Progress of V-I Cooperative Safety Support System, DSSS, in Japan

DSSS: Driving Safety Support Systems using IR Beacon

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ABSTRACT

Although the traffic fatality rate is decreasing in Japan, the number of people injured remains at a high level. While vehicle stand alone driver support systems have been developed and actualized, there are collision types which are difficult to approach using vehicle technology alone. To help address this challenge, research in Japan is actively developing safety applications using Vehicle-Infrastructure communication technology. Those applications are collectively referred to as the DSSS (Driving Safety Support Systems). The last quarter of fiscal 2008 was a milestone for ITS, where large-scale verification tests were completed with the cooperation of the government and private sectors. Here, we will introduce the progress of a FOT (Field Operational Test) conducted in Japan by the DSSS analysis working groups (29 participating companies), and the current quantitative test results from a large number of test participants.

THE UTMS and THE DSSS

The UTMS (Universal Traffic Management Systems) is a National Police Agency system which aims for the actualization of a "safe, comfortable and environment-friendly traffic society" by using an advanced information communication technology such as interactive communication between traffic control systems and individual vehicles using an Infrared Light (IR) Beacon. These systems are being utilized by the UTMS Japan (Universal Traffic Management Society of Japan), which was established in 1996.

The DSSS is one of the UTMS activities and is now developing a Vehicle-Infrastructure cooperative safety support system. The vehicle On-Board Unit (OBU) receives outside information via IR Beacon. The OBU has data sorting logic and provides an alert to the driver if necessary. The OBU will not give alert to the driver if the vehicle speed is low, for example, in order to avoid annoying the driver. There are 5 DSSS working group locations in Japan such
as Kanagawa, Aichi, Tochigi, Hiroshima and Tokyo (historical order). The regions are shown in Figure 1. Participating organizations include 6 car manufactures and 23 electric/electronic companies. These regional DSSS working groups (excluding Tokyo DSSS) have been developing the safety support system and system components such as OBU logic, HMI (Human Machine Interface), vehicle detection sensors, RSU logic, and more through field operational tests in each region. The chronology is also shown in Figure 1. Gathering the results from each area, we have made common specifications. A joint test in Tokyo which applies these common specifications have been held from Jan 2009.

SYSTEM CONFIGURATION of DSSS

The IR beacon of a Road Side Unit (RSU) sends data (Down-Link data) to the vehicle that passes under the IR beacon. Down-Link data are as follows: Road shape, Traffic signal information such as current color, rotation schedule and location, Traffic sign information such as presence of a stop sign, information about obstacles such as other vehicles, motor cycles, bicycles and pedestrians which are detected by road side sensors, and other data. Figure 2 shows the IR beacon.

The on-board beacon antenna receives the information. The antenna is the current “3 media VICS Beacon Antenna“ which is sold in Japan widely for traffic information services. We are trying to use these existing RSU and OBU not only for traffic information but also for traffic safety.

DSSS SERVICE APPLICATIONS

Major service applications are shown in Figure 3. Each regional DSSS working group is led by one of the car manufacturers and is conducting several of these service application field operational tests.

VERIFICATION of EFFECTIVENESS

It is very difficult to grasp the effectiveness of such kind system quantitatively. The Kanagawa DSSS working group, the first regional DSSS and the test area with the largest number of participant vehicles, created a data log system for verification of effectiveness as shown in
Figure 4. Figure 5 describes the on-board unit configuration. In this case, the cooperative driving assistance functions can be added to a customer’s vehicle by re-programming the car navigation system. It takes only 15 minutes for re-programming. The car navigation system is connected to the vehicle CAN bus, allowing the on-board system to send vehicle real time running data shown in Figure 4.

(Up-Link) A road side data logger stores the up-linked data for points A and B.

We did not request the participants to travel through the test sites with any specific frequency. Participants use their car in their every day car life without being conscious of the test. We only monitored and logged the data for participants who passed through the test sites. The number of participants,
2,000, was decided on the premise that some participants would never come to the test sites (9 intersections in Yokohama city). For comparison, traffic flow and speed change data from vehicles without DSSS functionality are also measured.

