Hitachi’s Total Solutions for Railway Systems and Services

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OVERVIEW: Japan’s railway utilization ratio is the highest in the world. Two main reasons why Japan’s railway systems are patronized by so many people are that they are safe and punctual. Achieving safe and punctual railway systems, however, requires a wide range of technologies including those for rolling stock, signaling systems, traffic management, and power conversion as well as operation and maintenance technologies. As a total system integrator, Hitachi, Ltd. proposes a variety of solutions to integrate these technologies. Today’s railway industry in Japan has various needs. In particular, it must find ways of dealing with environmental problems and the aging society, of easing urban traffic congestion, and of providing information services suitable for the Information Technology (IT) age. Hitachi proposes new solutions in response to these needs. These include “A-train” rolling stock having a recyclable modular structure, small-type monorail system featuring low-cost construction, traffic-management and signaling systems to make railway operations even safer and more reliable, and IT solutions to support new services as railway companies expand their business.

INTRODUCTION

JAPAN has the highest railway utilization ratio in the world. Its 62 million passengers per day is equivalent to about 40% of the worldwide utilization ratio of 160 million daily passengers[1]. The main reasons why so many people use the railway system in Japan are its

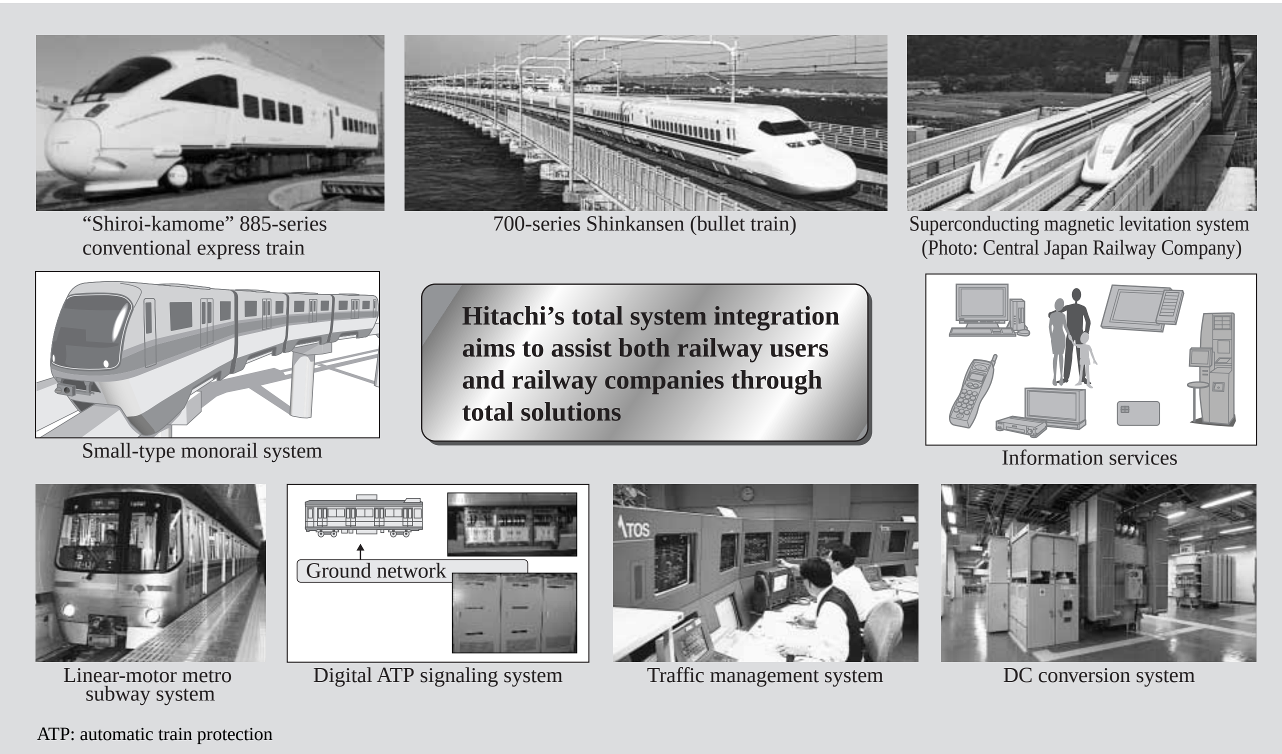


Fig. 1— Hitachi’s Total Railway Solutions.
As a total system integrator, Hitachi proposes a wide range of solutions for railway needs, including new urban traffic systems and rolling stock, signaling and traffic-management systems, information systems, and power-conversion systems.

safety and punctual operation.

