Effects of AHS for Safety in Curve Section

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Summary
The National Institute for Land and Infrastructure Management (NILIM) and the Advanced Cruise-Assist Highway System Research Association (AHSRA) have been promoting R&D for the Advanced Cruise-Assist Highway Systems (AHS). Metropolitan Expressway #4, Shinjuku Line, Sangubashi area is one of the locations for the AHS field tests on actual roadways that have been underway since fiscal 2002. The objective of the pilot program, implemented in the Sangubashi area from March-May 2005, was to reduce rear-end collisions, side wall collisions and decrease dangerous conditions under which near misses occur by providing information to regular vehicles through the already widespread VICS devices installed in cars. The results verified effective accident reduction and improvement in vehicle behavior, illustrating the effectiveness of the AHS service. We initiated an additional, long-term pilot study in September 2005 and are evaluating long-term effectiveness. This paper discusses the results of verification of the long-term effectiveness Vehicle-Highway System services obtained from the pilot study.

Keywords: AHS, Vehicle-Highway System, long-term pilot study, accident reduction

Introduction
Metropolitan Expressway #4, Shinjuku Line, Sangubashi area (hereafter, “Sangubashi”) is one of the locations for the AHS field tests on actual roadways that have been underway since fiscal 2002. The objective of the pilot program, implemented in the Sangubashi area from March-May 2005, was to reduce rear-end collisions, side wall collisions and decrease dangerous conditions under which near misses occur by providing information to regular vehicles through the already widespread VICS devices installed in cars. The results verified effective accident reduction and improvement in vehicle behavior, illustrating the effectiveness of the AHS service. Issues identified during the study were evaluation of long-term effectiveness, which could not be ascertained during the short-term pilot program, and improvements to the service reflecting drivers’ opinions. We therefore initiated an additional, long-term pilot study in September 2005 and are evaluating these factors. This paper discusses the results of verification of the long-term effectiveness Vehicle-Highway System services obtained from the pilot study.

The danger of curve sections on expressways within the metropolitan area
The accident rate on Japanese metropolitan expressways within 200 meters of a curve is 2.6 times the average rate for all roads. There are a total of 470 locations of this type and losses due to accidents are estimated at ¥10 billion a year. Twenty-one percent of these accidents on the metropolitan expressways are concentrated in curves
Most Accidents are Caused by Driver Action Just Prior to the Accident

Many of these accidents are thought to be due to perceptive delays and errors of judgment in the driver’s actions immediately prior to the accident (Figure 1). It is essential to assist drivers in understanding the road conditions ahead of them. That is the reason for conducting a trial in increasing driving safety with regard to obstacles in the driving path through such means as installing sensors in cars. However, since it is difficult for drivers to see the conditions in front of them within a 250 meter radius of sharp curves and also difficult for vehicle sensors to sense these conditions, it is necessary to provide information to vehicles from the road to assist safe driving.

Pilot study of services providing information on obstacles in the road ahead
Based on these conditions, the authors developed and conducted an experimental study on actual roads of a service that provides information on the impending obstacles (a service that uses sensors installed on the roads to detect cars that have slowed or stopped (including the tail end of traffic jams) on curves with poor visibility to provide this information to cars immediately before entering the curve) (Figure 2). This service is expected to reduce rear-end collisions with cars that have slowed or stopped for a traffic jam, and collisions (secondary accidents) with cars that have stopped for accidents or other reasons.

Figure 1: Breakdown of Accident Causes

Figure 2: Service Providing Information on Impending Obstacles Causes
Sangubashi is a heavily trafficked area where approximately 47,000 vehicles pass through a sharp curve with a radius of 88 meters each day. In fiscal 2003, there were 181 accidents in a 500 meter section which includes this curve. This high-accident area is touted as the #1 worst area of the metropolitan expressway, both in terms of the number of accidents and the accident rate.

From March-May 2005, a pilot study was conducted in Sangubashi in which regular drivers were given advance warning on traffic jams, stopped cars and slowing cars ahead on the curve through a 3-Media VICS-enabled car navigation system (approximately 10% of the cars on the road have these installed). A message board was also added from April 27. (Figure 3)

Information on impending obstacles was provided to regular drivers by using a simple VICS diagram. Providing this information resulted in the following:

1) The number of accidents decreased approximately 50% over the same month of the previous year.
2) There was a 12-14% improvement in actions such as abrupt braking (0.5 G or greater) by following cars when there was an impending obstacle.
3) Analysis of a survey of the experiences of regular drivers confirmed that the service was accepted; there were numerous responses such as, “The service is effective” and “I would like this service to be continued.”

