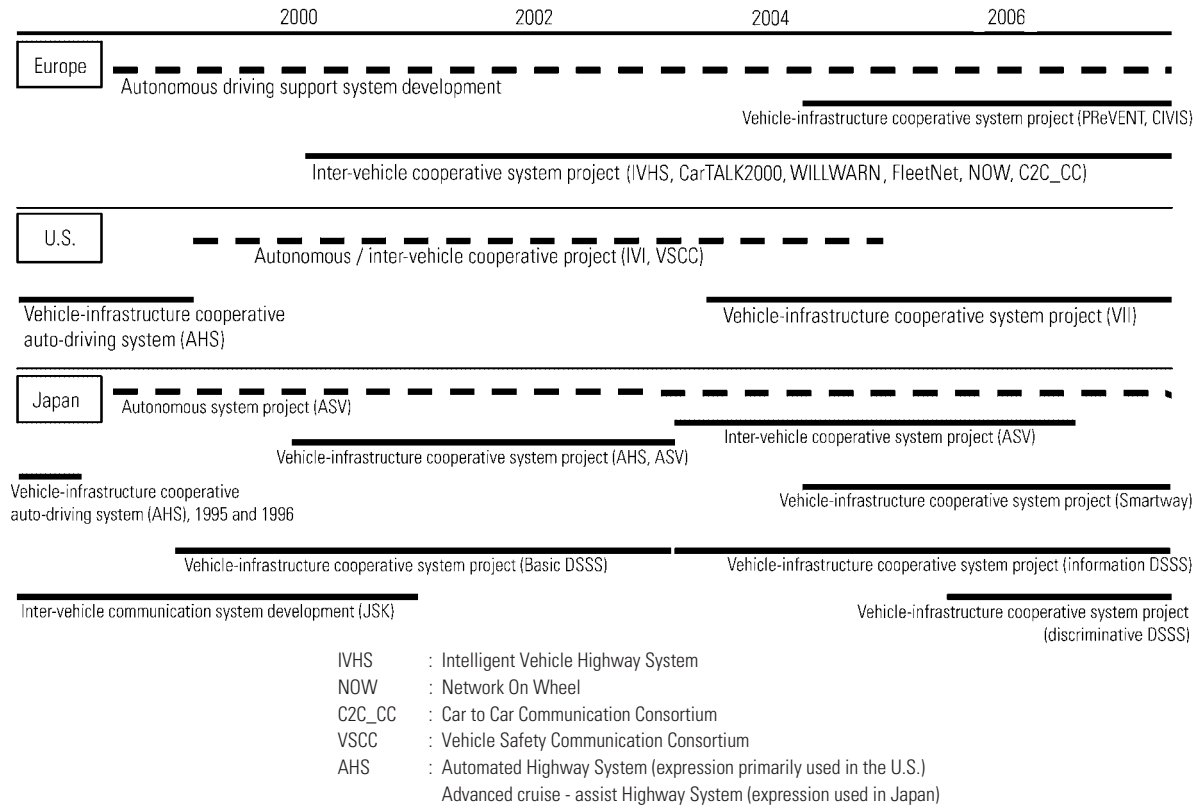


Fig. 2 Research and development history of cooperative type driving support systems

3. History of R&D on cooperative driving support systems

Many years of research and development efforts in autonomous-detection type driving support systems have led to commercial products with good performance. On the other hand, the development of communication technology-based vehicle-to-infrastructure cooperative driving support systems has made significant progress but such systems have only recently entered the commercialization stage due to reasons related to cost-effectiveness of road infrastructure installation, user acceptance and limited applications. Similarly, vehicle-to-vehicle cooperative systems have not yet entered practical use in spite of years of studies and experiments. The history of R&D on communication technology-based cooperative driving support systems is outlined below^{(3) - (5)} (Fig. 2).

In Europe, early R&D efforts targeted vehicle-to-vehicle support systems. In recent years, vehicle-infrastructure cooperative system projects, PReVENT (Preventive and Active Safety Applications) and CIVIS (Cooperative Vehicle-Infrastructure Systems), were developed to reduce traffic accidents at intersections, etc and they are still in action. In the United States, the cooperative vehicle-infrastructure auto-driving system was the focus of development in the 1990s. In 1998, the spotlight shifted to the Intelligent Vehicle Initiative (IVI) system, particularly onboard equipment. In recent years, as in Europe, vehicle-infrastructure cooperative systems regained attention for reducing traffic acci-

dents at intersections, and the Vehicle Infrastructure Integration (VII) system project has been in progress since 2004.