Railway safety and punctual operation in Japan are supported by various technologies and facilities including rolling stock and signaling systems, information control systems, and power-conversion systems, plus the maintenance technologies for those systems and facilities. Today's railway system in Japan has been constructed by the total of these technologies.

Railway needs, however, change with the times, and today's railway system in Japan is faced with an aging society, global environmental problems, and growing expectations for a more convenient and comfortable means of transportation. In the age of the information technology (IT), moreover, railway companies are looking to expand its business to a service industry. To meet all of above needs, Hitachi is proposing new solutions in support of railway services.

This report describes the total solutions proposed by Hitachi for railway services (see Fig. 1).

RAILWAY SYSTEM NEEDS AND NEW SOLUTIONS

From a global view, railway systems are being seriously reconsidered as an effective means of transport that can lower CO_2 emissions and help the environment as well as eliminate urban traffic congestion. The establishment of railway systems as a social infrastructure is moving forward with social consensus. At the same time, there is great expectation for railway systems as a means of transport that can ease traffic congestion in urban centers around the world and that are even cheaper to construct than subways. The same case applies to major regional cities in Japan.

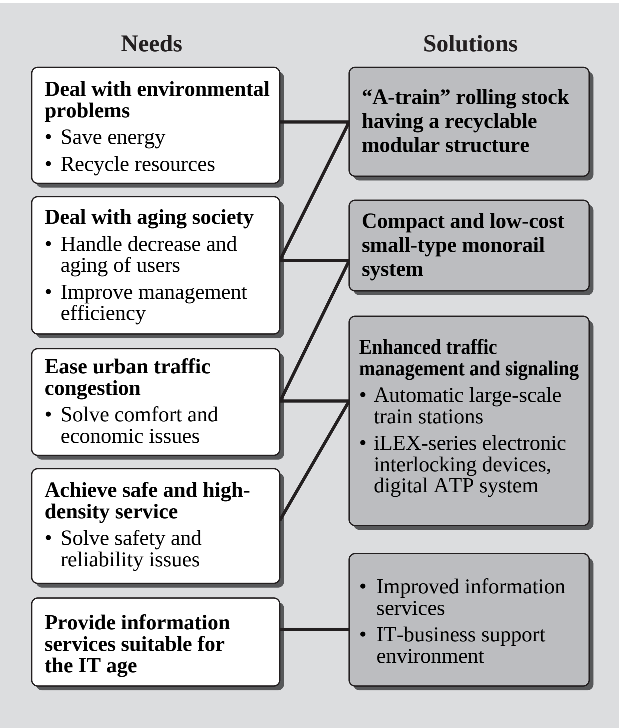


Fig. 2— Railway System Needs and New Solutions.
In response to recent needs, Hitachi proposes a wide range of new solutions from rolling stock to traffic-management and signaling systems and information services.

In addition, recent advances in IT have been accompanied by a diversification of demand, and services and conveniences more appropriate to the IT age are coming to be demanded in trains and stations where large numbers of people congregate.

In Japan, moreover, the coming of the aging society means not only a decrease in railway passengers overall but also an increase in elderly passengers. This tendency calls for a railway system that is even more comfortable and convenient.

At the same time, railway companies would be required to support for the recycling of materials like rolling stock and for saving energy to deal effectively with environmental problems. The aging society in Japan also means that the number of veteran employees is decreasing, and this means that raising the efficiency of operation and maintenance work is becoming all the more important.

Finally, in addition to meeting the demand for safe and stable high-density service, railway companies are finding it necessary to expand into the business of providing highly convenient services targeting a large number of passengers.

Based on the above needs of railway passengers and railway companies, Hitachi has come to propose a wide range of solutions that involve rolling stock, urban-transport systems, signaling systems, and new information services. The basic concept of this approach is illustrated in Fig. 2.

Several major solutions that have been recently proposed are described below.

