

Vehicle Entrance/Exit Management System with “INFOBEACON”, DSRC Roadside Units

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Abstract

More than 38 million ETC on-board units are now in use across Japan. They are used to control vehicles entering or exiting various buildings, factories, shipping storage areas etc., as well as at toll gates on expressways. NEC has developed the “INFOBEACON” that reads unique data from an ETC on-board unit and has also developed a “vehicle management system control unit” that is compatible with automatic electric car gate and roller shutter door entry systems. This paper introduces features of our developed systems and discusses actual case studies describing the installation and maintenance services that are provided throughout Japan.

Keywords

DSRC, ETC, ETC on-board unit, vehicle ID service of ETC
vehicle entrance/exit management, ITS SPOT service

1. Introduction

As of July 2010, ETC (Electric Toll Collection Systems for collecting road tolls without stopping) were installed at approximately 1,200 toll gates on expressways nationwide. The total number of ETC on-board units exceeded 38 million units. 87.9% of vehicles driving on the Tokyo Metropolitan Expressway use ETC, 84.8% on the Hanshin Expressway and 89.2% on the Honshu-Shikoku Bridge Expressway. The number of ETC on-board units used on expressways nationwide per day has reached approximately 6,740,000.

In March 2006, the Japan Ministry of Land, Infrastructures and Transport and the Organization for Road System Enhancement (ORSE) started the “vehicle ID service for ETC” aimed at promoting the multipurpose use of ETCs by private businesses, etc. This service uses information that is unique to each ETC on-board unit. Payments using the vehicle IDs are based on a mechanism that differs from the ETC toll payment system in that it requires advance registration of information on the credit card to be used.

When the vehicle ID service started, conventional ETC roadside units required by private companies for starting ETC related businesses along roads were too costly to be introduced under the constraints of their sales promotion budgets. In order to resolve this issue, NEC has developed a compact and light-weight “INFOBEACON” for multipurpose usage by reviewing the required driving speeds at ETC toll gates and in

data signal transmission areas.

“INFOBEACON” is a system that outputs contact signals to a car gate (entrance and exit), and verifies cars with the unique information of each on-board ETC. This verification was originally conducted using a PC. However, since it has been released to the market, a request from customers has reached us to conduct this verification without using a PC. In order to satisfy such requests, NEC has developed a “vehicle management system control unit”, in which all the necessary functions are included.

A radio station license is required to install “INFOBEACON,” so the companies introducing the “vehicle ID service of ETC” need to apply for a radio station license regulated in each local prefecture by the “Japanese Radio Act of the Bureau of Telecommunications.” As some customers have sent us requests to reduce their labor input for the requisite application documentation, NEC has prepared a supporting service to meet their demands.

2. INFOBEACON and the Vehicle Management System Control Unit

2.1 Development of INFOBEACON

We have designed INFOBEACON to integrate antenna and control units by omitting the SAM (Secure Application Module) function that encrypts information in the ETC card. Thus,

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Photo 1 INFOBEACON (with attachment bracket).

Table 1 Specification of INFOBEACON.

Item	Specifications
Technical requirements	Compliant with ARIB STD-75
Radio characteristics	
Transmission frequency	5,795 MHz, 5,805 MHz
Reception frequency	5,835 MHz, 5,845 MHz
Transmission power	10 mW or less
Modulation	ASK modulation
Data transmission rate	1,024 kbps
Dimensions/Weight	
Dimensions	182 W × 188 H × 115 D (without attachment bracket)
Weight	Main unit: Approx.900g Attachment bracket: Approx. 650 g (without mounting bolts)
Environmental resistance	
Operational temperature	-10 to +50°C
Protection grade	IP55 or equivalent
Interface	
Physical interface	100 BASE-TX
Electrical interface	CSMA/CD
Communication protocol	TCP/IP Socket
Power supply	PoE (Power over Ethernet: compliance with IEEE802.3af)

we made it possible to reduce both size and cost compared to those of the conventional ETC roadside units installed at toll gates on expressways (**Photo 1** , **Table 1**). We have also omitted functions other than these two of acquiring the device number and WCN (Wireless Call Number). Both of them are unique information to the ETC on-board unit.

