Next-generation ITS to Support Information Communication

— The development of vehicle-to-vehicle and vehicle-to-infrastructure communication technology needed by automated driving systems —

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1. Introduction

In 2013, the Japanese cabinet issued a declaration of Japan's intent to become the world's most advanced IT nation, stating that it would enable vehicle-to-vehicle, vehicle-to-infrastructure, vehicle-to-pedestrian and other modes of information exchange to be performed in a timely manner. It also stated its intention to implement an economical road traffic society that is both safe and environmentally friendly by using ITS (Intelligent Transport Systems) to avert traffic accidents and avoid road congestion, including the use of stored information and geospatial information such as map data and the locations of people and vehicles.

Wireless communication technology is an effective way of implementing a safe driving support communication system that reduces traffic accidents. It was realized that the reservation of a fixed frequency band in the region around 700 MHz vacated by the switch-over to terrestrial digital TV broadcasting would be suitable for this purpose because this frequency band exhibits favorable radio wave characteristics including diffractive and reliable information transmission, so the 760 MHz band was allocated for this purpose.

This paper introduces our verification trials of the vehicle-to-vehicle and vehicle-to-infrastructure communication technologies in the communication systems using the 760 MHz band according to the first edition of the ARIB STD-T109 standard published in February 2012.

2. Using ICT to establish the next generation of ITS

For the implementation and popularization of vehicle-to-vehicle and vehicle-to-infrastructure communication technology, the following issues should be addressed:

When the number of vehicles fitted with radio equipment is increasing, checks must be performed in real environments to verify that the communication performance is adequate for running applications. (Implemented as communication performance demonstration experiment)

During the period of increasing use, it will be necessary to ensure that sufficient capacity for radio communication by large numbers of vehicles is made available in the real world. We therefore made a plan to obtain diverse views and know-how for solving the problem through verification trials on public roads using large numbers of vehicles. The physical limitations are studied in conjunction with the simulations, and their differences are also considered. The experiments were performed in Nagoya and Yokosuka in consideration of the diversity of traffic environments in these two cities [1].

2.1 Communication performance verification trials

In these trials, dynamic evaluations of communication reliability were performed in Nagoya, and static evaluations were performed in Yokosuka. In Nagoya city, we used one set of roadside unit and 99 vehicles to perform tests ("dynamic evaluations") of vehicle communication performance while driving randomly under traffic conditions in the metropolitan area. In Yokosuka, we performed tests ("static evaluations") using one set of roadside unit and 79 sets of stationary vehicle-mounted radio equipment. These tests were performed in February 2015. Table 1 shows the scale of the Nagoya tests, and Table 2 shows the scale of the Yokosuka tests. Also, Figure 1 shows the test locations in Nagoya, and Figure 2 shows the test locations in Yokosuka. In these figures, Ⓐ, Ⓑ, and Ⓒ indicate the routes travelled by the measurement vehicle.

Table 1: Scale of Nagoya experiment

Scale of experiment	Vehicles	Radio transmitters	
Fake emergency vehicle	1	1	Instructable
Instructable vehicles	15	15	
Measurement lease vehicles	2	2	
Subtotal	18	18	
Ambulance	32	32	Not instructable
Ordinary vehicles, commercial vehicles	34	34	
Random driving vehicle	15	75	
Subtotal	81	141	
Total	99	159	

Figure 1: Location of Nagoya experiment

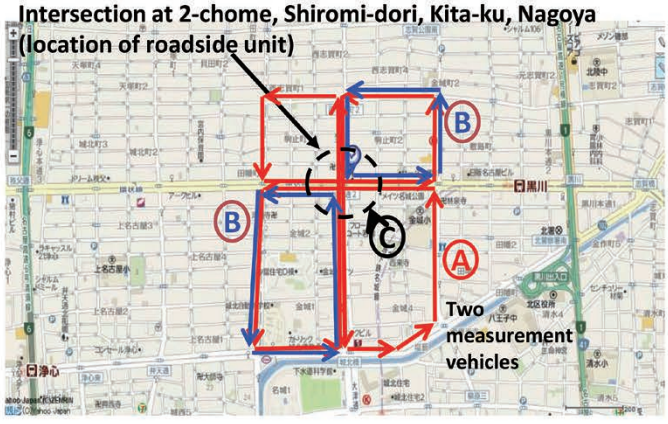
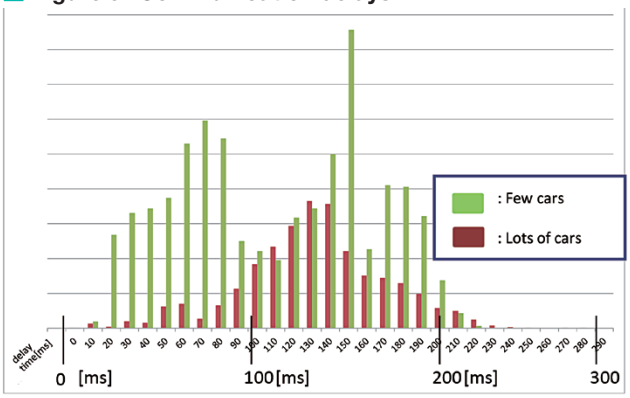


