VERIFICATION TESTS FOR PRACTICAL USE OF INFORMATION PROVISION SYSTEM TO ENSURE SAFE DRIVING
(DSSS: DRIVING SAFETY SUPPORT SYSTEMS)

Koji Kitta[1], Nobuhiro Hamba[2], Katsuji Muro[3], Masatada Seto [4]
*1, 2, 4. Universal Traffic Management Society of Japan (UTMS Japan)

*3. Traffic Control division, Traffic department, Aichi Prefectural Police Headquarters

*1,2. Panasonic System Solutions Company, Matsushita Electric Industrial Co., Ltd.

ABSTRACT

The Universal Traffic Management Society of Japan (UTMS JAPAN) has been conducting research and development for the practical use of information provision systems to lead drivers to safe driving, which enable drivers to deal with possible danger with ease by notifying them of possible accidents in advance. This paper describes beacon-based information provision systems to detect risk factors to notify drivers of them beforehand, as well as verification experiments of the systems.

INTRODUCTION

Aiming at reducing traffic accidents, the UTMS JAPAN has been conducting research and development of Driving Safety Support Systems (DSSS) employing the ITS technologies since 1997. Many of the systems researched were “warning systems,” which employ roadside sensors to notify drivers of imminent danger in order to encourage them to take steps to avoid possible accidents. In spite of the good results of verification tests carried out in both 1999 and 2000 and showing the effectiveness of the systems, it seemed to be difficult to diffuse the use of the systems in the near future due to some unsolved and difficult issues including reliability, cost and legal issues (e.g. [1], [2]).

Hence, to bypass such issues while aiming at the widespread use of this kind of system instead of the warning systems, the UTMS JAPAN proposed another system: “information provision systems,” which leads drivers to safe driving, in other words gives an advance notice of possible risk to allow them to deal with the risk with ease. We have learned that there was great expectation of the system as well as a great demand for information service with voice messages, based on the results of verification tests conducted in the year 2002 and 2004. Also, drivers were in need of timely information services at prompt locations. Besides, in terms of functionality, we confirmed the systems to be constructed by making good use of the existing systems without causing bad influence on them (e.g. [3], [4]).

PROPOSAL OF SYSTEMS

In spite of a variety of information we had offered depending on time of day or traffic congestion conditions during the second verification test in 2004, they strongly requested dynamic information service detecting risk factors to change information content depending on the factors. Therefore, we proposed a system, which detects the risk factors to provide drivers with messages beforehand to attract their attention to possible risks/accidents at accident-prone intersections, of which risk factors are already specified. Drivers would be able to pay attention to the risk factors informed and keep careful driving in their mind, which is expected to prevent traffic accidents.

Figure 1 shows the system concept. Basically, the system is composed of sensor(s) to detect risk factors, a DSSS controller to switch information service content based on data from the sensor(s), and roadside infrared beacon(s) (IR beacon) to transmit the information toward in-vehicle units.
The UTMS JAPAN drew up system models based on a traffic accident analysis carried out at the phase of basic research and study. And we conducted verification tests to evaluate the system models, two of which are described in the following sections.