2.2 Vehicle Management System Control Unit

The vehicle management system control unit can provide a vehicle entrance/exit management service simply by connect-

ing the control unit to an INFOBEACON and no PC or terminal computers are necessary to manage the service. This unit possesses the functions 1) transmission control of INFOBEACON, 2) vehicle information management and 3) output of contact signals. The WCN information registered to the control unit in advance is verified with the WCN information stored in the ETC on-board unit that is read by INFOBEACON. When the verified WCN information is matched, the control unit outputs a contact signal to a car gate, etc. and allows the registered vehicle to enter or exit the gate. This control unit is designed in consideration of its operability. Its built-in touch panel screen enables the user to operate vehicle registration and cancellation easily by using a WCN information, to browse vehicle passing records and to set and change various settings. Moreover, one of the expanded functions allows sending data of vehicle passing records to PCs via the network. When this control unit is connected to a higher level system, other systems and services may be configured.

Minimization of the unit size is also achieved in order to support improved ease of installation, (**Photo 2** , **Table 2**).

2.3 Evaluation of Environmental Characteristics

The vehicle entrance/exit management system is operated by connecting it to the car gate or roller shutter door. It is thus necessary to provide countermeasures for avoiding the occurrence of malfunctions due to electrical or physical interference between the system unit and car gate or roller shutter door.

We have conducted the environmental characteristics evaluation tests required for our system in cooperation with a door shutter manufacturer. The tests were conducted based on the



Photo 2 Vehicle management system control unit (image of installation).

Table 2 Specification of vehicle management system control unit.

General Specifications	Details
Dimensions (mm)	220 W × 330 H × 120 D (excluding projections)
Weight (kg)	Approx. 7.0 kg
Installation type	Fixed to pillars or walls
Protection Grade	IP65 or equivalent
Power supply voltage	100 V AC
Power consumption	Standby: approx. 20 W, Operation: approx. 50 W or less
Vehicle detection sensor input specification	Connection: Connected to Non-voltage contact output or NPN open collector output Rated load: 24 V DC, +/-10%, 10 mA Applicable sensors: Loop coil sensor, photoelectric sensor
Car gate control output specification	Connection: Non-voltage relay contact output Rated load: 250 V AC, 3 A (max.), 30 V DC, 3 A (max.) Operation Durability: Mechanically: 5,000,000 times or greater Electrically: 200,000 times or greater (@ rated load, open/close frequency 1,800 times/hour)
Main function	Details
Vehicle registration	Registration for WCN, vehicle license plate etc. are available. (Registration can be done via touch panel screen operation or sending details via USB memory.)
Available number of vehicle registrations	1,000 vehicles (with standard model)
Vehicle passing record display	Available to display on the touch panel screen (data output in CSV format available)
Error log display	Available to display on the touch panel screen (data output in CSV format available)
Alarm output	Alarm lamp lights if a unit abnormality occurs

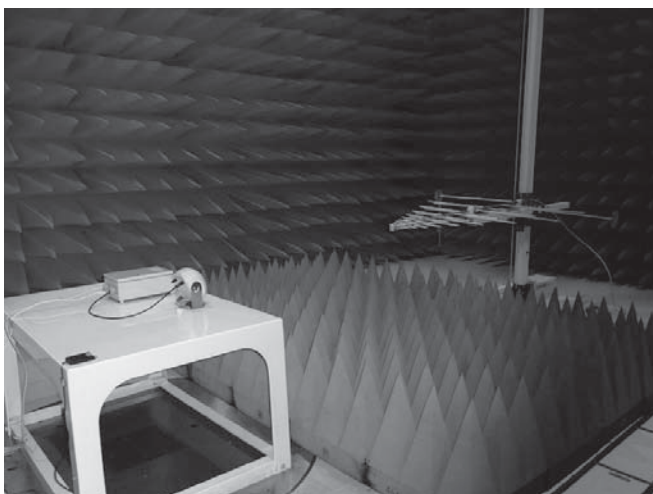


Photo 3 Evaluation of environmental characteristics. (Radio interference)