In Japan, verification tests on the vehicle-infrastructure support system were conducted (on test and actual roads in 2000 and 2002) jointly in the autonomous type driving support system development project (ASV) and the cooperative vehicle-infrastructure system development project – Advanced cruise-assist highway system (AHS). Since then, there has been active development of practical AHS systems and pilot programs conducted primarily on highways under the Smartway project⁽⁴⁾. In addition, another vehicle-infrastructure cooperative driving support system project to prevent traffic accidents at intersections on ordinary (non-highway) roads, etc. – the Driving Safety Support System (DSSS) – conducted basic experiments and verification experiments for information supply, and was successfully introduced as an information system in limited regions in 2005. Currently, DSSS is promoting the development of discriminative information service whereby the onboard system judges the danger of the present situation based on information about the vehicle's behavior and the surrounding conditions from the roadside devices, and supplies the necessary information to the driver⁽⁵⁾.

4. ASV-3 project – inter-vehicle communication type driving support system

The MLIT-led ASV project has been developing automotive safety technologies for over 15 years. Since

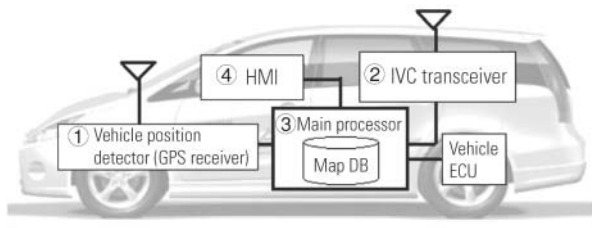


Fig. 3 Configuration of the Mitsubishi ASV-3

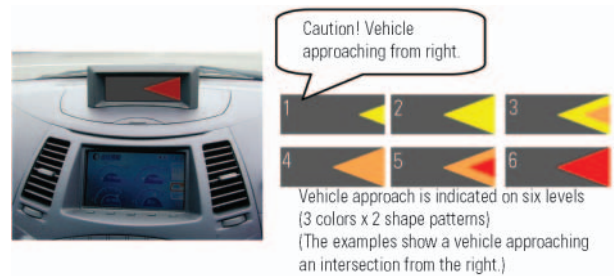


Fig. 4 Examples of HMI image

2001, when the third phase of the project was launched, efforts have been made to promote the technologies already developed under the project while at the same time developing new technologies. As part of the new technology development theme, verification tests of roadside information-based driving support systems were conducted jointly with AHS, using wireless communication technologies as a means of vehicle-infrastructure communication.

Roadside information-based driving support systems using roadside sensors did not function in regions not equipped with such systems. Therefore, efforts were made to develop driving support systems that function in any region. Inter-vehicle communication type systems were developed that allow vehicles to exchange information on their position and behavior using the latest wireless communication technologies to keep drivers informed of their own vehicle's separation from surrounding vehicles. In 2005, verification tests were conducted on test roads, for which Japanese car manufacturers provided large-, medium-, compact- and mini cars, motorcycles and pedestrian-simulating mannequins.

4.1 Test vehicle system configuration

Fig. 3 shows the system configuration of the test vehicle, GRANDIS ASV-3, which MMC contributed to the verification test on inter-vehicle communication type driving support systems.

The IVC driving support system basically consists of an IVC transceiver, a vehicle position detector and a human-machine interface (HMI). The experiment was primarily aimed at clarifying the feasibility and acceptability of the system's wireless inter-vehicle communication-based driving safety support functions. The wireless communication means available at the time (2005), namely the 5.8-GHz DSRC (dedicated short-range communication), was used for the test. The actual method of applying the system would be based on the most appropriate wireless communication technologies available at the time.

In the test, the position of the test vehicle was measured using a commercially available GPS receiver. The measurement was then projected onto a previously prepared shared map of the test course (hereafter "the map database (DB)") stored in the main processor in order to determine the test vehicle's position. The positions

of surrounding vehicles were then measured and the measurements were sent via the IVC transceivers to the main processor of the test vehicle. The position data was then projected onto the map DB of the test vehicle. The determined relative positions of the test vehicle and surrounding vehicles were then converted into separations using the map DB scale, based on which decisions were made regarding the timing of driver notification.

Driver notification was made via an on-dash HMI unit, using different colors and shape patterns as well as voice messages to alert the driver to approaching vehicles. Fig. 4 shows examples of the HMI display.