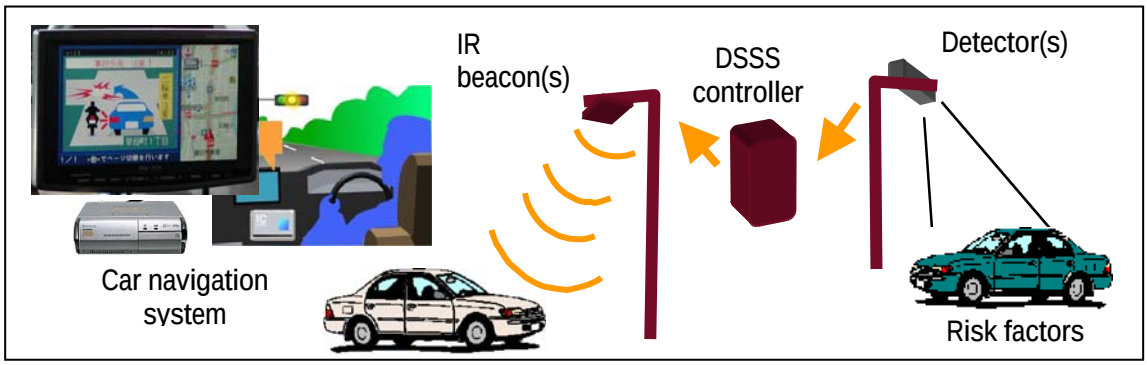

Figure 1 - Concept of the system

SYSTEMS FOR VERIFICATION TESTS

Rear-end collision of right-turning car avoidance information provision system

This system is designed to avoid collision with a right-turning vehicle at intersections without exclusive right-turn lanes. When the vehicle detector detects a right-turning vehicle standing in the intersection, the detected data is to be transmitted to the beacons together with traffic light data. The beacons then give a message saying “beware not to rear-end right-turning car ahead!” to follow-on vehicles, which allows them to have enough time to step on the brake instead of sudden stop, or to shift lanes to avoid the right-turning vehicle.

Configuration of the system

Figure 2 illustrates the configuration of the Rear-End Collision of Right-turning car

Avoidance information provision System (RECRAS) for the verification tests. The location of the infrared beacon was determined on condition that vehicles informed of a right-turning vehicle were able to safely stop at or before the stop line in front of the intersection, to shift lanes to avoid it with safety. Also, assuming that the vehicles provided with the information were traveling at the legal speed, we considered deceleration, idle running time and avoidance action time to determine the location.

An imaging vehicle detector was employed to detect right-turning vehicles. We carried out a spot investigation to check actual positions that right-turning vehicles tend to stand in order to determine a detection area.

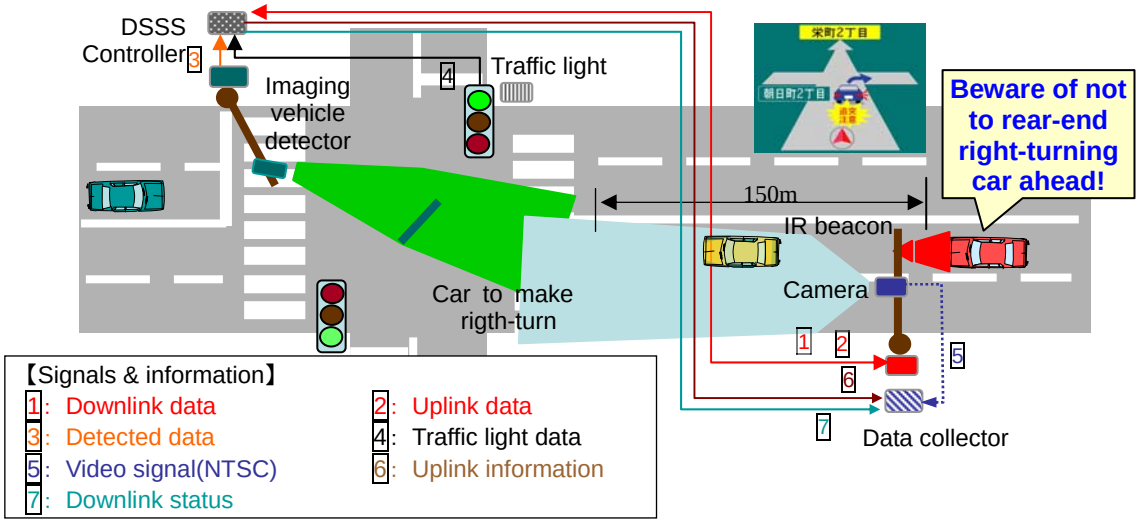

Figure 2 – Configuration of RECRAS

Operation outline and judging conditions of the system

Figure 3 shows the operation outline and judging conditions of the RECRAS.

a. An imaging vehicle detector detects vehicle(s) in an intersection waiting for good timing to make a right-turn then output a detected data to a DSSS controller, which determines the message to be provided. Note that the detected data is to be output even for minutes as far as a right-turning vehicle is standing in the intersection.

b. The state of "green signal" of a traffic light ahead is to be input to the DSSS controller. When a right-turning vehicle is being detected and the state of the traffic light ahead is "green," the DSSS controller sends information about the right-turning vehicle (to which drivers' attention should be paid) to an infrared beacon before the intersection.

c. When the right-turning vehicle is no longer detected or the state of the traffic light ahead is not "green," the unit is to offer destination guide information to the infrared beacon before the intersection

It should be noted that we set the detector to judge "there was a right-turning vehicle" when a vehicle was detected for three seconds or longer within the detection area while judging

"there was no right-turning vehicle" when the vehicle was no longer detected.