COMFORTABLE, ENVIRONMENTALLY FRIENDLY ROLLING STOCK SYSTEM

New Environmentally Friendly Rolling Stock Concept: A-train

Hitachi has developed the "A-train" next-generation aluminum rolling stock system featuring completely new materials, structures and production system. The aim of this new system is to reduce environmental load (by saving energy and recycling/reusing resources) and

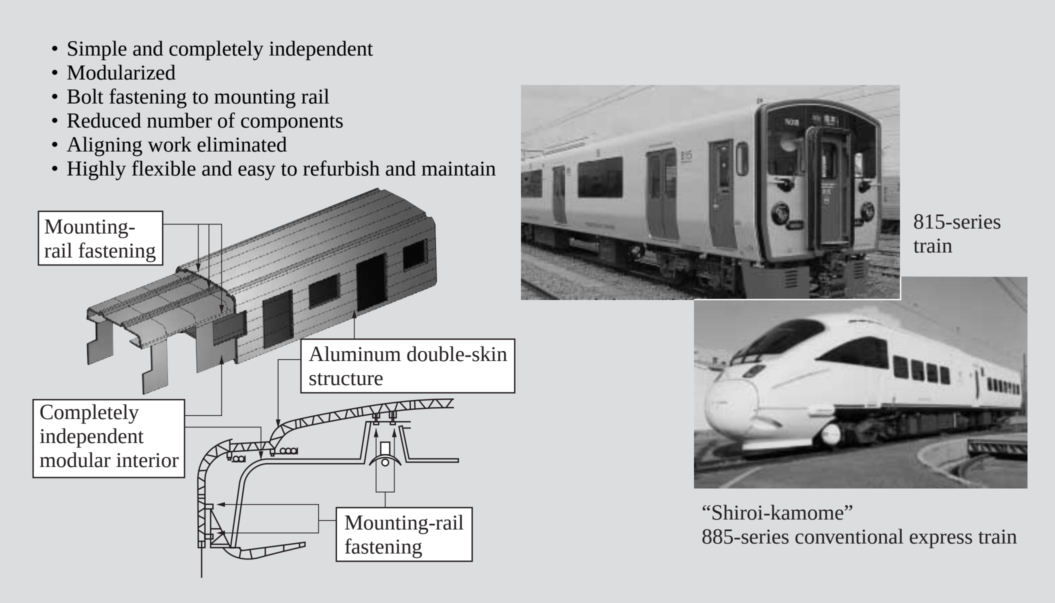


Fig. 3— A-train Concept and Appearance of Rolling Stock Based on That Concept.
Rolling-stock structure and production system have been dramatically modified with the aim of achieving high-grade, high-precision rolling stock conducive to resource recycling and reusability.

decrease recycling costs, and to deal with the reduced number of experienced engineers at rolling stock manufacturers as a result of an aging society. Application of the A-train system has already begun in commuter and express trains. Fig. 3 shows the A-train concept and examples of rolling stock manufactured according to that concept.

In this basic configuration, a high-precision, high-grade aluminum double-skin structure conducive to recycling and reuse is employed for the carbody, and the interior fitting is given a modular structure. These hollow extruded shapes are fastened to integrated mounting rails by bolts. What makes this configuration possible is a new welding technology called as friction stir welding (FSW).

A-train features are as follows:

(1) The characteristics of the aluminum double-skin structure make for a quieter cabin and a stronger body due to high rigidity, which results in improved safety. This aluminum double-skin combined with FSW technology enables the manufacturing of an attractive carbody without deformations.

(2) Adoption of a completely modular interior makes easy refurbishing resulting in a positive economic effect.

(3) From an environmental perspective, adoption of an aluminum-double-skin body structure and a modular interior makes it possible to achieve a lighter structure, decrease energy consumption, and reduce CO_2 emissions. It is also easy for disassembly and component sorting of carbody, resulting high recycling feature.

Train Traction System for Better Passenger Comfort and Easier Maintenance

Hitachi has been developing vector-control techniques, high-voltage insulated gate bipolar transistors (IGBT), and snubberless inverters with the aim of making train traction systems smaller, lighter, highly functional, and easier to maintain.

Recently, however, there has been more need for easier maintenance, small and lightweight configuration through enhanced efficiency (by improving energy efficiency and simplifying cooling equipment), and better passenger comfort. Hitachi has been engaged in the following developments to meet these needs. Fig. 4 shows the new train traction solution.

