Introduction

The number of traffic fatalities in Japan has been trending downward in recent years due to such measures as improvement of road alignment, construction of sidewalks, the seatbelt law, revision of collision safety standards, and airbags. However, approximately 9,000 precious lives continue to be lost every year in traffic accidents. Furthermore, the number of traffic accidents continues its upward trend, now surpassing 940,000 per year. Drastic measures to reduce traffic accidents are urgently needed.

The major causes of traffic accidents are delay in recognition (50%) and errors in judgment (16%) or operation (9%). Thus, human error accounts for 75% of all accidents. Human error can be effectively reduced by providing drivers with advance warning about dangers as quickly as possible to avoid them. Japan has been promoting research and development of Advanced Cruise-Assist Highway Systems (AHS) as such a countermeasure.

This report discusses the traffic accident-reducing effect of variable information signboards and information provided by on-board equipment, as determined in field operational test conducted in fiscal 2002 and 2003 on a service to support provision of information on stationary and slow-moving vehicles ahead, as well as test conducted with a driving simulator (DS).
The Service to Support Provision of Information on Stationary and Slow-Moving Vehicles Ahead

Collisions with stopped vehicles and other obstacles ahead account for approximately 8.5% of all traffic fatalities. Of these, 69% (or 5.9% of all fatalities) are due to delay in recognition. Therefore, giving drivers advance information about obstacles ahead should allow them to avoid the danger, thereby reducing traffic accidents.

Figure 1 illustrates the concept of support for prevention of collisions with forward obstacles. Information about stationary vehicles ahead, which is not visible to, is picked up by the roadside infrastructure and transmitted to the driver by means of variable information signboards or on-board equipment.

Effectiveness of the Service on a Test Course Overview of the Test

This section describes the results of a test on a test course to verify the effectiveness of the service providing information about stationary and slow-moving vehicles ahead. Verification was based on differences in vehicle speed between with and without the service.

Figure 2 is an overview of the test. The distance from the vehicle to the variable information signboard and the size of the displayed text both conformed to road sign deployment standards and to road information sign design standards. The distance from the variable information signboard to the incident location was calculated as braking distance (L) less vanishing distance (L2). Braking distance (L) is defined as the greatest distance from the incident location from which the service-capable vehicle can avoid the incident by braking, which is calculated using the maximum speed appropriate for the vehicle. L is calculated according to equation 1:

\[ L = \frac{V^2}{2\alpha} + V(T + T_0) \]  

where L: braking distance (m)  
V: maximum velocity appropriate for the service-capable vehicle (m/s)  
\( \alpha \): deceleration of the service-capable vehicle (m/s^2)  
T: driver response time (sec) (assumed to be 3 sec in this test)  
T0: roadside system delay time (sec) (assumed to be 0.3 sec in this test)

The values of L used were those for large trucks and buses, the largest value in the test. The value used for L2 (vanishing distance) is the distance beyond which the driver of a vehicle approaching a variable information signboard cannot read the messages displayed. The values specified in road information sign design standards were used.

Figure 3 shows the layout of the test course used in the above-described test, as well as a scene from the actual test. The variable information signboard displayed the message STATIONARY VEHICLES AHEAD. The driving distance needed to read the signboard was...
calculated from the correlation between character count and reading time as determined by previous research, and it was verified that this value did not exceed Lr (reading distance).

Dates of test: February 6 and 7, 2001
Location: Test course, Public Works Research Institute (now the Ministry of Land, Infrastructure, and Transport), 1 Asahi, Tsukuba City, Ibaraki Prefecture
Test drivers: 18 total: young (25 and under)—3 men, 3 women; middle aged (26 to 64)—3 men, 3 women; elderly (65 and over)—4 men, 2 women.

