A Survey of Communication Technologies for Next-Generation ITS

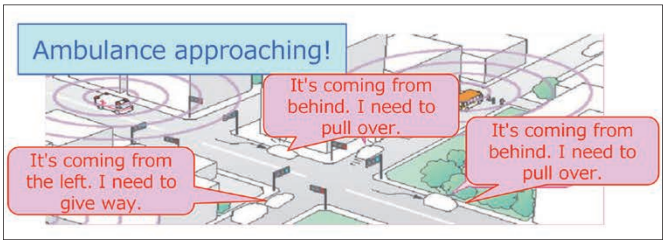
Masayoshi Okano
Project General Manager
Partner Strategy Group
Information Technology Business Department
Toyota Tsusho Corporation

1. Introduction

The use of advanced ITS technology is expected to help Japan realize its aim of achieving the world's highest level of road safety. Now that Japan has switched over to terrestrial digital television, the 700 MHz band (755.5–764.5 MHz) is available for use by ITS technology. In this study, with the aim of hastening the commercialization of safe driving support systems using the 700 MHz band for purposes such as vehicle-to-vehicle communication, we identified and examined the issues that need to be studied in order to build roads and test courses that model actual working conditions based on comprehensive verification.

Furthermore, with the aim of developing a practical pedestrian communication system, we identified the requirements of pedestrian terminals, and considered ways in which they might be introduced.

Figure 1: Conceptual illustration of a safe driving system



2. About the study process

As for the investigation and verification of technical aspects, based on the results of various studies performed prior to this survey, we identified services that are expected to be implemented at an early stage, studied the security functions and message sets for these services, and compared them with foreign specifications to check their validity. After performing interconnection tests in a laboratory environment, we performed verification trials using real vehicles both on test courses and on public roads, and were able to confirm the feasibility of achieving the vehicle-to-vehicle communication needed to provide safe driving support.

The commercialization of services depends not only on the establishment of technical aspects, but also on the study and verification of operational management aspects. With regard to the latter, we performed a study of operational management methods including the registration, issue and storage of security keys, and an investigation of operational management methods for performing interconnection tests in practical applications, and we confirmed that the equipment functioned correctly.

3. Results of the study

(a) Extraction of services

To identify safe driving support services that are expected to be implemented at an early stage, we evaluated the achievements and issues of the ASV (Advanced Safety Vehicle) project (run by the Ministry of Land, Infrastructure, Transport and Tourism in partnership with various vehicle manufacturers), and services that have been studied by various organizations including the ITS Info-Communication Forum, ITS Japan, and ITS World Congress Tokyo. As a result, we extracted nine services requiring prompt attention: (1) crossing collision prevention, (2) right turn collision prevention, (3) left turn collision prevention, (4) provision of emergency vehicle information, (5) recognition of vehicle surroundings, (6) provision of quasi-public vehicle information, (7) using road management vehicles to report when roadworks are in progress, (8) using road management vehicles to provide information about congestion and dangerous locations, and (9) providing information about trams. Of these, items (1) through (4) are expected to be implemented in practice at an early stage. Compared with the services that are being studied in other countries, we confirmed that the directions of these services are broadly in agreement, although studies are being performed according to the traffic conditions in each country.

(b) Study of message sets

By studying whether or not the requirements of the services extracted in A are satisfied by the experimental inter-vehicle communication message guidelines drawn up by the ITS Info-Communication Forum (ITS FORUM RC-013), we confirmed that these guidelines are perfectly appropriate for the provision of message-based services. We also found that there were not major departures from foreign specifications, and that any differences that did exist could be made accommodated by minor modifications, thus confirming the suitability of the message set.