environmental characteristics evaluation conditions (conforming to the test methods defined by IEC international standards, JIS and VCCI) in both electrical and mechanical aspects (**Photo 3**). Major evaluation details are 1) insulation resistance test, 2) voltage withstanding test, 3) temporary power interruption test, 4) radio interference test, 5) radio resistance characteristics test, 6) impulse noise resistance test and 7) vibration resistance characteristics test.

From the results of these evaluation tests, we can confirm that our system has high compatibility with electrical roller shutter doors and other equipment installed at car gates.

3. Services to Support System Introduction

At the present time a service provider that installs the IN-FOBEACON has to apply for and acquire a radio station license and may then open a radio station under the provisions of the Japanese Radio Act. Moreover, after acquiring the license, it is required to appoint and register a person to take charge of the radio operations. The application process for the radio station license is rather complicated and requires specialist knowledge. We have received requests from customers asking us to provide application and documentation services.

In order to meet this request, NEC Mobiling, Ltd. has begun to provide services to deal with the various legal procedures and also for installation and maintenance services to support a smooth introduction of our system. NEC Mobiling is a company that offers nationwide businesses related to mobile phone based stations and it also provides engineering solutions for radio systems and services that support design, operation, repairs and maintenance.

NEC Mobiling has engineering centers (EC) in seven areas of Japan and is able to provide consistent services in any of these areas (**Fig. 1**). Engineers will be sent from the nearest area to a location where our system is installed, so that a maintenance service may be expected, even for emergency issues. Also NEC Mobiling allocates many staff with radio station licenses throughout Japan thus enabling provision of a comprehensive nationwide turn key service that ranges from system design to installation, operation and maintenance. The service further includes a substitutional registration of “licensed radio operator” to the local Bureau of Telecommunications, basing on the service contract between customers and NEC Mobiling.

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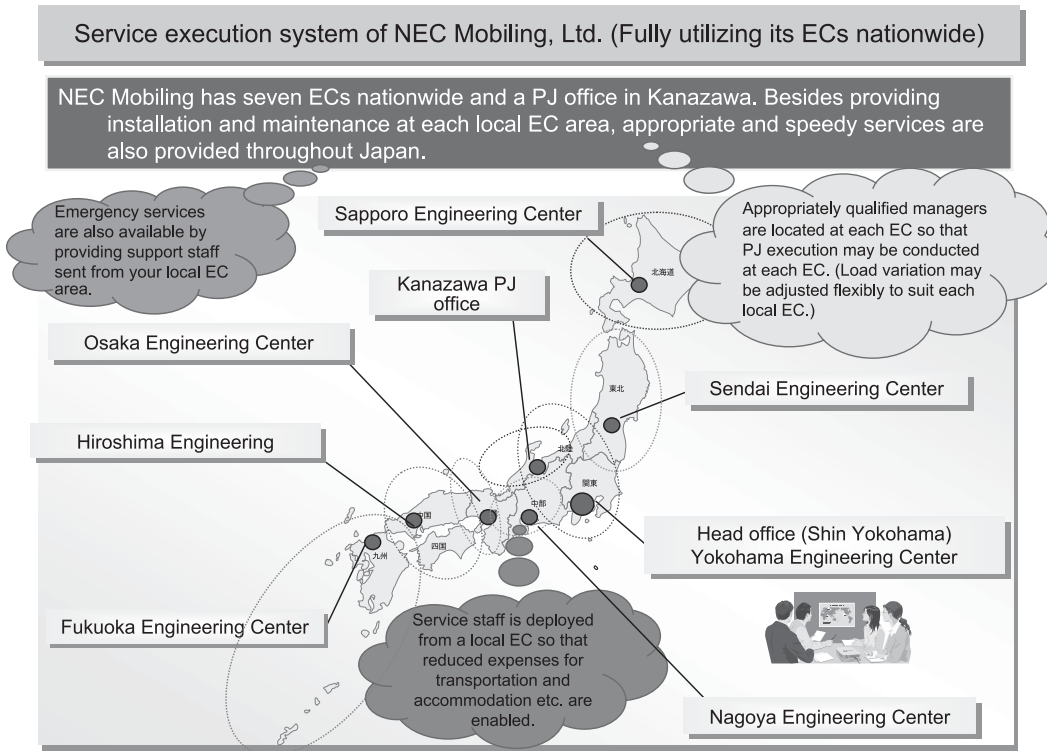


