

# Expansion of ITS Services Utilizing On-board ETC equipment

Yoshihito Oomori  
Yuzuru Yamazaki

Motoatsu Yoshikawa

The Electronic Toll Collection (ETC) system enters its fourth year since its start of full operation that followed a trial operation period of one year. Initially, the toll booths dedicated to ETC ("ETC lanes") were limited to the toll booths at only 73 locations along the expressways of the Chiba district, Okinawa district and the Metropolitan district in Tokyo. The installation of the ETC lanes has now been completed at almost all toll booths of expressways throughout the country. The number of on-board ETC equipment setup in vehicles surpassed 2.1 million by the end of 2003, due to the user incentives provided by various toll discounts for ETC users, as well as the effects of a subsidy program for the purchase of on-board ETC equipment. According to the Japan Highway Public Corporation, the number of ETC system mounted vehicles on expressways for from the end of last year to the beginning of this year, was 400,000 per day, which is a rate that is four times more than the same period of the previous year. On some days and at some tollbooths, the situation was such that one out of five vehicles, passing through the tollbooths, were ETC system mounted vehicles.

In this paper, we shall describe possible new services for the ITS for vehicles equipped with on-board ETC equipment, which is quickly becoming more and more prevalent.

## Environment Surrounding the ETC System

The ETC is a system that becomes functional through wireless communications between the infrastructure of toll booths and on-board ETC equipment, using a communications method known as the Dedicated Short Range Communications (DSRC) system.

This is a communications specification that was initially established primarily for the purpose of collecting tolls at toll booths. The specification was later expanded so that it would be able to accommodate a diverse range of services that use the DSRC technology. A proposal for the standardization of the protocol specifications for credit card settlements has also been formulated, with possible applications to settlement services in the private sector. At the present time, the development phase has moved on to the development of on-board DSRC equipment and roadside DSRC equipment for the expansion of services to the private sector, including settlement systems.

The establishment of a technical foundation for the next generation DSRC standard for consumer products is well on the way, with specific steps taken since the beginning of 2003, such as various function evaluations and validation tests.

An overview of the actual market, on the other hand, indicates that a spread of the system is definitely occurring, as shown in Figure 1 by the number of on-

board ETC equipment set up<sup>1)</sup>. The number of vehicles having ETC equipment mounted peaked during the months of June and July of 2003, due to the subsidy program for the purchase of on-board ETC equipment, introduced by the Ministry of Land, Infrastructure and Transport. The number of units in application increases month after month, with the recent number of vehicles installing ETC equipment increasing at a rate of 150,000 to 200,000 per month. Further, although in the past the spread of the system was mainly limited to around the three major cities of Japan, recent trends indicate that an increase in other areas has been occurring, resulting in a nation-wide spread of the system.

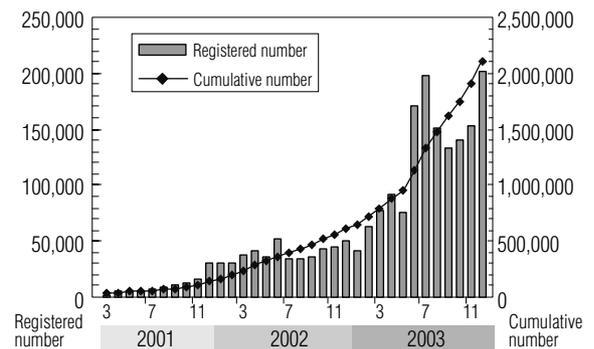


Fig. 1 Number of vehicles with on-board ETC equipment installed

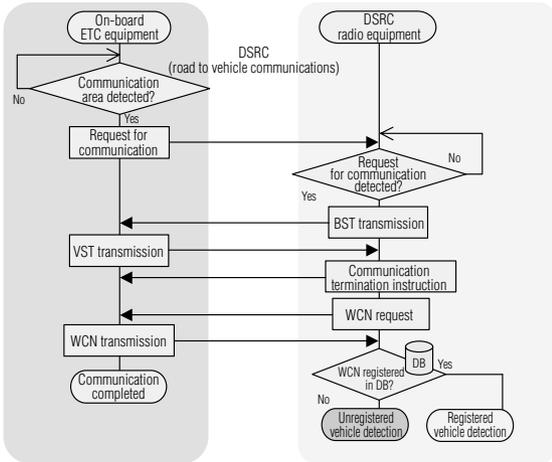
In this paper we introduce ITS services for the already popular on-board ETC equipment, aside from the on-board DSRC equipment, for which there is a lot of anticipation for development in the near future.