(c) Study of security features

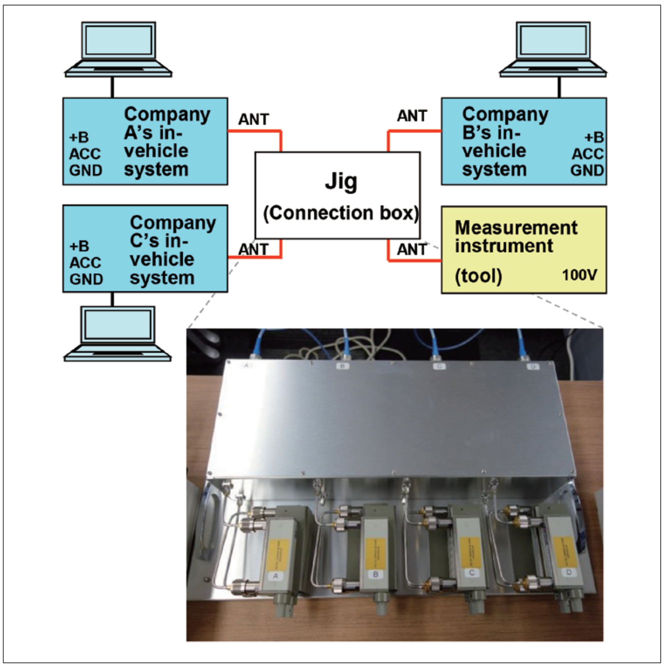
We investigated the five vehicle-mounted functions that perform secure communication — secure information storage, basic communication, authenticity checking, integrity checking, and confidentiality management — and obtained the expected results. Furthermore, in a simulated environment with many vehicles, we confirmed that it was possible for vehicles to transmit signals without difficulty while performing reception processing.

We also studied operation and management methods for the construction of a prototype system needed for managing the issue and registration of security keys. We tested this system under conditions close to actual operational workflow, and confirmed that the security requirements were all satisfied.

(d) Ensuring interoperability

To perform interoperability tests that will be needed for actual operations, we prepared documents such as “Interoperability confirmation testing” and “Operational management regulations”, and we also created test jigs and measurement tools. We performed interoperability tests on prototype equipment from several companies based on the test procedure documents, and confirmed that it was possible to transmit vehicle information correctly between vehicle-mounted equipment that had been adapted for testing. After trying out the series of procedures for interoperability test applications, the scheduling and execution of tests, and the approval of equipment types based on the operational management regulations, we confirmed that it was possible to implement the expected tests and to take the steps necessary for the approval of equipment types.

Figure 2: Equipment configuration of interoperability tests



4. Comprehensive verification

Following the above studies and verifications, we used vehicles fitted with on-board equipment to perform comprehensive verifications on a test course simulating actual road conditions (simulated city roads at the Japan Automobile Research Institute), and on public roads (near the Yokosuka Research Park). As a result, we confirmed that vehicles were able to send messages to each other with the correct security functions in place. In the trials performed on the test course, we were able to recognize the security information of emergency vehicles for the provision of emergency vehicle information, which is one of the services that is expected to be put into practice early on, and we were also able to recognize fake emergency vehicles (i.e., ordinary vehicles that are pretending to be emergency vehicles by sending false messages.

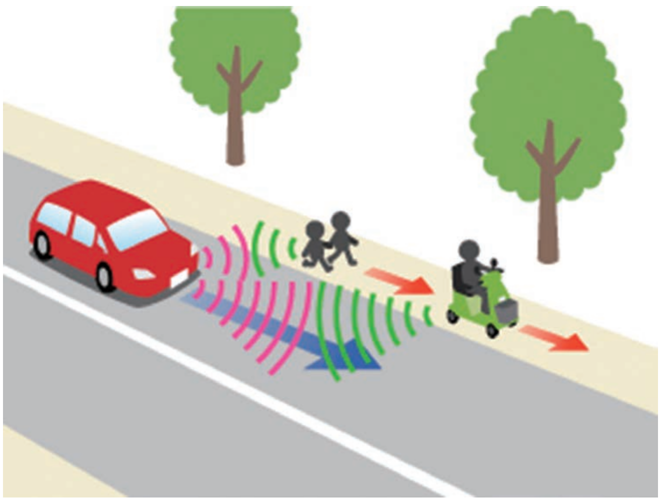
The on-board equipment verified in the comprehensive verification was used in the large-scale verification tests of the SIP (Strategic Innovation Promotion) program.

Figure 3: Comprehensive verification (test course) setup

5. Vehicle-to-pedestrian communication

Besides vehicle-to-vehicle communication, we also expect that vehicle-to-pedestrian communication systems will be introduced at an early stage to prevent pedestrian accidents (Figure 4). In this study, we examined terminals that are carried by pedestrians to communicate with vehicles. Through the selection of key targets by an accident analysis survey, a questionnaire survey of consumers, and an interview survey of manufacturers in various industries, we studied the functional requirements of pedestrian terminals and the acceptability of service pricing and the like. We also considered combinations of pedestrian terminals and existing products/services that are liable to be widely used.

Figure 4: Conceptual illustration of vehicle-to-pedestrian communication system



6. Conclusion

As described above, in this study we examined communication technologies that are fundamental to the practical implementation of next-generation ITS. In the future, it will be necessary to tackle the remaining issues with a view to facilitating the spread of this technology.