Land Transportation Systems and Their Future

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1. Introduction

Mitsubishi Heavy Industries, Ltd. (MHI) is developing guideway transportation systems, such as railroad systems and new transit systems (transportation systems), for land transportation. MHI is also manufacturing products for road transportation such as toll collection and intelligent transport systems (ITS). This paper gives an overview of transportation systems, toll collection system and ITS technology, and their prospects.

2. Transportation systems

2.1 Overview

MHI has been manufacturing conventional railway vehicles such as steam, diesel, and electric locomotives and rail motors and freight trains since early 1900s. MHI has also been developing new transportation systems to meet diversified transportation needs. The section that follows details these transportation systems and their prospects.

2.2 Present transportation systems

MHI developed monorails, then constructed new transit systems and urban railroads. MHI is now developing linear Shinkansen.

(1) Monorails

Monorails are roughly classified into straddled and suspended. MHI is manufacturing suspended monorails, which do not generate loud noise and can turn sharply. Suspended monorails are unaffected by adverse weather conditions such as snow. MHI suspended monorails are operating on the Shonan Monorail and Chiba Urban Monorail (**Fig. 1**).

(2) New transit systems

New transit systems use rubber tires that do not generate loud noise and ensure high performance, making them suitable for automatic operation. In Japan, MHI is now constructing new transit systems by providing vehicles, electrical power systems, and maintenance facility to Tokadai New Transit, Kanazawa Seaside Line, Kobe-Rokko Island Line, Port Island Line, Hiroshima Rapid Transit, and Tokyo Waterfront New Transit “Yurikamome” (**Fig. 2**).

MHI exports the new transit system by full turnkey contract. An in-airport transit system to Hong Kong International Airport and a transit system to

Fig. 1 Suspended monorail "Chiba Urban Monorail"

Fig. 2 New transit system "Yurikamome"

Seng Kang Newtown in Singapore as urban transportation are in operation. MHI is also constructing new transit systems at Miami Airport in the U.S.A., at Changi International Airport and Punggol Newtown in Singapore.

"Crystal Mover," a transit system vehicle developed by MHI, has been evaluated highly, winning the METI (Ministry of Economy, Trade and Industry) Prize. The photo beside the title shows the vehicle.

(3) Skyrails

Skyrails have been developed to transport small loads along steep slopes. Vehicles are suspended from a slender I-shaped girder. Its "Traction by rope" mechanism ensures high performance and climbing stability. Linear motors at stations control transport speed. MHI tested a skyrail system on a test line at the works and introduced it to Senogawa. This skyrail now connects the Newtown, constructed on a slope, to a nearby station (**Fig. 3**).

(4) Light rail transit (LRT)

Light rail transit (LRT) has attracting considerable attention as urban transportation for short and intermediate distances. MHI implemented a turnkey project to provide an LRT, including civil engineering and construction work, to Manila. This LRT has eased traffic congestion and provided convenient transport to citizens (**Fig. 4**).

(5) Linear motor systems

Linear motor systems (superconducting magnetically levitated (maglev) railroad) are now being developed as next-generation ultrahigh-speed transportation. MHI has used airplane technology to aerodynamic design of the front shape of maglev vehicles, and has delivered 3 lead vehicles. MHI is also supplying bogies, air brakes, hydraulic systems, ventilation and air-conditioning systems, and generators. At the Yamanashi Maglev Testline, test runs are being conducted (**Fig. 5**).

(6) Shinkansen

As a system integrator, MHI is developing a Taiwan Shinkansen for the first such export from Japan.

2.3 Future of transportation systems

MHI will develop, improve, and introduce short, intermediate, and long-distance transportation to create "passenger-friendly towns."

(1) Short and intermediate-distance transportation systems

Automated people movers (APMs) are typical transportation suitable for short and intermediate-distance transportation. To provide better passenger service, waiting time of passengers should be reduced by shortening operation intervals. This requires high-density operation. To fulfill such needs, MHI will develop new signal systems.

LRTs are attracting attention for easing urban traffic congestion. Smooth boarding and alighting are prevented by gap of height between vehicle floor and station platform for conventional vehicles. MHI will provide low-floor vehicles to align floor and station

Fig. 3 Senogawa Skyrail

Fig. 4 LRT "Manila line 3"

Fig. 5 Linear motor system "Yamanashi Maglev Testline"