## DSRC Technology Elements Make New Services Possible for On-board ETC equipment

An ETC system conducts wireless communications between the roadside radio equipment of toll booths and on-board equipment, using the DSRC system. A "security module" exists in an ETC system, which secures a high degree of security for settlement system processes. This security module is linked closely with communication functions, making the system unusable for purposes other than those intended<sup>2)3)</sup>. In other words, on-board ETC equipment that has been designed for the ETC application can provide essentially no operations other than ETC operations.

However, because the on-board ETC equipment is also radio equipment, it is applicable under the codes of the Japanese Radio Act. As such it has a function that responds with its identification, known as a Wireless Call Number (hereinafter referred to as "WCN"), when an inquiry is received from a radio administrator. Unlike the unique identification of the on-board equipment used for ETC communications, a call for the WCN can be made

through communication methods other than those for the ETC. Now that the Ministry of Public Management, Home Affairs, Posts and Telecommunications (the government agency for the administrative supervision of radio communications), has granted permission for the use of this function, there is a lot of activity in the industry<sup>4)</sup> to realize new applications with the use of this function.



**Fig. 2 WCN reading sequence**

The WCN reading sequence is shown in Figure 2. The DSRC radio equipment, loaded with the new application, is used to establish communications by following a communication connection procedure similar to that of the ETC and then a request for the transmission of the WCN of the vehicle is made. This scheme enables it to identify the particular on-board ETC equipment, which in turn makes it possible to realize various services, explained later in this paper.

**New Services for On-board ETC equipment**

Various new services, intended for use with existing on-board ETC equipment, are introduced below. These all identify the on-board ETC equipment and the provision of services by verifying information against a database stored in the DSRC radio equipment or a center's equipment.

**(1) Parking system for contracted vehicles**

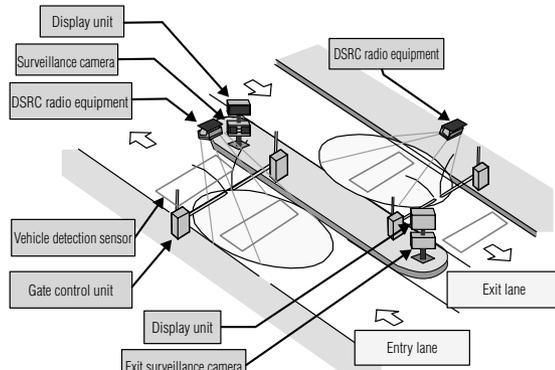
This system is suitable for parking with pre-designated users, such as monthly leased parking and parking for the employees of plants and business establishments. Since the WCN is usually not disclosed to users, they must bring in the vehicle equipped with on-board ETC equipment to register for an entry permit. The WCN obtained through communications is used for the registration.

An image of the parking system for contracted vehicles is shown in Figure 3. This is a service wherein a contracted vehicle engages in DSRC communications at the gate, transmits its WCN and the DSRC radio equipment, which receives the WCN, initiates a search for the WCN in the database. Once the WCN matches that of a registered vehicle in the database, the gate will be opened.

A photograph of an underground parking system, realized through cooperative efforts with Oki Electric, is shown in Photo 1. A combination with an ordinary ticketing machine is a key feature of the system since this parking facility is also available to the general public as well. We shall continue to promote our development effort, based on a barrier-free concept included, on providing services for the handicapped contractors. Such services include

ticketing machines which permit entry into parking lot without feeding a ticket.

