Improved Convenience and Reduced Environmental Impact Using Intelligent Transportation Systems

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Intelligent transport systems (ITS) improve convenience in motorized societies and reduce the environmental effects of automobiles by connecting them closely to the transportation infrastructure they use. Mitsubishi Heavy Industries, Ltd. (MHI) has been developing and delivering two unique ITS applications for many years: the Electronic Road Pricing (ERP) system and the Electronic Toll Collection (ETC) system. Together they eliminate traffic jams at tollbooths, control traffic volumes, improve fuel efficiency, and offer many other benefits. ITS will help create a more environmentally friendly and sustainable society by balancing and controlling traffic flow with enhanced On-Board Equipment and the shared use of Infrastructure by individual drivers and public transportation networks.

1. The Role of Intelligent Transport Systems (ITS)

Traffic jams cause congestion in cities worldwide, and in recent years have had major influences not only on people's lives, but also on the environment. As a social problem, their magnitude is alarming, and concerted efforts have been made to reduce them. One such effort is the intelligent transport systems (ITS), a system integrating vehicles with the infrastructure to provide solutions that are not possible with just the vehicles or infrastructure alone. ITS improves convenience and preserves the environment at the same time.

Each city requires its own type of ITS, which depends on the existing traffic conditions, measures, and policies. To meet this widely varying demand for ITS, MHI and others are expanding their technical approaches to broad range of solutions. This paper describes the efforts by MHI in developing the three systems shown in **Fig. 1**.

Fig. 1 ITS expansion

2. Independent Systems

One method already used to solve traffic problems is Electronic Toll Collection (ETC) system, which eliminates traffic jams at tollbooths, and another is the Electronic Road Pricing (ERP) system, which controls the volume of traffic moving into city centers. These systems consist of roadside equipment installed at each entry of roads, or at toll lanes for the management and control of passing vehicles. Methods of identifying vehicles in these systems include radio communication with On-Board Equipment and image-processing for car license plates.

(1) ETC system in Japan

The ETC system in Japan uses Dedicated Short Range Communication (DSRC), a radio communication system with 5.8-GHz band. Since the start of the ETC service in 2001, nearly 20 million On-Board Equipment have been installed. According to a report by the Ministry of Land Infrastructure Transport and Tourism, this service is estimated to save about ¥350 billion and reduce CO_2 emissions by as much as 140,000 tons every year. In addition, with the various charging policies which enable to discount toll in midnight and so on, traffic volume are so averaged as to improve utilization efficiency of the whole road network. This in turn reduces the impact on the environment.

(2) ERP system designed for Singapore

The ERP system using 2.4 GHz radio communication delivered to Singapore by MHI in 1998, which included both roadside radio equipment and On-Board Equipment, has dramatically reduced traffic jams. Starting this year 2008, a new generation of On-Board Equipment will also be delivered (**Fig. 2**). With this system, the ISO14443 contactless card already widely used in Singapore as a transport card will also be usable together with present dedicated contact-type card. Ultimately, this will allow a
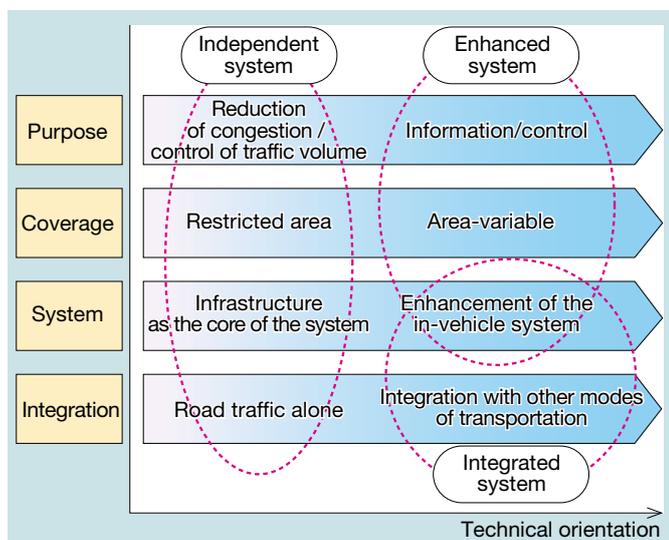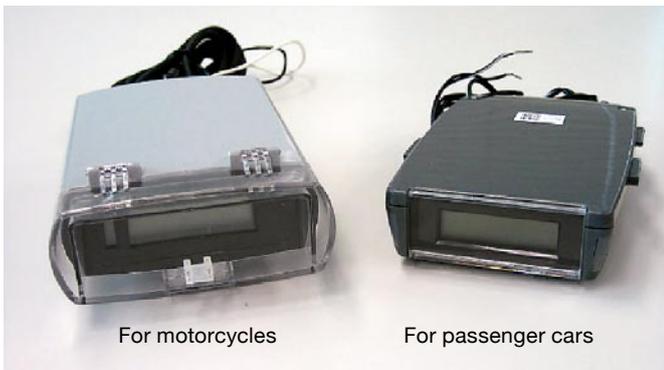
For motorcycles　　For passenger cars

Fig. 2 Next-generation type in-vehicle equipment for the ERP designed for Singapore

traveler to use a single transport card to pay for different types of transportation services including public transport like buses and trains, as well as road toll. This further improves convenience for the travelers.

