Field Tests of Safety Measures for Curve Sections on Urban Expressways Utilizing Cooperative Vehicle-Highway System

H. MAKINO  I. YAMAZAKI  T. HIRASAWA  K. YAMADA
National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure and Transport (NILIM)

H. MIZUTANI
Advanced Cruise-Assist Highway System Research Association (AHSRA)
Accident rate by R on urban expressways in Japan

Approximately 2.6 times greater

Source: The Metropolitan Expressway (MEX), the Hanshin Expressway, the Nagoya Expressway, and the Fukuoka-Kitakyushu Expressway (Traffic accident data for the Metropolitan Expressway alone covered fiscal years 1999–2001, and for the other three expressways, 2000–2002.)
Analyzed Breakdown of accident causes in Japan

Drivers’ behaviors immediately before accidents account for 75% of causes

Source: Institute for Traffic Accident Research and Data Analysis, *Traffic Accident Statistics 2000*
Japanese ASV samples

Source: Web site of Nissan Motor Co., Ltd.


Source: Web site of Toyota Motor Corporation

Limitation of standalone on-board sensors

Difficultly of detecting forward obstacles using standalone vehicle methods on sharp curve sections

Detection difficult at curves with $R \leq 250$ m.

Road-vehicle coordination necessary
Concept of curve caution service by AHS

AHS = Advanced Cruise-Assist Highway System
Location of field operation test section

Tokyo Metropolitan Expressway Route No.4 Shinjuku Line
Information flow at the operation test field

A sensor detects traffic congestion, stopped/slow-moving vehicles

Toward Tokyo city center

Infrared sensor

VICS beacon

Inbound

Outbound

Toward Hachioji

A sensor detects traffic congestion, stopped/slow-moving vehicles

Conditions on curve ahead shown by simple diagram

Car navigation system display

Approximately 300 m
Information provision

Forward obstacle information displayed on 3-media VICS-enabled car navigation system

About 10% of vehicles through this section equipped with 3-Media VICS-enabled car navigation system.

3-media
• FM multiplex broadcasting
• Radio beacon
• Optical beacon
AHS image processing sensors

Processed image from AHS image processing sensors (infrared image processing sensors)
Objective data (1) - Accidents reduced

Accidents on the Route No. 4

All inbound lanes on Route No.4 (13.5km) - 14% increase

Similar sharp curves on inbound lanes of Route No.4 (4 locations) - 100% increase

Sangubashi curve (inbound) - 44% reduction

Note1. MEX data (main line). Figures for each year are for March 1 to April 27 at 21:00.
Note2. Accident data for similar sharp curves are aggregates of the numbers of accidents occurring on curved sections with a radius of curvature of 200 m or less.
Objective data (2) – Near miss situations reduced

Before and after service by sensor data

<table>
<thead>
<tr>
<th>Section</th>
<th>Under congestion or stationary or low-speed vehicles on the curve ahead</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vehicles approaching at &gt; 30 km/h</td>
</tr>
<tr>
<td></td>
<td>Effective sample (vehicles/28 days)</td>
</tr>
<tr>
<td><strong>Before service</strong></td>
<td></td>
</tr>
<tr>
<td>28 days from October to November 2003</td>
<td>10,344</td>
</tr>
<tr>
<td><strong>After VICS service</strong></td>
<td></td>
</tr>
<tr>
<td>28 days from March to April 2005</td>
<td>13,181</td>
</tr>
<tr>
<td><strong>Effect</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questionnaire survey results to test monitors (1)

Q. Was the information useful for your safer driving?

- Because I could prepare myself in advance: 102 persons
- Because I could slow down in advance: 66 persons
- No need because there was congestion before the curve so speeds were already low: 42 persons
- Other (most because the road was already congested): 10 persons
- No need because there was congestion before the curve so speeds were already low: 44 persons
- Other (most because the road was already congested): 17 persons

N=271
N=145
N=57
N=69
Q. How did you behave immediately after receiving information?

I judged that I could maintain my speed without any problem, but exercised caution

I tried to slow down, but it seemed that the cars behind would run into me, so I just proceeded with caution

I let up on the accelerator

I let up on the accelerator and put my foot on the brake pedal

I applied the brakes slowly

I applied the brakes suddenly

Others
Questionnaire survey results to test monitors (3)

Q. What was your impression when you received information?

- I dealt calmly with the information provided
- I felt an appropriate amount of tension due to the information provided
- I was slightly surprised by the information provision, but was not flustered
- I was surprised by the information provision, and felt flustered
- The information was provided too soon, so my attention dulled back down before I entered the curve
- The information was provided too late, so I felt rushed
Questionnaire survey results to test monitors (4)

Overall evaluation of the service throughout the period of the field tests (By test monitors based on their experience)

Q. Was the service effective?

- Effective: 61%
- Somewhat effective: 24%
- Not very effective: 5%
- Not effective: 1%
- Cannot say: 9%

Q. Do you desire the continuation of this service?

- Continue in the future: 63%
- Perhaps continue: 27%
- Perhaps do not continue: 5%
- Cannot say: 5%
Conclusion

1. AHS safety service concept for curve section with analysis of 3-months field operation tests

2. Generally favorable data acquired from traffic flow observation + questionnaire surveys

3. Room for further adjustments to cope with driver’s preference / machine performance

4. Second phase field operation tests ongoing for chronological study
Further deployment

1. Second phase field operation tests for …
   1. Chronological data collection
   2. Evaluation of service improvement
   3. Operability tests

2. Other applications for …
   1. 100 curve sections at urban expressways
   2. 2000 curve sections at general roads
   3. Intersections, Crests etc.