Results of Test
Figure 4 graphs vehicle speed upon entering the test course curve when information about the stationary vehicle ahead was provided via the variable information signboard. The abbreviation AVE indicates average; STD+ and STD- represent the ranges of standard deviation. As the data indicate, information provision reduced curve-entry speed by approximately 12%.
Test on Actual Roads

Overview of the Test

On roadways, information about stationary vehicles ahead was provided via the variable information signboard to verify the resultant reduction in curve-entry speed. Measurements were made on National Highway 25 (the Meihan Expressway) in the Maitani district of Nara Prefecture, and at the Nagoya-Nishi Junction of the Higashimeihan Expressway in Aichi Prefecture (see Figure 6). The distance from the vehicle to the variable information signboard and the size of the displayed text both conformed to road sign deployment standards and to road information sign design standards.

Photo 1 shows a variable information signboard in place.
National Highway 25 (the Meihan Expressway) in the Maitani district of Nara Prefecture
- Display orientation: Horizontal
- Displayed message: Flashing alternating messages STOPPED VEHICLES AHEAD and COLLISION DANGER AHEAD when a stationary vehicle was present.

Nagoya-Nishi Junction of the Higashimeihan Expressway in Aichi Prefecture
- Display orientation: Vertical
- Displayed message: COLLISION DANGER AHEAD when a stationary vehicle was present

Results of Test

Speed-Reduction Effect

Figure 7 shows curve-entry speed measured when information about stationary vehicles ahead was provided via the variable information signboard. On National Highway 25, average speed fell from 71.6 km/h before the information was provided to 64.5 km/h after, by a decrease of 10%. At the Nagoya-Nishi Junction, average speed fell from 78.0 km/h to 70.0 km/h, by an 11%. This means information provided via the variable information signboard
decreased vehicle speeds as same as test course resulting. Furthermore, the speed-reducing tendency was depending on local installing conditions.

Using a Traffic-Accident Database to Estimate Effectiveness in Reducing Fatality Rates

Figure 8 shows the correlation between vehicle speed and fatality rates. As this shows, the fatality rate tends to increase exponentially as vehicle speed rises. The primary reason is that collision force increases in proportion to the square of speed.

Based on Figures 7 and 8, Figure 9 estimates the reduction in fatality rates from the provision of information about stationary vehicles ahead via the variable information signboard. According to these estimates, such a system would reduce the fatality rate from 3.5% to 2.1% in National Highway 25 (the Meihan Expressway) in the Maitani district of Nara Prefecture, and from 5.2% to 3.2% at the Nagoya-Nishi Junction of the Higashimeihan Expressway in Aichi Prefecture.

Post-Adoption Effectiveness in Reducing Accidents

Figure 10 shows the number of accidents at the National Highway 25 (the Meihan Expressway) in the Maitani district of Nara Prefecture with and without information provided via the variable information signboard. The two periods were both 17 months in duration: December 2000 to May 2002 (without information) and June 2002 to November 2003 (with information). As the data show, providing information via the variable information signboard reduced accidents by approximately 40%. Incidentally, no personal injury accidents occurred
during the period of information provision. The preceding demonstrates that by reducing vehicle speed, the provision of information on stationary vehicles ahead via the variable information signboard not only lowers fatality rates, but also reduces the number of accidents.

![Graph showing number of accidents with and without information provision in National Highway 25 (the Meihan Expressway) in the Maitani district of Nara Prefecture.]

**The Effectiveness of Providing Information via On-board Equipment**

**Overview of the Test**

The scenario of AHS deployment is envisioned as the following steps: 1) Using road administration and management, 2) providing information to drivers by variable information signboards, and 3) providing information to drivers via on-board equipments.

The effectiveness of providing information via on-board equipments was verified using the driving simulators.

The service's effectiveness was measured by measuring drivers, avoiding action when another vehicle was stopped in a low-visibility curve.