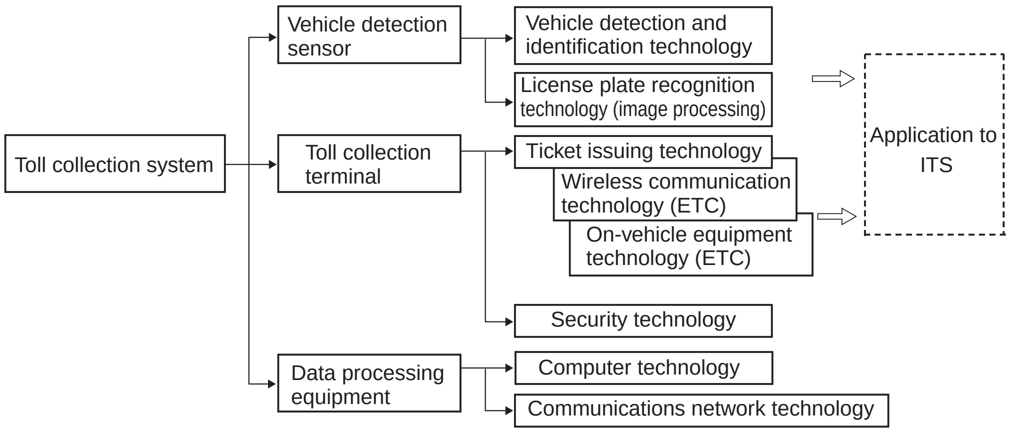

Fig. 6 Construction of toll collection system
Toll collection system and element technology

height, to provide "passenger-friendly" vehicles.

(2) Intermediate and long-distance transportation systems

Intermediate and long-distance transportation may require new railroad lines, but improvement of existing railroads is also effective. MHI will electrify existing lines and improve single-track lines to double- or quadruple-tracked to enable trains to travel at higher speeds, reducing operation time. MHI also will install and improve signals to improve safety.

(3) Long-distance transportation systems

High speed is required for long-distance transportation. MHI will contribute to testing of maglev with its technology developed in various fields.

3. Toll collection technology and projected ITS development

3.1 Overview

In the 1960s, MHI developed and delivered the first toll collection system in Japan and since then MHI has provided toll collection systems implementing the latest technology and catching up with the needs of customers such as automation.

Also, MHI is the first company in Japan to develop electronic toll collection (ETC) for nonstop cashless payment, which is the ultimate goal of toll collection systems. MHI delivered toll collection systems to Malaysia and Singapore. In Singapore, the first electronic road pricing (ERP) system in the world was established, and the system attracted the attention of the whole world. In Japan, ETC has been operated since the spring of 2000. MHI delivered ETC systems to Tohoku Highway, Daini-Shinmei Highway, and Hanshin Expressway in operation now. This section details the technology of toll collection system, including ETC, and the prospect of ITS applying this technology.

3.2 Element toll collection technology

The toll collection system are mainly composed of vehicle detection sensors, ticket-issuing units, toll collection terminals, and data collection equipment. Vehicle detection sensors detect vehicles and calculate the number of vehicles passing through a toll gate. Ticket-issuing units issue the toll tickets. Toll collection terminals read tickets and calculate tolls. Data collection equipment collect data from vehicle detection sensors installed at tollgate lanes and from toll collection terminals, calculating data for each lane and tollgate. Elementary technology used for these units is shown in **Fig. 6**. This section focuses on license plate recognition and radio communications technology.

(1) License plate recognition

License plate recognition equipment was originally developed to distinguish the type of vehicles by the numbers and sizes of license plate. Cameras, illumination lamps, and image processing units were installed on Singapore ERP systems to take pictures of license numbers of illegal vehicles traveling at 180 km/hr or less. Singapore ERP systems are used on toll-gateless free-flow multi lanes. The technology developed for these lanes is now used in free-flow systems in Japan (**Fig. 7**).

(2) Radio communications

The radio communication for ETC is dedicated short-range communication (DSRC) and the radio

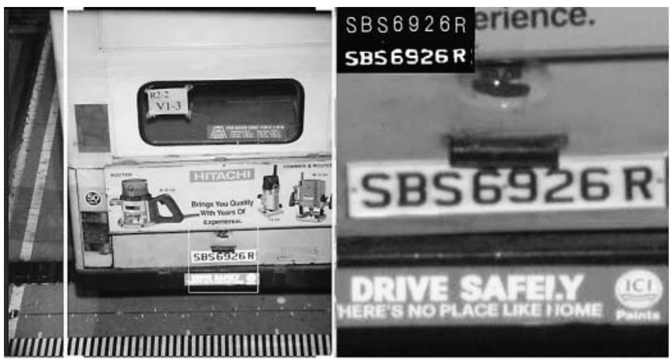

Fig. 7 Vehicle photographed by Singapore ERP and license plate number displayed on monitor

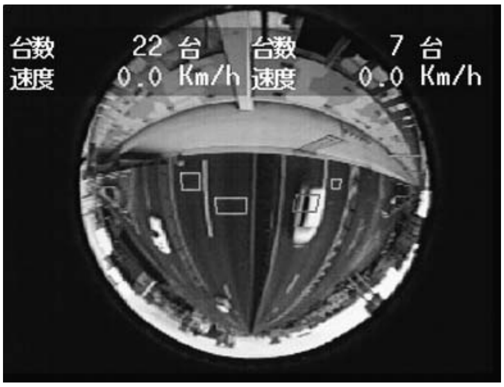

Fig. 8 Traffic flow measurement system with fisheye lens
Monitor screen of traffic flow measurement system with fisheye lens

communication area is narrow. At first, MHI implemented a frequency of 2.45 GHz for passive communications for ERP/ETC systems of Singapore and other cities in Southeast Asia. MHI then implemented a frequency of 5.8 GHz and active communications systems for ETC systems in Japan. This communication enables free setting of the communication area according to the services provided, making this communication system expandable and suitable for communication between roadside equipment and vehicle for ITS.