(1) Low-loss, high-voltage power devices called "high-conductivity IGBT" (HiGT) that simplify cooling equipment to reduce maintenance and raise efficiency

(2) New control systems for raising efficiency and functionality such as rolling-stock speed sensorless vector control and electrical brake control that expands the application area of regenerative braking

(3) Train power control using on-board data-transmission equipment for improved comfort in rolling stock

(4) Low-maintenance motor

NEW URBAN TRANSPORT SOLUTIONS

Hitachi has been developing and delivering medium-capacity transport systems to reduce the cost of constructing urban transport systems. These include urban monorails and the linear-motor metro subway system that can decrease the cross-sectional area of

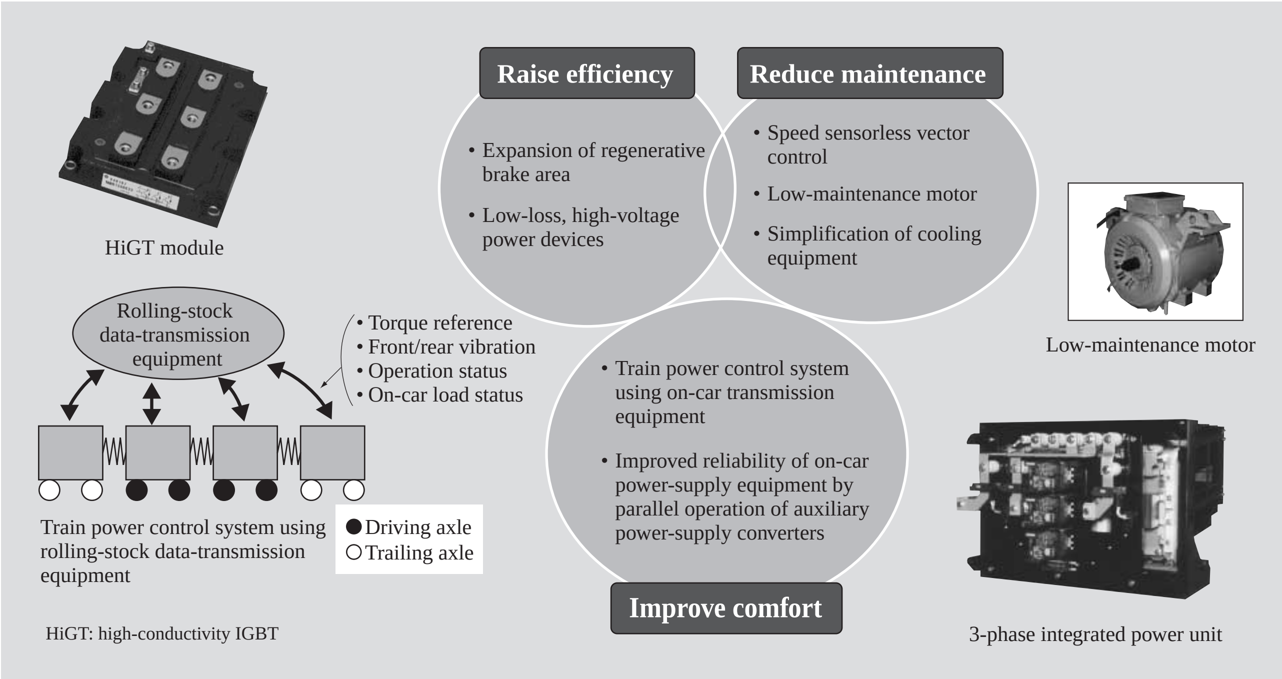


Fig. 4— Train Traction Solution.
Hitachi proposes a train traction system that covers the need for high efficiency, easier maintenance, and improved passenger comfort.

the tunnel. Hitachi is also proposing a compact monorail to meet the need for small-scale urban transport and a one-man system for raising the efficiency of urban transport. The following describes these solutions.

Small-type Monorail System

Hitachi has been providing a straddle type monorail as a means of urban transport. The straddle type monorail system was first deployed for the Tokyo Monorail between Hamamatsucho and Haneda Airport and thereafter for other major regional transportation companies. In general, an urban monorail constructed above a public roadway does not hinder surface traffic and is environmentally friendly since it blocks the roadside from sunlight only slightly and produces little noise. It is also a very economical means of transport in terms of construction cost compared to subways. Because of these features, the overhead monorail is considered to be an exceedingly effective type of urban transport that can eliminate traffic congestion not only in regional core cities in Japan but also in major cities throughout the world. At the same time, even smaller cities have expressed the need for compact monorails that can be economically constructed, and Hitachi has been researching compact monorails that can further reduce the cost of construction.