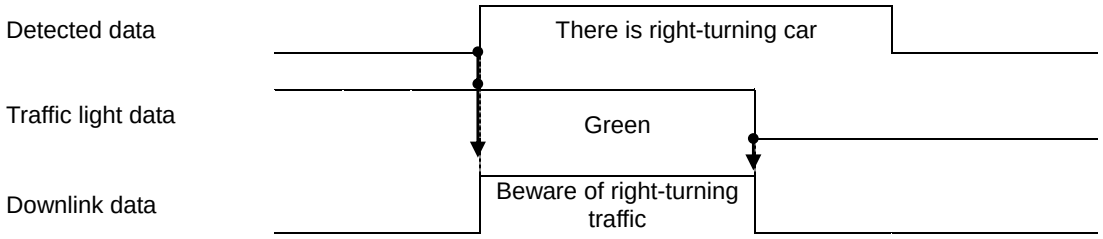

Figure 3 - Condition of RECRAS

Right-turn collision avoidance information provision system

This system avoids collisions with oncoming vehicles at intersections with exclusive right-turn lanes. It is required to install vehicle detectors along the opposite lanes and infrared beacons transmitting information before the intersections. When the detectors detect oncoming vehicles, the beacons installed nearby the stop line of the intersection provide a message of "beware of oncoming vehicle" to right-turning vehicles. The detectors measure the speeds of the oncoming vehicles, so as to compute good timing to begin and end information provision. Only voice message is available to allow drivers to avoid driver's distraction as the system provides the information just before the intersection.

Configuration of the system

Figure 4 illustrates the configuration of the Right-Turn Collision Avoidance information provision System (RTCAS) for the verification tests. The system units were arranged based on conditions described in the following sentence.

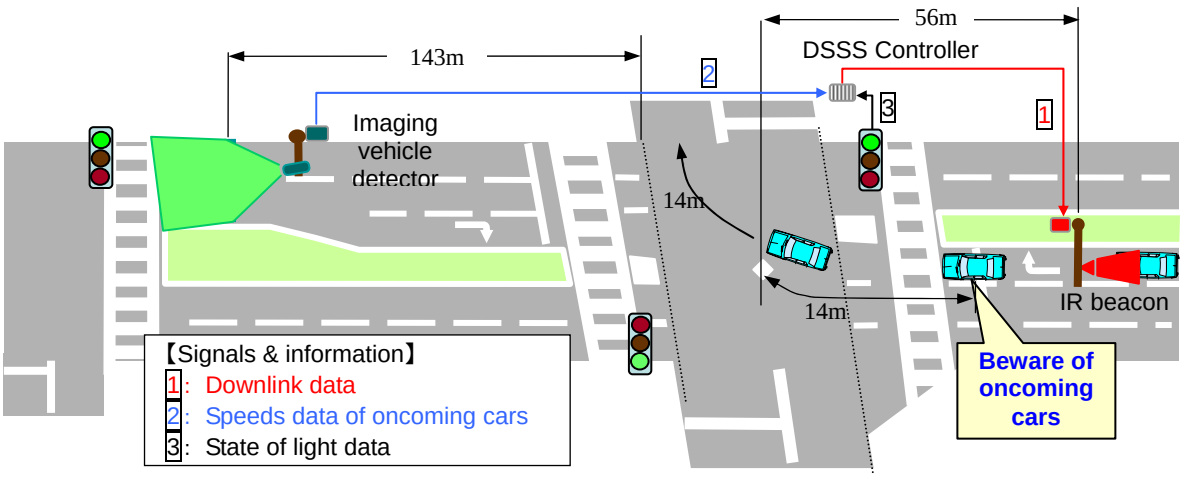

Figure 4 – Configuration of RTCAS

As or the location to install the infrared beacon Assuming that right-turning vehicles would decelerate to approach an intersection as they may stop near the center of the intersection to wait for timing to make a right-turn, information for the right-turning vehicles is to be provided to allow the drivers to listen to a full sentence of a message before they pass through a stop line.