4.2 Verification test

One of the test items was collision prevention at intersection corners. To create poor visibility conditions, walls were erected at an intersection of the test course (Fig. 5). The GRANDIS ASV-3 was equipped with nose-view cameras. Images of an approaching vehicle on the crossing road of the intersection that were sent from the camera, combined with corresponding driver notification messages based on inter-vehicle communication, proved effective in making the driver aware of the approaching danger.

4.3 Issues identified in the verification test

In the autonomous-type driving support system, the surrounding vehicle position detection sensor mounted on the vehicle directly measures the separation (relative positions) between the vehicle and the surrounding vehicles. The accuracy of measurements, therefore, depends on the accuracy of the vehicle's sensor. On the other hand, with the IVC-type system, the tests revealed various issues that must be resolved in order to achieve accurate vehicle positions (Fig. 6). These include: measurement error by vehicle position detectors of own vehicle and surrounding vehicles; asynchronous measurement timing among vehicles; and the fact that vehicles will be at different positions by the time the measured positions are communicated between the vehicles.

The levels of driving support offered (caution, warning, control) depend heavily on position accuracy. For practical implementation, it is important to remember that the levels of driving support offered should be set in accordance with the position accuracy that can be achieved by the technologies employed.

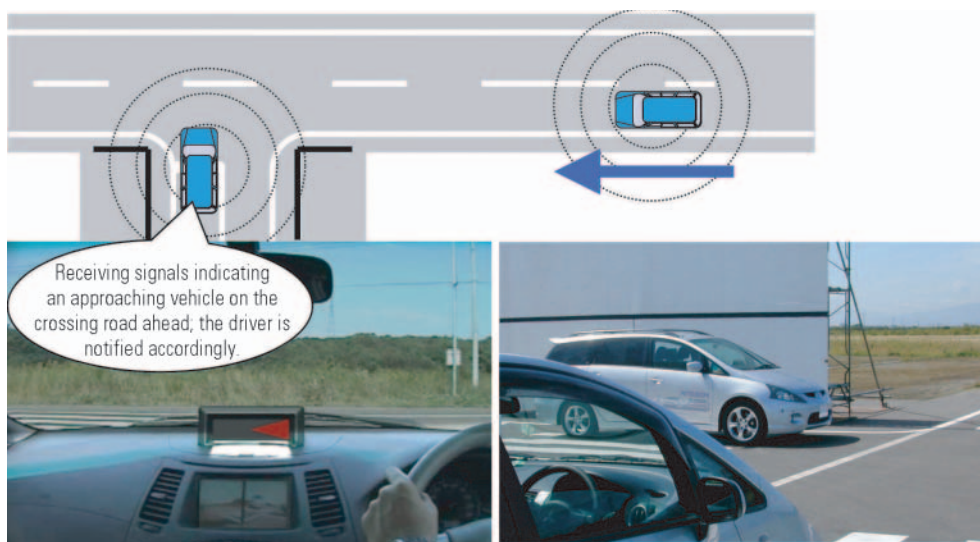


Fig. 5 Verification test on collision prevention at intersections

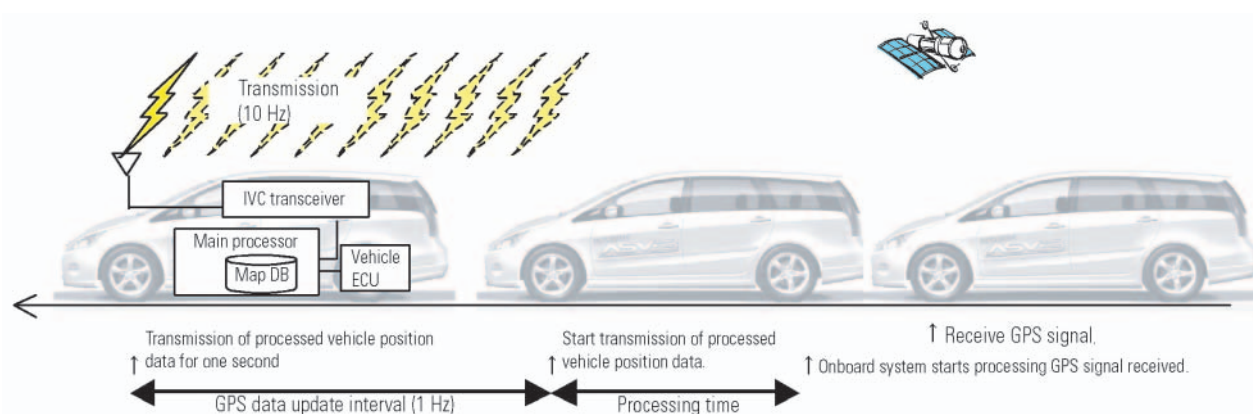


Fig. 6 Consideration of delay in positional information processing

5. New IT Reform Strategy and the future of cooperative-type driving support systems

The New IT Reform Strategy sets targets and policies to achieve the “World’s safest road traffic environment.”. One of the targets aims to “Reduce the number of traffic fatalities and serious injuries by deploying Cooperative Driving Safety Support Systems that cooperate with traffic infrastructure.”. To achieve the target, a joint public-private sectors’ project road map has been set up, as outlined in **Fig. 7**. In line with the scenario, related activities have been started, such as the establishment of specifications and basic experiments across the country. In other words, approximately 10 years after the Vehicle Information Communication System (VICS) was launched in 1996, the route to practical implementation of next-generation cooperative driving support systems is now clear.