The DSRC radio equipment used for the system is shown in Photo 2.



**Fig. 3 Image of a parking system for contracted vehicles**



**Phot. 1 Entrance of a parking system for contracted vehicles**



**Phot. 2 Photograph of DSRC radio equipment**

**(2) Visitor management system**

This system is intended for improving the service to customers at public relations organizations of department and suburban stores, whenever customers arrive in vehicles.

An operation image of the visitor management system is shown in Figure 4. The DSRC radio equipment, installed at the entrance of the parking lot, communicates with the on-board ETC equipment that is mounted in the customer's vehicle. The WCN is received by the DSRC radio equipment and promptly verifies it with the customer database. Once a match is found, the relevant personnel will be notified of the incoming customer's visit. This service makes it possible for stores to attend to their customers, as the persons in charge will be furnished with all the relevant data, the moment the customer enters the store.

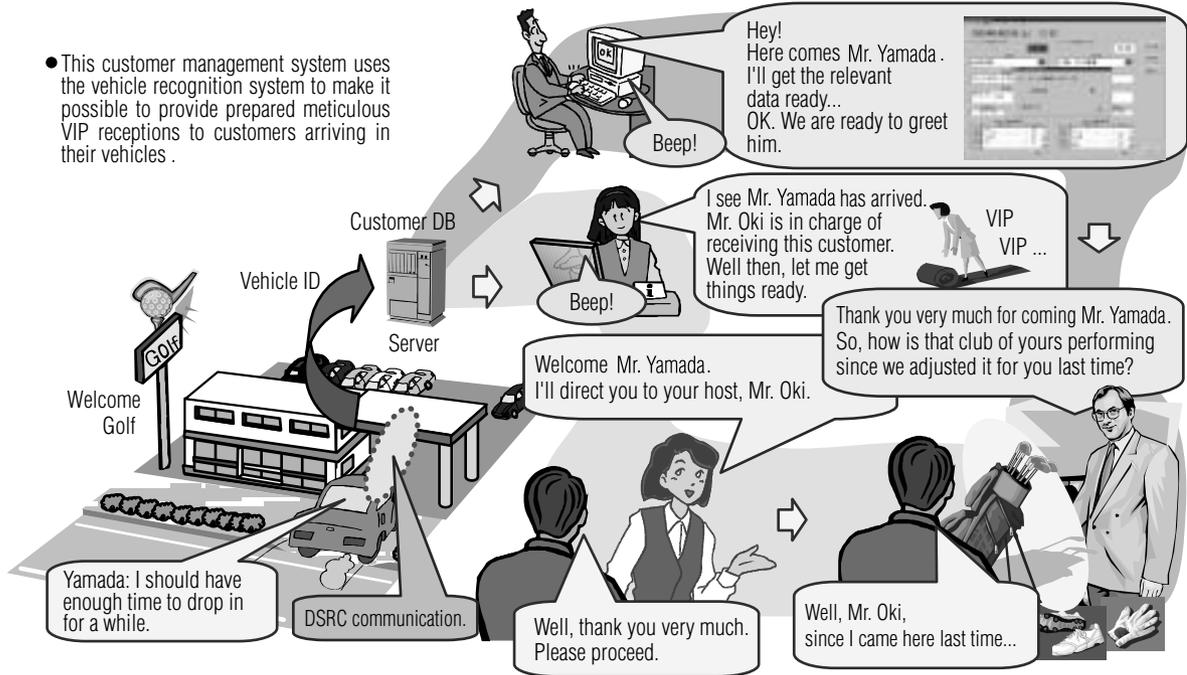


Fig. 4 Visitor management system

### (3) Handicapped parking area management system

This service offers support to physically disabled persons at parking areas of government offices, hospitals and suburban shopping centers.