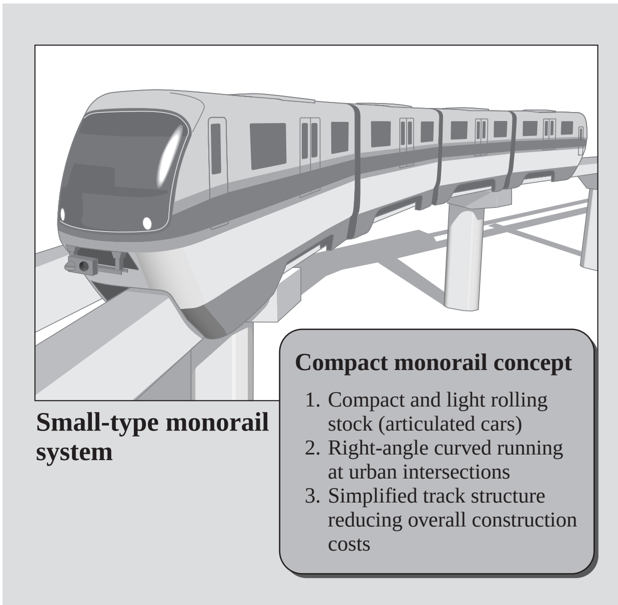


Fig. 5— Appearance of Small-type Monorail System and Design Concept.
Hitachi proposes the small-type monorail system that reduces overall construction costs as a solution for easing traffic congestion in small- and medium-size cities.

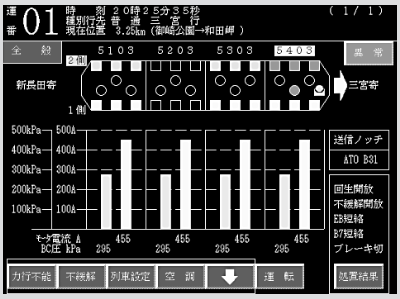
Against the above background, small-type monorail system has been developed by a straddle type monorail-system group centered about Hitachi (see Fig. 5). The features of this system are summarized

below:
(1) Articulated bogie system to achieve compact rolling stock and to enable 90-degree turns at urban intersections (minimum radius of curvature: 40 m)
(2) Adoption of DC750V for the rolling-stock trolley power supply from the viewpoint of compatibility with other small-scale traffic systems
(3) Adoption of a new blocking system in the signaling system suitable for small-scale transport

Efficient and Safe One-man-operation Support System

One-man operation and driverless operation are adopted to new and relatively small-scale transport systems. There are few examples, however, of one-man operation in existing medium- and large-scale systems. The recent environment surrounding railway companies, however, is prompting the adoption of one-man operation even in medium-capacity, high-speed railways with the aim of improving management efficiency. In fact, one-man operation is being planned from the start in recent construction of new lines and studies are being performed on migrating to one-man operation in existing lines.

Platform gate system:
Mita Line of Bureau of Transportation, Tokyo Metropolitan Government



Typical screen for one-man operation:
Kaigan Line of Traffic and Transportation Bureau, Kobe City

Fig. 6— Platform Gate and One-man Operation Screen.
A platform gate system to ensure platform safety for train boarders and a typical screen supporting one-man operation are shown.

To achieve one-man operation, Hitachi first of all proposes the systems not only to support driver operations including automatic train control (ATC), automatic train operation (ATO), and autonomous decentralized train integrated system (ATI), but also to provide a platform gate system combined with a platform monitoring system. In this way, Hitachi is proposing new operation-support systems as total solutions on both the train side and ground side. Fig. 6 shows an example of a platform gate system and a typical screen view of on-board one-man operation system.

TRAFFIC-MANAGEMENT AND SIGNALING SYSTEMS SUPPORTING SAFE AND RELIABLE OPERATION

Japan's railway systems are well known for their "safe and punctual operation," of which the basic platform systems that support these features are a traffic management system and signaling system.