(3) Integrated Urban Road Pricing system

Environmental problems get critical with economic development in Asian cities with their traffic-jammed streets. In many cases, the infrastructure, civil administration, and other related systems in many Asian countries make it difficult to introduce uniform national level of traffic control systems as has been successfully achieved in Japan and Singapore. To address this challenge, MHI has developed Integrated Urban Road Pricing (IURP), an ERP system for worldwide use that provides low-cost diverse operational solutions with extensive scalability.

On a system level, MHI has developed both DSRC and Global Positioning System (GPS) approaches to IURP. The DSRC method achieves high reliability in road-to-vehicle communications using DSRC that complies the ARIB STD-T75 standard used in Japanese ETC systems. Flexible security measures are implemented in software to meet the specific security requirements for each customer. To increase availability, the On-Board

Equipment is designed to be operated on batteries and requires no special installation. The system meets the requirements for ISO14443 transport cards, the world's most prevalent cashless payment measure with this type of system. Furthermore, the roadside equipment such as antennas and enforcement cameras are included in the complete system to facilitate its introduction in various configurations.

3. Enhanced Systems

Individual vehicles that use road infrastructure can be used to collect information on road infrastructure conditions. By sharing information among individual vehicles, it will be possible to rationalize and spread the use of the road infrastructure even further. Future ITS will need to evolve beyond their original functions as independent systems to ease traffic at toll lanes or in city centers. In future systems, enhanced On-Board Equipment that integrates vehicles closely to the infrastructure will facilitate the flexible implementation of traffic policies and measures tailored to the specific traffic conditions, while providing safe driving assistance and managing the traffic volume by providing traffic guidance. This will improve the efficiency of the road network use and facilitate the adoption of environmentally friendly measures.

(1) Next-generation road service

In Japan, work is now under way on the practical application of the next-generation road service. MHI is also developing ITS On-Board Equipment that will meet the requirements for this service. The next-generation road service is based on DSRC communication using the ETC system to provide information such as warnings about upcoming obstacles, or extensive information on the traffic ahead. Because information on travel history can be stored in ITS On-Board Equipment and collected by roadside systems, it will also be possible to improve the accuracy and diversity of the information provided. The implementation of these services is expected to smooth and average the flow of traffic to achieve a better level of safety and reduce the environmental impact.

Battery box
Main body
Card　　Card holder

Fig. 3 DSRC in-vehicle equipment for the IURP system (prototype)

Fig. 4 DSRC portion of the ITS in-vehicle equipment (prototype)

(2) GPS-type ERP system

To control traffic volumes more flexibly and accurately under diverse and variable conditions, it will eventually be necessary to trace the status of every vehicle on the road. MHI is now developing a next-generation system with this capability using GPS.

GPS-based ERP systems now in operation compare the location of every vehicle with a central geographical data base to measure the distance driven and the money to be charged. This method requires a robust communication infrastructure and a central system capable of processing enormous quantities of data.

The system now being developed by MHI uses a high-performance GPS receiver combined with dead-reckoning navigation in the in-vehicle unit. The system will process travel-distance measurement and billing zone detection in the in-vehicle units without depending on the central system. This reduces the load on the central system and the communication infrastructure, and will enable the application of many types of traffic measures and policies. In one proposed policy that may be possible using this system, the degree of environmental impact will be incorporated in the road pricing. Last year, MHI evaluated a prototype in-vehicle unit under various driving conditions, including streets lined with high-rise buildings, a difficult operational environment for GPS. Even under this sort of condition, MHI was able to achieve a distance-based charging accuracy error of 2% or less. MHI is now accelerating the development of this type of system to the point in which it can be fielded.

4. Integrated Systems

A future vision for ITS is the stricter management and control of traffic flow in collaboration with other systems for traffic signal control and transportation demand management. It should also be effective for sharing traffic facilities such as parking lots and public transportation
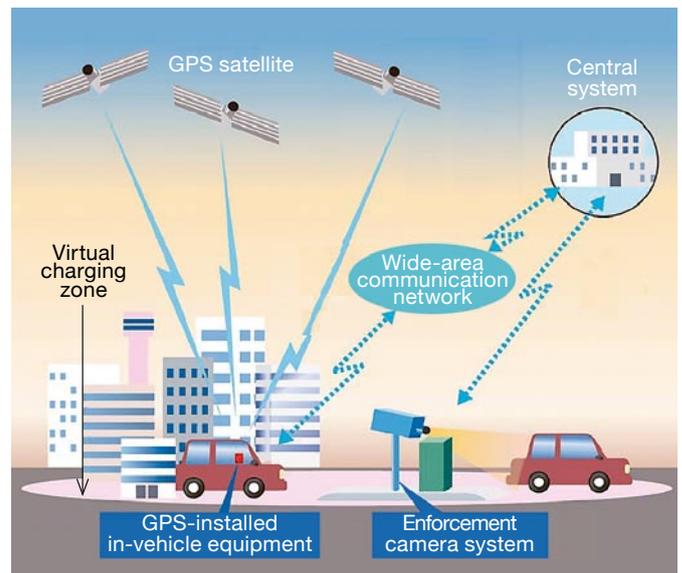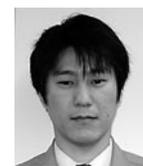

Fig. 5 Next-generation ERP system

systems, with just a single in-vehicle device or transport card. With a further integration of various systems, traffic measures, and policies, ITS will go a long way toward improving convenience and reducing the environmental burden of a motorized society.

5. Conclusions

As society continues to motorize even further, ITS will assume a larger role in improving convenience and reducing environmental effects, and MHI will be increasing its ITS development and working toward the creation of a sustainable and environmentally friendly society.

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