An image of a handicapped parking system is shown in Figure 5. The system is comprised of major elements, such as a wheel locking device, DSRC radio equipment and a guiding device for use with handicapped parking. Parking is made possible only to vehicles equipped with on-board ETC equipment registered to handicapped persons by the lowering of the flap. The system also provides a means to warn ordinary drivers of their bad manners if they try to use parking areas intended for disabled persons.

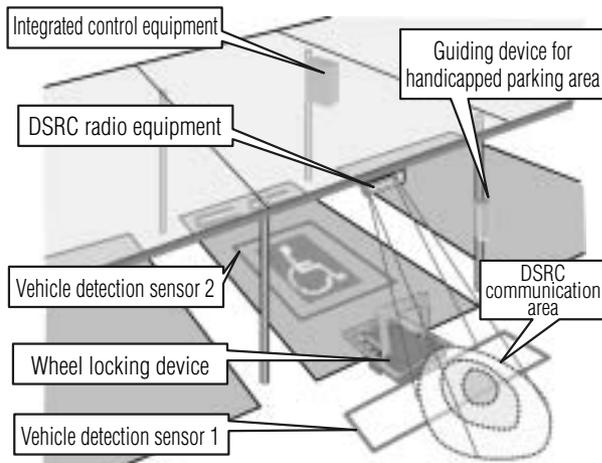


Fig. 5 Handicapped parking area management system

### (4) Parking area system for large-scale stores

This is a toll parking area system that is linked with a

point card or other system, intended for an unspecified number of customers at locations such as department stores or airports.

The configuration of the entrance and exit of the parking area is the same as that for contracted parking areas. A feature of this system, however, is its ability to deal with an unspecified number of customers with vehicles equipped with on-board ETC equipment while correlating the WCN of individual vehicles with their respective parking fee discounts and payment methods.

One of the methods used for collating the incoming vehicle, equipped with on-board ETC equipment and a point card, is shown in Figure 6. The DSRC radio equipment performs DSRC communications when a vehicle arrives and obtains the WCN of the on-board equipment. The DSRC radio equipment then searches the database of registered users and if the vehicle is not registered in the database, an ordinary parking ticket will be issued. At the same time, the received WCN and the number of the issued parking ticket are recorded in the database of pending registered users. The user then supplies the point card and the parking ticket to the service counter. Collation of the point card number and the WCN becomes possible when the pending registered user database is searched using the parking ticket number. Once this is done, the system will allow the user smooth and ticketless entry and exit to the parking area.

### (5) System for filling stations

This service is a major candidate for the implementation of multiple applications that use settlements performed within DSRC communications. It is also a service that can be realized using existing on-board ETC equipment.

An image of an installation at a filling station with DSRC radio equipment is shown in Figure 7. Although the basic configuration is almost identical to that of other systems, the distinguishing feature of this application

includes the addition of a personal identification number for DSRC radio equipment or a filling pump. At self-service filling stations, the user engages in the filling procedure as the system prompts the user with a proposed fuel type and quantity based on the information from previous records, while the entry of a personal identification number is used as a means of verifying the identity of the user and confirming the purchase details.

ETC service, there are obviously segments that are not ideal for application in other services, such as display features and guidance features for the on-board equipment. We intend to bring the system up to an operational level by supplementing these features that are lacking, through a system or methods implemented to realize the services, such as the addition of display features to the DSRC radio equipment.

Further, considering a tradeoff between privacy and convenience, it is essential to evaluate the establishment of an organization for the comprehensive management of the WCN, as the WCN is critical for operating the on-board ETC equipment with other services.