Autonomous and Decentralized Traffic Management System for More Efficient Operations

Japan's railway systems feature high-density service, in which trains run with a headway (running interval) of two minutes or less, and punctual operation. The traffic management system has the role of ensuring these features. An issue in constructing a traffic management system is how to deal with a disrupted train operation. Up to now, the autonomous decentralized transport operation control system (ATOS) and similar systems in high-density railway sections within the Tokyo metropolitan area have enabled quick restoring of traffic from the disrupted situation. Such systems have also made it possible to provide reliable traveler information services based on updated running data[4].

Existing traffic management systems on conventional lines, however, are faced with a number of issues that must be addressed if traffic operations are to become more efficient. One important issue relates to control at large train stations. In addition to on-site switching that must be performed at the discretion of individual stations, large-scale stations were traditionally asked to perform main-line control individually although fully automatic control by a traffic management system was preferable. This approach made traffic adjustments at the time of a disturbance complicated and created delays in traffic operation. It also became an issue in terms of raising

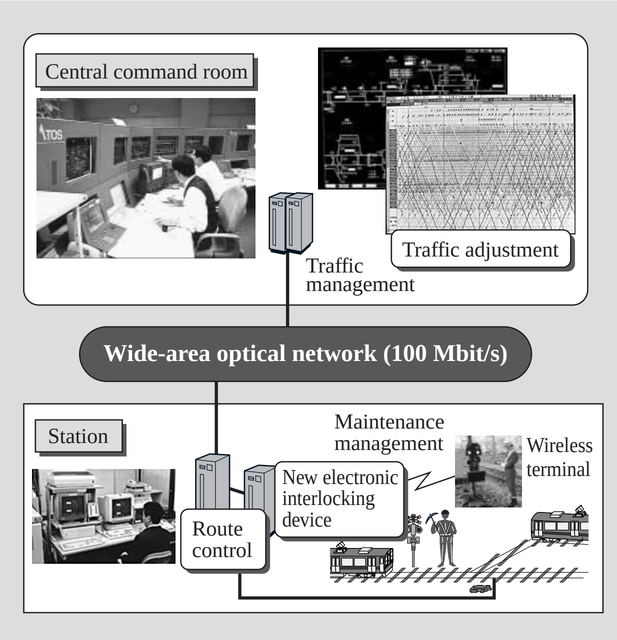


Fig. 7— Basic Configuration of Autonomous and Decentralized Traffic Management System.
The system is designed to automate large stations and to manage maintenance operations.

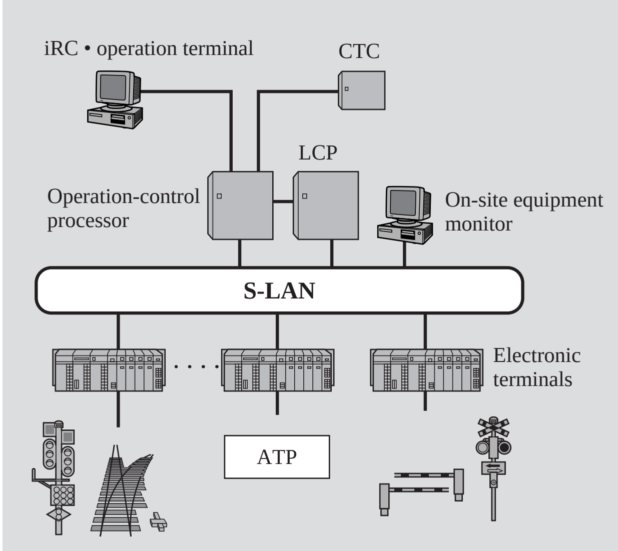


Fig. 8— Configuration of iLEX2000-series Electronic Interlocking Device.
Connecting the operation-control processor and the electronic-terminal section via a signal local area network enhances reliability and maintenance.

the efficiency of traffic management. Recently, however, decentralized station control systems have been introduced in large stations with the result that in-station switching operations and main-line control from a control center have become automated and efficient.

Another important issue is how to ensure safety and raise efficiency in maintenance work such as that on train tracks. In this regard, Hitachi's maintenance management system has made contributions to achieving safer and more efficient maintenance operations[4)]. The basic configuration of an autonomous and decentralized traffic management system is shown in Fig. 7.