- Type of location: Ordinary road—outer perimeter road (R100)
- Test drivers: 15 men (ages 20–34, average age 24.4) and 15 women (20–37, average age 26.3)
- Test scenario: Shown in Figure 11. The test drivers were instructed to maintain a speed of 60 km/h on a two-lane road. A stationary vehicle was stopped at a point 52.3 m from the entrance to a left-banking curve on the course. Forward visibility was poor because of a concrete wall on the left shoulder, so that the stopped vehicle was visible from only approximately 50m away. Figure 12 is a screen capture of the DS program.

![Diagram showing the concept of the driving simulator scenario.]

![Screen capture of the driving simulator.]

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Figure 11. Concept of the driving simulator scenario

Figure 12. Screen capture of the driving simulator
• Type of service
  1. No warning (vehicle recognized)
  2. Warning by the on-board equipment
  3. Warning by the variable information signboard
• Means of communication: In the obstacle scenario, the warning shown in Figure 13 was communicated by the on-board equipment or the variable information signboard.

![On-board equipment](image1)
![Variable information signboard](image2)

**Figure 13. Information [warning messages] displayed**

**Results of Test**

Figure 14 shows the braking reaction ratio for each warning scenario. The term "braking reaction ratio" refers to the percentage of drivers who braked in response to the service-communicated information before actually seeing the stopped vehicle. As the figure indicates, 55% of drivers braked in response to the variable information signboard, 92% in response to the on-board equipment. This indicates that on-board equipment is more effective than variable information signboards at alerting drivers and encouraging them to take avoiding action.

Figure 15 shows the types of avoiding actions taken by drivers upon recognizing the stopped vehicle in the various service scenarios. In the figure, "decelerated" indicates that the driver decelerated to avoid the stopped vehicle. "Steered without decelerating" means that the driver, having decelerated sufficiently before recognizing the vehicle, avoided the vehicle by steering only, without decelerating. The former response is clearly more dangerous than the latter because of the sudden deceleration upon recognition of the stopped vehicle. In ascending order, the scenarios in which drivers most often were able to avoid the obstacle by steering only (without decelerating) were No service, Warning by variable information signboard, and Warning by on-board equipment. In the case of warning by on-board equipment, drivers were able 70% of the time to avoid by steering only, without having to decelerate after recognizing the vehicle.

![Braking reaction ratios](image3)
![Evasive actions taken by drivers](image4)

**Figure 14. Braking reaction ratios**

**Figure 15. Evasive actions taken by drivers upon recognizing the stopped vehicle**

**Conclusions**

This report has discussed the effectiveness of AHS in reducing traffic accidents, by analyzing data on actual road tests in fiscal 2002 and 2003 using services to support provision of information about stationary and slow-moving vehicles ahead. Also this has reported the
results of DS tests to verify the effectiveness of on-board equipment. These results are summarized below.

On a test course, using a variable information signboard to provide information about a stationary vehicle ahead reduced curve-entry speed by an average of 12%. On an actual road, speed reduction is 10% on National Highway 25 (the Meihan Expressway) and 11% at the Nagoya-Nishi Junction of the Higashimeihan Expressway. From these results it was estimated that fatality rates could be reduced from 3.5% to 2.1% in National Highway 25 and from 5.2% to 3.2% at the Nagoya-Nishi Junction.

In National Highway 25 deployment of the variable information signboard reduced the occurrence of traffic accidents by 40%. No personal injury accidents have occurred since service began.

DS test showed on-board equipments to be more effective than variable information signboards in warning drivers and encouraging them to take avoiding action.

The preceding has clearly demonstrated that using variable information signboards to provide information about stationary vehicles ahead can reduce vehicle speeds, lower fatality rates, and reduce the number of accidents; and that providing information via on-board equipment may make traffic conditions even safer. The next step is long-term verification of the effects on drivers' habits.

References:
1.) Traffic-accident database: Institute for Traffic Accident Research and Data Analysis
2.) Road sign deployment standards and related administrative guidance: Japan Road Association
3.) Road information display equipment standard specifications (draft): Association of Electricity and Telecommunication Engineering for Land and Infrastructure