Fig. 1 Main PJ office and ECs (Engineering Centers) of NEC Mobiling.

Since we prepared these services, owners of apartments or condominium management associations and even house owners have begun to consider introducing our system.

4. Vehicle Management System Operations and Case Studies

In this section we introduce vehicle management system operations and their case studies (Fig. 2). Vehicle entrance/exit management services using the INFOBEACON and ETC on-board units provide different services to the one provided by the GPS location information management service. The purpose of the vehicle entrance/exit management service is to provide evidence (presence guarantee) that a vehicle was actually present at a certain location at a certain time. With regard to transportation operations the system enables the provision of evidence that a vehicle mounted with its products actually started its journey at an appointed site, or that a vehicle with industrial waste delivers its load to a designated location.

(1) Case Study 1: Emergency Vehicle Entrance/Exit Management System for Expressway Use

In 2009, NEC delivered the “emergency vehicle entrance/exit management system” to the Central Nippon Expressway Company Limited. This system was constructed as an experimental system at the Kakegawa test driving course located on the Second Tomei Expressway. The vehicle entrance/exit management system mounted with the INFOBEACON was installed on the roller shutter doors at the entrances and the exits in the Kakegawa parking area. (Photo 4)

A description of how the system operates is provided below.

- 1) An emergency vehicle parks near the roller shutter door.
- 2) A vehicle detection sensor detects the vehicle and the INFOBEACON is activated.
- 3) The INFOBEACON acquires WCN registered in the ETC on-board unit mounted on the targeted emergency vehicle.
- 4) The control unit verifies the WCN (WCN registration will be carried out if necessary).

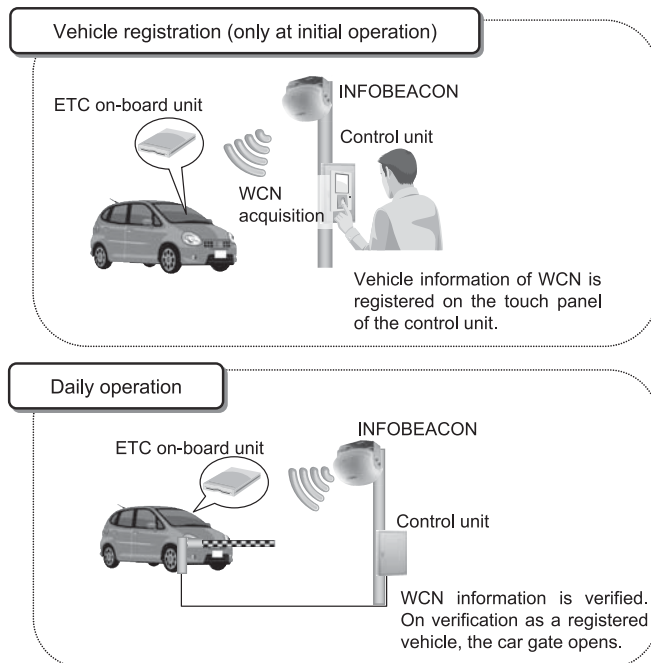


Fig. 2 Operational scheme of the vehicle entrance/exit management system.