Using the stored data, statistical analysis will show whether there is any difference between the data gathered from vehicles with or without safety support systems/information.

**TEST RESULTS**

We have collected over 20,000 data logs during the last 2.5 years. In an attempt to help avoid what might be the potential negative impacts of ITS (i.e. over-trust, misunderstanding, and system distrust), the driver support level was kept at a minimum. However, we are receiving good quantitative results that drivers positively change their driving behavior (drive more safely) as a result of the support information.

The 2.5 year long test will also enable us to understand how experience with the system will influence drivers and also how much over-trust or learned-adaptation will be seen when drivers who have once experienced the system do not receive information at the test site anymore.

Example results are shown in Figure 7.

1. **Stop sign recognition enhancement**
   - 41% of vehicles exceed the posted speed limit. The system can help reduce that rate to 23%, especially in higher speed vehicles. Vehicles with the system show a 35% increase in the complete stop rate at the stop line.

2. **Signal recognition enhancement**
   - 70% of vehicles exceed the posted speed limit. The system can help reduce that rate to 56%, especially in higher speed vehicles.

3. **Crossing collision prevention**
   - 38% of vehicles exceed the speed at which drivers can avoid a crash if a vehicle appears from the side road. The system can help reduce rate to 22%, especially in higher speed vehicles.

4. **Learning adaptation**
   - Intersection approach speed is decreasing as time passes. Since the intersection is not visible to the driver at the point this measurement is made, it is considered that the driver is learning potential dangers.

5. **Over-trust**
   - Crossing collision prevention does not provide an alert if there is no vehicle on the side road. An example of over-trust would be a driver who exhibits riskier driving behavior, in this case higher approach speed, during a no-alert approach because they interpret the lack of alert as an “all clear” signal.

Test participants at one of the crossing collision prevention locations did not receive an alert for approximately 60% of intersection approaches. However, the data show that rather than increasing speed when no alert is provided, approach speed decreased over time.
Table 1 shows the summary of the observations. We have confirmed many drivers with the DSSS exhibited different driving behavior than drivers without the system. The observed lower intersection approach speeds can be considered consistent with safer driving practice. During 2.5 years of monitoring test, no influence of drivers’ experience with the system is found. No influence of driver’s over-trust is found even if no information is provided at the test site.

Drivers who experienced this system slow down before an intersection. (Driver’s learning adaptation)
Additionally, results from a questionnaire survey show that a majority of consumers responded favorably to the system. 98% responded positively when asked their opinion about wide application of DSSS. (1,200 answered) (figure 8)

Regarding to joint test in Tokyo, we are collecting the same data as in the Kanagawa test and are now analyzing the test result.

<table>
<thead>
<tr>
<th>Service</th>
<th>General vehicles</th>
<th>Participants vehicles</th>
<th>Change</th>
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</thead>
<tbody>
<tr>
<td>Stop sign recognition enhancement</td>
<td>Rate of overspeeding vehicles</td>
<td>41% → 23%</td>
<td>18Point</td>
</tr>
<tr>
<td>Signal recognition enhancement</td>
<td>Rate of overspeeding vehicles</td>
<td>70% → 56%</td>
<td>14Point</td>
</tr>
<tr>
<td>Crossing collision prevention</td>
<td>Rate of crash unavoidable vehicles</td>
<td>38% → 22%</td>
<td>16Point</td>
</tr>
</tbody>
</table>

Table 1 Test Results (still in progress) Summary

SUMMARY

Here we have introduced the DSSS activities. We will continue to pursue the realization of the world’s safest road traffic society by further strengthening the cooperation system between the government and private sectors, while promoting efforts towards the success of the large-scale verification tests to realize practical use of the driving safety support systems.

REFERENCES

[1] Vehicle Infrastructure Integration (VII)
   National System Requirements
   Research and Innovative Technology Administration
   Feb 2008 Version 1.3

[2] PReVENT
   IP_D15 Final Report Amendements
   6 May 2008