Table 2: Scale of Yokosuka experiment

	Vehicles	Radio transmitters
Ambulance (or deputized vehicle)	2	2
Measurement vehicle	2	2
Heavy load prevention vehicle	15	75
Total	19	79

Roadside unit	No. of sets
No. of roadside unit	1
Total	1

Figure 3: Communication delays



2.2 Results of checking the communication performance

The test results are considered by comprehensively judging the dynamic tests conducted in Nagoya and the static tests conducted in Yokosuka. Specifically, we evaluated the delays in communication and the packet arrival ratio as the number of vehicles was increased.

The communication delays are shown in Figure 3. Despite the increasing number of devices, the majority of them were still able to communicate within 0.3 seconds. We also achieved cumulated packet arrival rates within the assumed ranges for vehicle-to-infrastructure communication up to approximately 500 m, and for vehicle-to-vehicle communication up to approximately 250 m.

3. Future work

In the future, we will continue to study the communication techniques used in cooperative automated driving systems.

4. Conclusion

This technology is the result of research and development commissioned under the Ministry of Internal Affairs and Communications program to establish next-generation ITS using ICT, which is part of the research and development relating to SIP (the cross-ministerial Strategic Innovation Promotion program) and automated driving systems.

REFERENCES
[1] Denso Corporation, et al.: "Development of vehicle-to-vehicle and vehicle-to-infrastructure communication technologies for automated driving systems," Lecture & Exhibition: ICT for the Next Generation ITS, http://mic-its-conference-2015.net/en.html, March 2015

Figure 2: Location of Yokosuka experiment

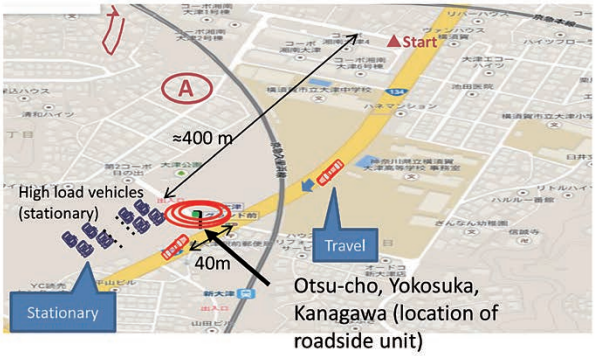
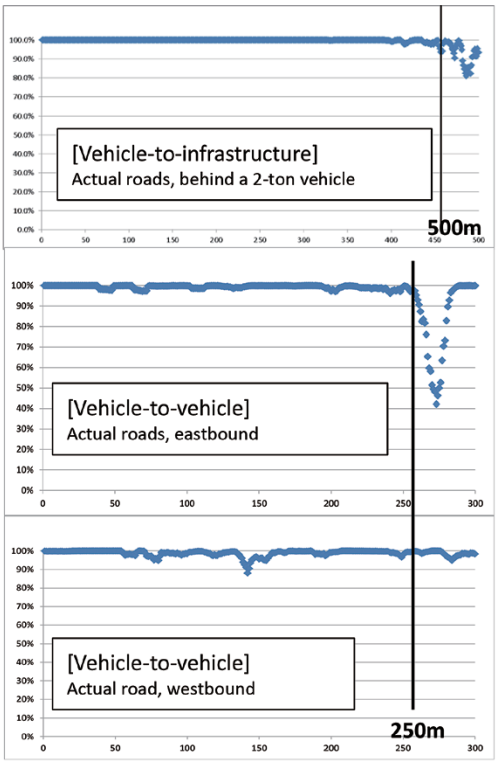


Figure 4: Cumulative packet arrival rates



Cover Art

Meisho Edo Hyakkei Ohashi atake no yudachi
(Sudden Shower over Shin-Ohashi bridge and Atake, from the series One Hundred Famous Views of Edo)

Utagawa Hiroshige (1797-1858)

Woodblock print:
Courtesy of Sakai Kokodo Gallery