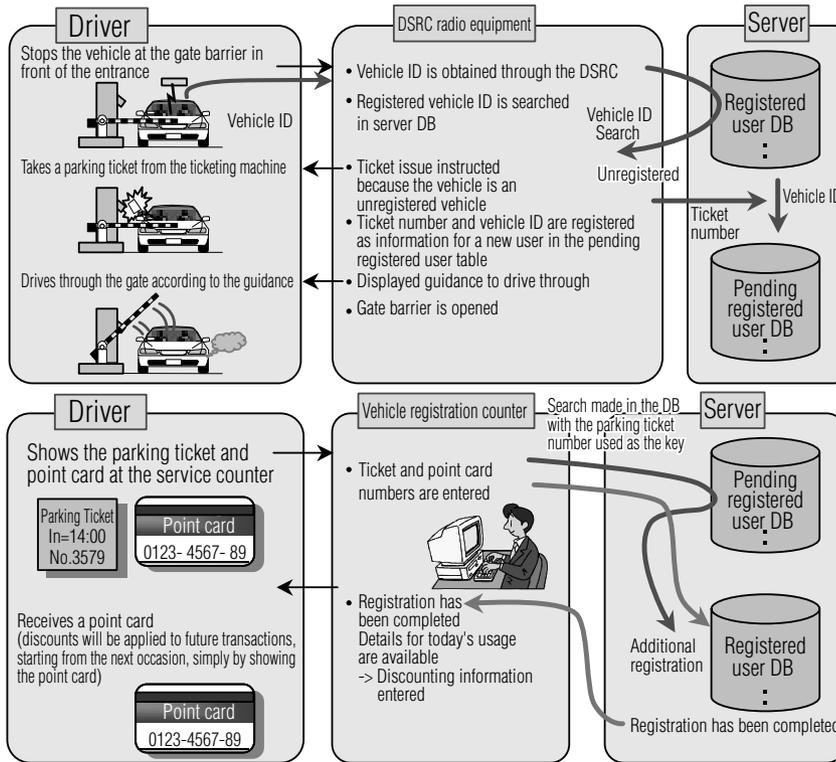


Fig. 6 Collation of ETC equipped vehicles and point cards

### Conclusion

After the realization of the ETC system it took a long time before new services of the ITS were sought. It appears that services complying with the DSRC's common specification will start eventually. However, we hope to contribute, through vigorous efforts to enhance ITS services by offering users convenience, improvement of safety with environmental considerations, along with services that are possible with on-board ETC equipment while making all this happen in the shortest possible time.

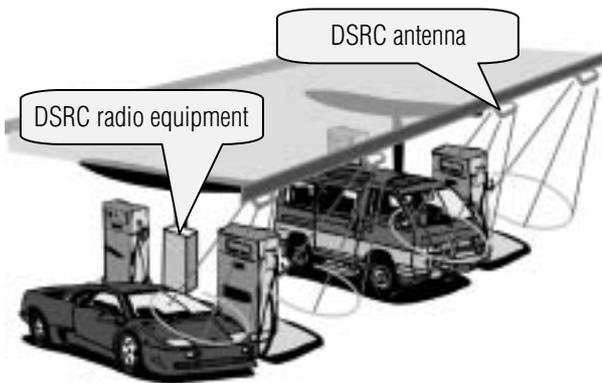


Fig. 7 System for self-service filling stations

### Developments for the Future

This paper described services that can be realized using the widely prevalent on-board ETC equipment. We believe that the ability to offer various services to drivers who have purchased on-board ETC equipment and are already using ETC services, without any need to change the on-board ETC equipment, is an important aspect. Since the on-board ETC equipment is intended for the

### References

- 1) Organization for Road System Enhancement: "Sum Total of Issuing a Set-up", from the web site of the Organization for Road System Enhancement, January 2004.
- 2) Kikuo Tachikawa: "Dedicated Short-range Communications for ITS — Trends in Research, Development and Standardization", Society of Automotive Engineers of Japan, 2000.
- 3) Association of Radio Industries and Businesses: "Dedicated Short Range Communications (DSRC) System Standard ARIB STD-T75", October 2003
- 4) Highway Industry Development Organization: "ITS HAND BOOK", 2003.

### Authors

Yoshihito Oomori: System Solutions Company, Intelligent Transport System Div., ITS Solutions Dept.  
 Yuzuru Yamazaki: System Solutions Company, Intelligent Transport System Div., ITS Solutions Dept.  
 Motoatsu Yoshikawa: Oki Consulting Solutions Inc., Infrastructure Information Systems Consulting Group