Recent traffic management systems have also become large in scale, and many have been developed in a stepwise fashion since one-time development may not be possible. In such a case, that part of the system which is up and running and that part which is currently being constructed will coexist, and ensuring reliability in a system that is still in construction becomes an important issue. The same sort of problem occurs when replacing such a system. The technology needed to ensure reliability in such a growing system is called "assurance technology." Hitachi considers this to be vital technology and is engaged in its research and development[5)].

New Signaling System

New electronic interlocking device

Hitachi has delivered electronic interlocking devices to over 130 train stations mostly in high-density railway sections within the Tokyo metropolitan area. This equipment has the following features:
(1) Execution of interlock processing based on an interlocking table can shorten the development period when implementing an electronic interlocking device in a station and shorten the time required for modifying track wiring.
(2) Functions are provided for performing track maintenance and other maintenance-related operations (not possible with conventional interlocking equipment) and for preventing train collisions.

Furthermore, as a new solution that expands on the above, Hitachi has developed the "iLEX2000 series" of electronic interlocking devices featuring integrated electronic terminals. The configuration of iLEX2000 electronic interlocking devices is shown in Fig. 8 and their features are summarized below:
(1) Using simple tabular formats for interlocking/control tables and for facility lists that include a portion of electronic terminals enables stations to be newly

constructed or modified in an even shorter period of time.

(2) Remote monitoring, which includes status monitoring of on-site equipment such as terminal switches and signaling devices, enables faulty sections to be quickly identified in the event of equipment failure. In addition, the operating state of on-site equipment can be easily understood enabling preventive maintenance to be carried out.

Ground-train integrated signaling system

A conventional signaling system can detect train position from the ground side and it possesses control logic for issuing commands from the ground. This approach, however, results in many ground facilities and a large maintenance load. Hitachi's new ground-train integrated signaling system, on the other hand, gives on-board equipment intelligent features so that control can be performed independently on the train side. This system has the following features:

(1) A single-stage brake system that shortens the interval between trains and helps ease congestion.

(2) On-board control that decreases ground-based facilities substantially and eases the maintenance load.

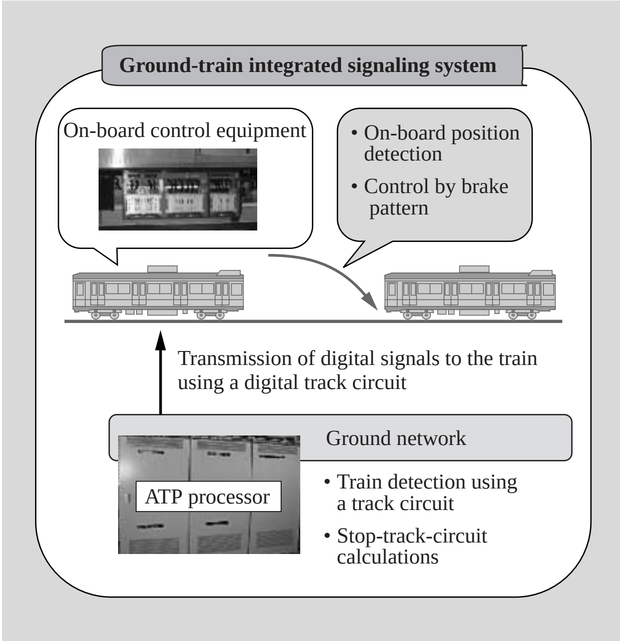


Fig. 9— Configuration of Digital ATP System.
Hitachi proposes a digital ATP system that aims to achieve high-density service for easing congestion in high-density railway sections, decrease ground facilities, and improve maintainability.