3.3 ITS development

(1) Image processing technology development

In the field of road management and assistance for safe driving, attention is focused on products and systems of visible image sensor using ITV camera because of expanding the sphere of road management, the needs for real-time, diverse, enhanced traffic information.

MHI has been developing traffic flow measurement sensors while applying license plate number recognition and vehicle detection technologies. These sensors count the number of vehicles, calculate the speed, and identify the type of vehicles.

Recently, MHI also developed the system that including a fisheye lens to upgrade image processing performance. In traffic congestion, conventional systems could not provide accurate measurement. The use of fisheye lens enables accurate measurement even in traffic congestion, monitor vehicle movement and ambient conditions over a wide range using a single camera. This system is thus applicable to transportation and road management equipment, such as at crossings. MHI is now studying the application of this new system to different fields such as parking charge and toll collection, sudden event and falling object detection, road surface condition checking, and intruder detection (**Fig. 8**).

(2) Radio communications technology development

DSRC radio communications technology is used for ETC. MHI is studying how to apply this technology to other systems, and testing prototypes. MHI is also standardizing applications, disseminating systems, and marketing DSRC products. MHI is focusing on application of DSRC technology to MHI products such as parking lot equipment and harbor facilities. MHI has introduced a DSRC electronic parking system (EPS) to Singapore and nonstop toll collection systems are now operating at parking lot gates (**Fig. 9**).

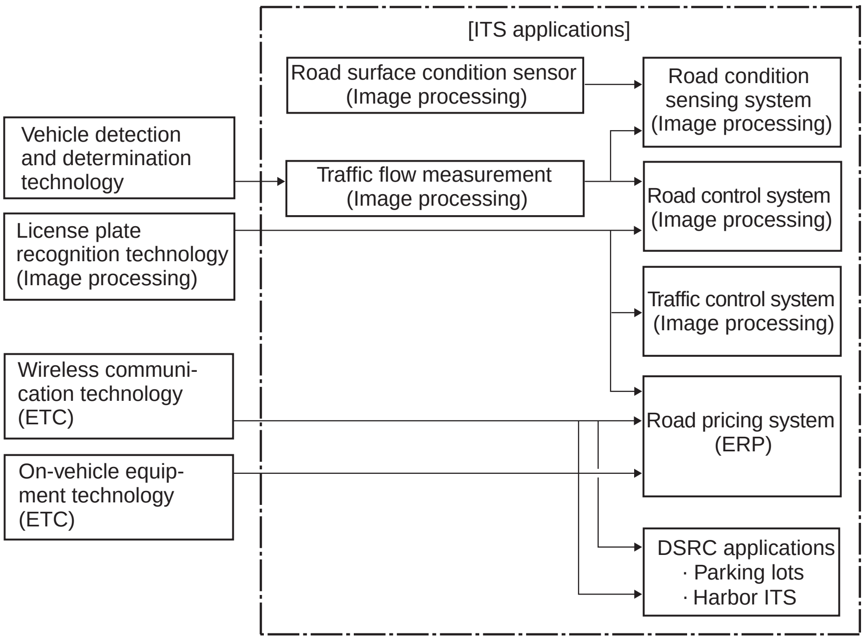

Fig. 9 Development of major ITS technologies

(3) Other MHI technology

In road and traffic management, MHI is developing proprietary technology for the environment and efficiency of ITS. MHI is, for example, developing noise barrier with ASE (Active Soft Edge) that reduce dynamic road noise using a reverse-phase wave sound source, and applying biological evolution models to the distributed intelligence technology to develop new traffic control algorithms.

4. Conclusion

We have reviewed MHI land transportation system technology. MHI will apply vehicle manufacturing technology developed over many years and aerodynamic and machinery manufacturing technology to transportation systems. MHI will, as a total transportation system supplier, manufacture faster, denser, lower-noise, higher-performance transportation systems so that human-friendly towns can be created.

In toll collection system and ITS, MHI will apply image processing and radio communications technology and global positioning system (GPS) technology mobile communications technology to cell phones and the Internet. MHI will thereby help establish more convenient systems to meet social needs and solve road traffic problems, developing and providing more efficient, eco-friendly, safer products.

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