The location to install the vehicle detector to detect oncoming vehicles was determined based on a computation applying time taken from when a right-turning vehicle received information via the beacon to when it completes a right-turn as well as distance that an oncoming vehicle would travel within the time.

Operation outline and judging conditions of the system

Figure 5 shows the outline and judging conditions of the RTCAS.

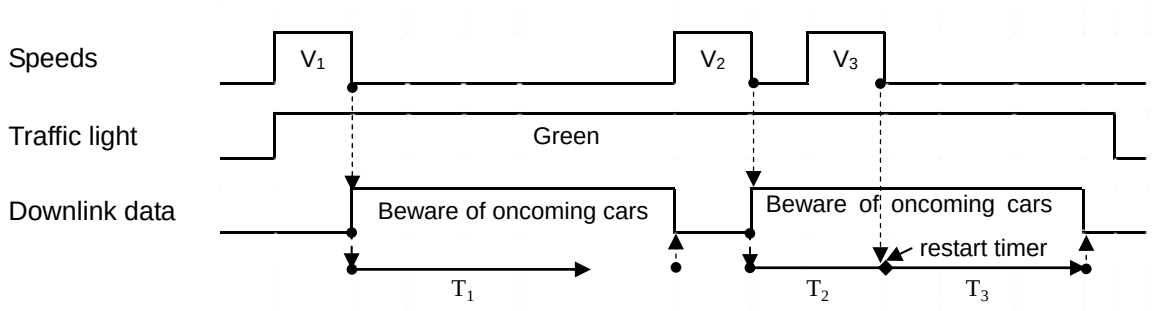

Figure 5 - Conditions of RTCAS

a. An imaging vehicle detector measures the traveling speeds of oncoming vehicles, which is output to a DSSS controller for information provision.

b. The DSSS controller for information provision, having being input the state “green” of traffic light ahead, is ready for transmitting a message of “beware of oncoming cars” toward an infrared beacon as soon as it receives the speed data when green signal is indicated on the traffic light ahead.

c. After transmitting the message of “beware of oncoming cars,” the unit keeps time to ensure that the message is indicated for specific duration. And then, it sends a request for stop transmission of the message toward the beacon when the preset duration was over or the state of the traffic light ahead was no longer “green.” Note that the DSSS controller will request that the message is to be indicated for the duration of another oncoming vehicle, followed by restarted timekeeping when it received the speed data of another vehicle before the preset duration of the first vehicle is over.

Message calling for driver’s attention

Graphic and text messages, which were registered with DSSS controller, were transmitted to

in-vehicle units, which were commercial car navigation systems with VICS (e.g. [5]) function we modified to provide voice messages, via the infrared beacons. We utilized text-to-speech reading function built in the car navigation system to convert text message into voice message. Examples of the rear-end collision of right-turning car avoidance information provision system are shown in the table below.

Event	Categories	Graphic message	Text/voice message
Right-turning car is detected & green signal	Beware of right-turning traffic		Beware not to rear-end right-turning car ahead!
Other than those above	Destination guide		-

VERIFICATION TEST

The UTMS JAPAN conducted the verification test of RECRAS and RTCAS in Toyota City, Aichi Prefecture, in February 2006. We evaluated the systems focusing on appropriateness of content and timing of information provided in addition to the effectiveness of the systems during the verification tests.

IMPLEMENTATION DATA

Functional evaluation based on monitor vehicles

Test period: From Monday, February 20, 2006 to Wednesday, February 22, 2006
Target systems: RECRAS, RTCAS
Evaluation method: Monitor vehicles traveled several times to check the functioning and impacts of the systems.
Evaluation items: Comparison between the content of information provided and actual situations (matched/unmatched), timing of information provision (too early/good/too late) and actions to decelerate/avoid collision (confirmed/unconfirmed).