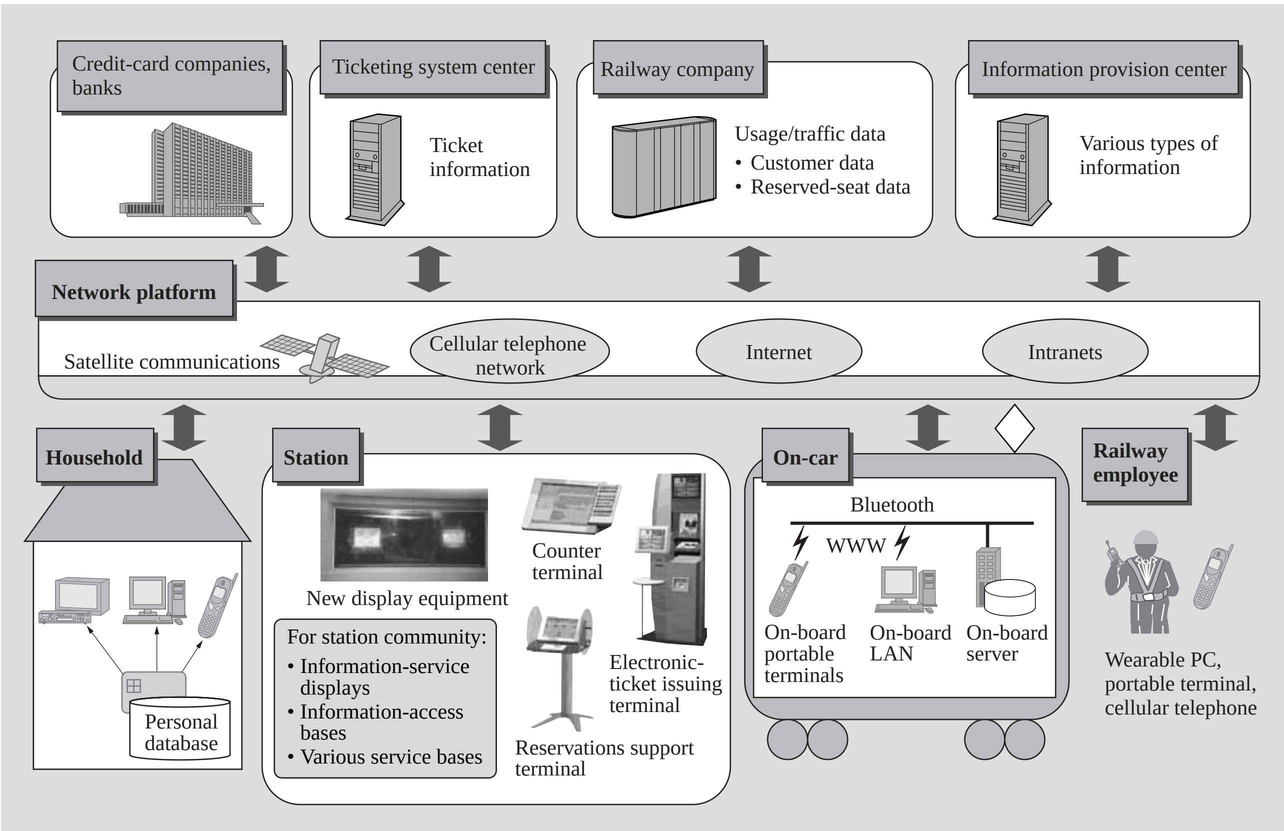


Fig. 10— Concept of Information Service Systems for Railways.
Hitachi proposes information-service-system solutions to enhance railway-user services and support expansion of railway companies into the information services field.

The following two systems are currently being promoted in collaboration with the East Japan Railway Company as part of the development of the above ground-train integrated signaling system.
(1) Digital ATP: Uses a track circuit for transmitting ground-based and train-based information.
(2) Wireless train-control system: Uses a wireless scheme for transmitting ground-based and train-based information.

The configuration of the digital ATP system is shown in Fig. 9.

NEW INFORMATION SERVICE SYSTEMS FOR RAILWAYS

On the user side, there is a growing need to make railway services more appealing through the use of information technology, and on the railway-company side, there is a growing desire to expand business by entering the information services field. In response to these needs, Hitachi proposes the following solutions for achieving new information service systems for railways (see Fig. 10).
(1) IT solution for improved railway services: New railway services using IT for home, station or while traveling in a train
(2) Service solution targeting the station community[3]: Providing information access and value-added services at stations where a large number of people congregate
(3) Solution related to electronic ticketing: With regard to the digitization of railway tickets that has already begun in part, an electronic ticketing system that covers ticket reservation, issuing, and payment and the services that use these functions

CONCLUSIONS

This paper has described Hitachi's total solutions for railway services.

The railway, as an environmentally friendly institution of public transport, and the station, as a public site where a large number of people come, are expected to undergo major expansion in the years to come. The safe and punctual features of Japan's railways are being reexamined throughout the world for a new global expansion of railways.

For the future, Hitachi, as a total system integrator for railways, will continue to propose innovative solutions to cover a broad range of user needs from rolling stock to signaling and service systems.

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