Photo 4 The INFOBEACON installed at the Kakegawa test road site.

5) When verification is completed, the roller shutter door will open.

By installing INFOBEACONS at entrances and exits for emergency vehicles on expressways, the system is expected to support emergency vehicles in entering expressways smoothly and also in recording the vehicles that enter and exit to and from expressways at these locations.

(2) Case Study 2: Vehicle Entrance/Exit Management System for a Market Place

In 2008, NEC delivered a vehicle entrance/exit management system for Itabashi Market to the Tokyo Metropolitan Government. INFOBEACONS are installed on the car gates at the front and west gates of the Itabashi Market. The system was constructed there in order to control the entry and

exit of the vehicles that bring vegetables from nearby farms to the market. In addition, the system controls the entry and exit of vehicles driven by people who work at the market (e.g. wholesale dealers, retailers, buyers, etc.).

The data recorded in the system is used to support management of the entry and exit times of vehicles and it is also used to prevent illegal parking in the market place.

(3) Case Study 3: Vehicle Entrance/Exit Management System for a Shipping Storage Area

In 2008, NEC delivered a vehicle entrance/exit management system to NEC Logistics, Ltd. The INFOBEACON was installed at the front gate of the Kanagawa Logistics Center (at Zama in Kanagawa prefecture) to enable construction of a system for acquiring entry records of the trucks that deliver cargos to the storage area.

Recently, higher security logistics controls are demanded to support storage businesses. NEC operates and evaluates an improved system that achieves a higher security level, which at the same time is capable of analyzing the entrance data of all vehicles entering the shipping storage area.

5. ITS SPOT Service and Its Projected Development


In 2010, the Ministry of Land, Infrastructure, Transport and Tourism announced the installation of “ITS (Intelligent Transport Systems) SPOT service” on the main expressways and service areas nationwide. This was a world first two-way communications system between vehicles and roadside units. The system will enable the provision of traffic information and safe driving support information from roadside units to vehicles with ETC on-board units, as well as driving information such as “vehicle probing information” from vehicles to the roadside units.

Relationships between the INFOBEACON, ITS On-board Unit and ETC On-board Unit

The ITS on-board unit functions as an ETC on-board unit. Automobile manufacturers and electrical component manufacturers have started marketing ITS on-board units that provide ETC toll correcting services as well as Internet connection services and other services conducted by commercial business companies. Major car products retailers have started to sell ITS on-board units and they have also begun to offer services to install them in vehicles.

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Table 3 Relationships between INFOBEACON and on-board units.

Types of roadside unit Services	INFOBEACON	ITS SPOT 		
		ETC roadside unit	Information provision	Internet connection
Compatible vehicles	ITS on-board unit			
	ETC on-board unit		—	
Modulation system	ASK		QPSK	
Transmission conditions Parking/Driving	Stop	Driving		Stop
Information provision				
Traffic information (VICS)	—	—	Available	—
Safety driving support	—	—	Available	—
Information provision from a vehicle to a roadside unit	Available (WCN, on-board unit number)	—	Available (Probe information)	—
Internet connection	—	—	—	Available
Payment				
ETC settlement	—	Available	—	—
Credit card	Available by matching on-board units and credit card details.	—	—	Available

ITS on-board units have just started to be marketed as of 2010, so as yet not many businesses located along roadsides have begun to invest them in their budgets to support ITS on-board unit related businesses.

In order to explain the above, **Table 3** shows the relationships between the INFOBEACON, and the ITS-on-board and ETC-on-board units.

6. Conclusion

As is explained above, when a vehicle entrance/exit management system with an ETC on-board unit employs the “INFOBEACON” and a “vehicle management system control unit”, the desired services can be provided with less complications. Software to support the introduction and operation of the system, such as radio station license applications and license maintenance procedures etc. are also available.

We expect that vehicle entrance/exit management systems using the INFOBEACON will be employed at various locations and will provide more beneficial services than have been available hitherto.

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