The following issues were identified:
1) An evaluation of the sustainability of the effectiveness of the service over the long term which cannot be measured in the short time period.
2) An evaluation of the results of improved service reflecting the suggestions of regular drivers; e.g., they did not need information on traffic jams that extended to where they could see them before entering the curve.

Figure 3: Service Schematic for the Pilot Study
Evaluation of a long-term pilot study

An additional, long-term experimental study of the service, reflecting the opinions of regular drivers, was initiated in September 2005 to address the above issues and is still underway (as of July 2006). As was the case with the March-May study, the conditions under which accidents occur and the behavior of vehicles, as well as the results of a survey of regular driver experiences conducted for this study, were evaluated.

Conditions under which accidents occur

Figure 4 shows the trend in the number of accidents occurring at Sangubashi by month, from April 2002 to July 2006. This shows that the number of accidents continues to trend at low levels following introduction of this service.

High performance pavement with superior water drainage capabilities to enable better visibility and control under rainy conditions was installed at the same time the service began (December 2004). This safety measure can be considered a contributing factor to the reduction in accidents, but we can see from Figure 5 that accident reduction was better at Sangubashi than for nearby curves.

Figure 4: Trend in Number of Accidents Occurring at Sangubashi

Figure 5: Status of Accidents Occurring on Similar Curves of the #4 Shinjuku Line (By number and type of accidents)
Figure 6 shows accidents occurring during the four years from 2002 onward, by year and by type. This shows that the number of rear-end collisions and secondary accidents that was expected to be reduced through the provision of information on impending obstacles was actually reduced by 79%.

As noted above, the expressway was repaved with high performance pavement at the same time that the service began, so the dual benefit of these can be considered to have reduced the number of accidents. Since the benefits of high performance pavement are exhibited when the road surface is wet, a comparison of the number of accidents occurring when road surface conditions were dry was extracted in Figure 7, in order to ascertain the benefit of this service. The number of rear-end collisions and secondary accidents that was expected to be reduced through the provision of information on impending obstacles was actually reduced by 67% when the road surface was dry, illustrating the effectiveness of the service.

Figure 6: Trend in the Number of Accidents Occurring at Sangubashi by Type

Figure 7: Trend in the Number of Accidents Occurring at Sangubashi by Type (When the road surface is dry)
Analysis of survey responses from regular drivers

It is generally claimed that the benefits of traffic safety measures are visible immediately following implementation, but that these benefits decrease over time. We believe that this service will provide sustained benefit by “providing the necessary information when needed.” In order to demonstrate this, we recruited 79 people for trial monitoring and conducted an ongoing survey to assess changes in driver awareness over the long-term as they experienced the service.

Figure 8 shows the results of the survey of awareness of the service and the cumulative number of times information provision was experienced at the 3-month and 6-month marks in the trial monitoring. Drivers’ awareness of service provision remained at approximately 90%, without much change, even with an increase in the number of times experienced, showing that awareness does not change even when the service is implemented over a long period of time.

**Figure 8: Cumulative Number of Times Information Provision Was Experienced and Awareness of the Service**

Figure 9 shows the survey results for the questions: “When you were provided information, did you think there was something ahead on the curve?” and “When information was not provided, did you think there was nothing ahead?” Nearly all the drivers thought there was something ahead when they received information and the percentage did not decline with the passage of time, leading us to believe that the benefits of providing information are sustained. Moreover, close to 20% of drivers thought there was nothing ahead when information was not provided. It is possible that these drivers will believe the information provided and act accordingly, even when there are erroneous reports or no reports. This illustrates how essential it is to continue efforts to ensure that the nature of the service is properly understood.

**Figure 9: Driver Awareness Depending on Whether Information Was Provided**
Figure 10 shows the survey results from whether drivers felt the service was beneficial after experiencing it over the long-term. Approximately 90% of the drivers either felt it “effective” or “somewhat effective.” These results did not change much over time, showing that the benefits were sustained.

Q. Is the service at Sangubashi effective?

Figure 10: Changes in Evaluation of Effectiveness After Experiencing Long-term Service

Conclusion

Analysis of the results from the long-term pilot study of a service providing information on impending obstacles conducted at Sangubashi demonstrate that the effectiveness of the service is sustained by “providing the necessary information when needed.” We intend to collect further data to demonstrate this.

\[1\] Hiroshi Makino, et al.: Field Tests of Safety Measures for Curve Sections on Urban Expressways Utilizing Cooperative Vehicle-Highway System, 12th World Congress on ITS