Questionnaire survey to monitors driving rented cars with commercial car navigation systems with VICS function

Test period: From Thursday, February 23, 2006 to Thursday, April 20, 2006
Survey method: Monitors (28 people) drove their private/rented cars equipped with car navigation systems with VICS function to experience the system **(information provision without voice messages)**, and then filled in questionnaires.
Target systems: RECRAS

Evaluation items: Understandability of message, timing of information provision, system impacts, expectation for the systems and desirable way to provide information

RESULT OF VERIFICATION TESTS

The evaluation of functions and effectiveness

Result of the evaluation of RECRAS

- Among 21 test drives, the content of information provided and actual situations matched in 15 cases and unmatched in 6 cases. In 4 cases of all the unmatched cases, monitors who received information on a right-turning vehicle found no right-turning vehicle standing at a test site intersection when they arrived there as the vehicle, which was the trigger of the information provision of "beware of right-turning vehicle," did turned to the right just after they received the information. Also, there was 1 case that the monitors found no right-turning vehicle in spite of the information provision, but as a vehicle traveling ahead of them have turned out to make a right-turn after they had passed by an infrared beacon this time.

- There were 10 cases that the monitors received the message of "beware of right-turning vehicle" and then actually found right-turning vehicle(s) ahead, in 9 cases of which the system was successful in providing timely information. Also, in 6 cases, the monitors decelerated or shifted lanes to avoid collision after they were provided with the information.

Result of the evaluation of RTCAS

- Among 18 test drives, the content of information provided and actual situations matched in 16 cases and unmatched in 2 cases.

- The monitors who received the message of "beware of oncoming vehicle" actually found vehicle(s) stuck in the intersection to make a right-turn in 13 cases, while they found no such a vehicle in 3 cases allowing them to arrive in the intersection at the head.

- The monitors were provided with timely information in any of the 3 cases that they reached there at the head.

Result of questionnaires survey

- Seven out of 28 drivers were provided with the message of "beware of collision," four (i.e. 57 percent) of which answered that they decelerated or took actions for collision avoidance because of the message.

- Of all the drivers provided with the message, 4 people found the system to be effective, yet 2 drivers answered that they were disturbed by the system.

- Seven out of 28 people answered that information provision via the display screen of a car navigation system might cause dangerous situations even if it was for attracting drivers' attention to careful driving. Four out of these 7 people said that the system needed to draw their attention by providing voice messages.

CONCLUSION

The information provision systems, which detect risk factors and provide drivers with information on it in advance, have been in practical use in some areas already. Besides, the accelerated deployment of the systems is expected as the verification tests of the new systems we conducted this time confirmed the effectiveness of and great expectation for them. At the same time, we learned that the information provision with just graphics not merely would deteriorate the system impact but may impose additional stress on drivers adversely.

We would be working on the further development of the new systems for practical use while enhancing in-vehicle units as well as promoting the research and development of information provision systems at more proper timing and locations from now on.

ACKNOWLEDGEMENT

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REFERENCES

[1] Shinichi Yamaoka, Toshihiko Ohta, Teruyuki Tajima, "Research & Development of Driving Safety Support Systems", eSAFETY Congress, September 2002

[2] Toshio Minakata, Atsushi Maeoka, Teruyuki Tajima, "Experiments for Practical Use on Driving Safety Support System of UTMS JAPAN", 8th World Congress on Intelligent Transport Systems, Sydney, October 2001

[3] Nobuhiro Hamba, Kazuhisa Kurata, Teruyuki Tajima, "Evaluations of Driving Safety Support System for Accident-prone Intersections", 10th World Congress on Intelligent Transport Systems, Madrid, November 2003

[4] Nobuhiro Hamba, Koji Kitta, Kazuhisa Kurata, Teruyuki Tajima, "Second field test of The DSSS for Accident-prone Intersections", 11th World Congress on Intelligent Transport Systems, Nagoya, November 2004

[5] "Vehicle Information and Communication System Center", http://www.vics.or.jp/english/