To prevent traffic accidents, it is important not only to ensure cooperation between vehicles and roadside systems, but also to maintain vehicle-pedestrian and inter-vehicle cooperation. Expectations are high for wireless communication technology to further improve vehicles’ capability to recognize surrounding circum-

stances, for onboard sensors to ensure such vehicle recognition capability, and for cooperative driving support systems based on the integration of the two to emerge.

6. Conclusion

In this paper, we presented an overview of the existing cooperative driving support system development projects, and described the issues identified in a verification test on an IVC-type driving support system that we developed.

In an attempt to help eventually eliminate road traffic accidents by means of cooperative vehicle-infrastructure driving support systems that will be deployed in 2010 and onwards, we will continue with technological development and commercialization efforts for integrated autonomous, vehicle-infrastructure and inter-vehicle driving support systems, by collaborating with other concerned bodies.

In conclusion, we thank all those involved in the ASV verification test for their cooperation, including those from the ASV coordination office and from the companies that participated in the test.

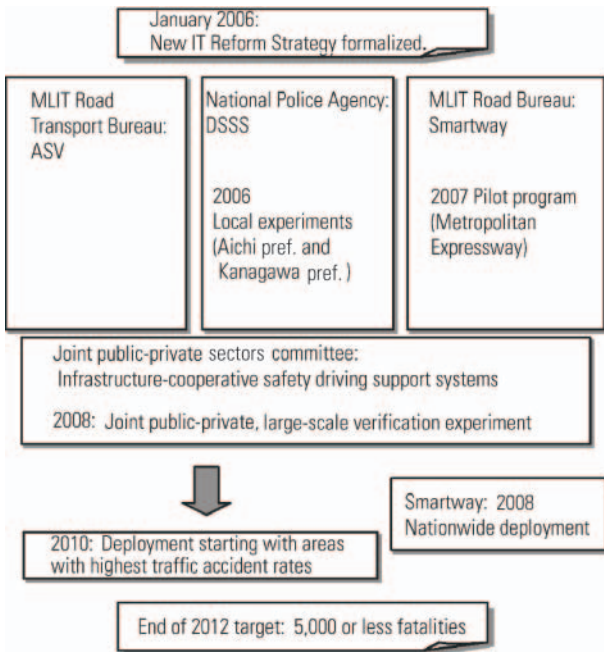
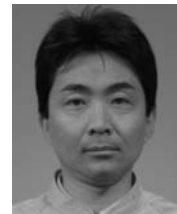


Fig. 7 Road map for the development of cooperative driving support system

References

- (1) Strategic Headquarters for the Promotion of an Advanced Information and Telecommunications Network Society (IT Strategic Headquarters)
<http://www.kantei.go.jp/jp/singi/it2/index.html>
- (2) ASV Promotion Committee of the Ministry of Land, Infrastructure and Transport; Advanced Safety Vehicle (ASV): Inter-Vehicle Communication (IVC)-type Driving Support System Pamphlet; 2005
- (3) ASV Promotion Committee of the Ministry of Land, Infrastructure and Transport; Update Meeting of the 3rd Phase of the Advanced Safety Vehicle (ASV) Project; 2006
- (4) 2006 AHS Symposium Report; June 2006
- (5) The 3rd Universal Traffic Management System (UTMS) Meeting; July 2006
<http://www.npa.go.jp/koutsuu/kisei29/20060727.pdf>
- (6) The 7th Smartway Project Advisory Committee Working Groups; November 2006
http://www.its.go.jp/ITS/j-html/topindex/topindex_smartway_bukai.html



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