# Leading-edge Solutions for Next-generation Railway Systems

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*OVERVIEW: Interest in railway systems as a sustainable means of medium to long-distance mass transit is increasing worldwide. To meet that interest requires improvements in passenger car quality, even greater environment-friendliness and use of IT to provide information. It also requires more advanced train control that involves cooperation between on-board and track-side systems through use of broadband communication systems that employ wireless links. As a comprehensive railway system integrator, Hitachi has implemented the Nanakuma Subway Line system of the Fukuoka City Transportation Bureau, the Tsukuba Express railway system of the Metropolitan Intercity Railway Company and a passenger system that incorporates advanced IT. We also continue to improve quality in the various aspects of railway transportation systems and to develop advanced system solutions.*

## INTRODUCTION

THE railway is an excellent transportation system with respect to both people and the natural environment, so expectations for effective use of railways in the future are on the increase worldwide. Many people choose rail as a means of transportation, and to respond to social expectations, we must further expand on safety and punctuality, which are the main features of rail travel, and improve quality in various respects from the users' point of view (see Figs. 1 and 2).

We have been planning the development of information processing technology to supplement an existing travel information service system that is used by the passenger before boarding the train and provides ticket issuing, seat reservation and operating information. The control systems that support train operation include various kinds of technology concerning the railway cars in which passengers ride and the signaling systems and traffic management systems, which are the crux of safety support and which are moving toward integration into a single, huge system. Efficient functioning of these systems

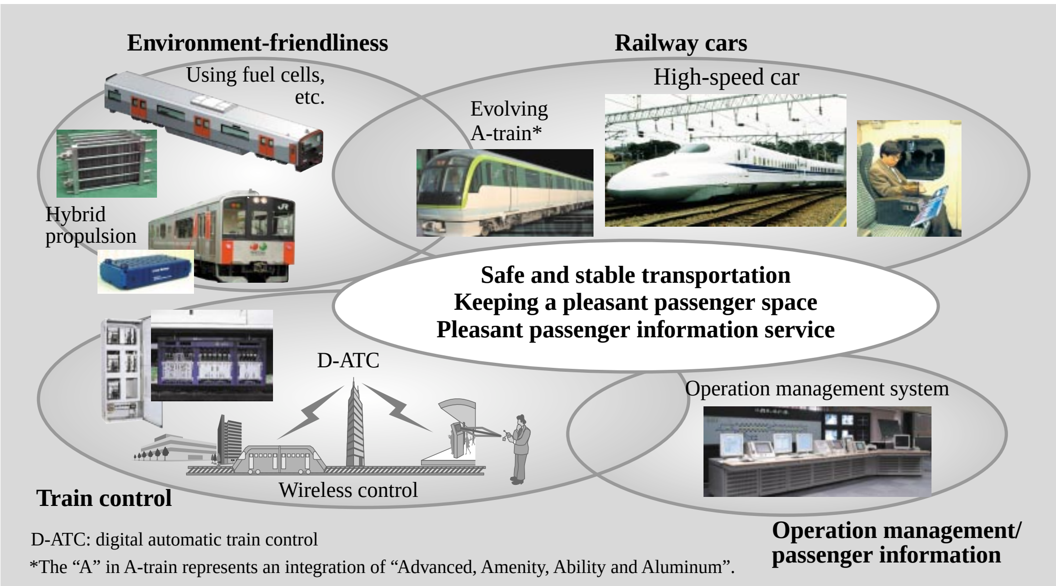


*Fig. 1—Overview of Hitachi Total Solution Railway System.*
*Hitachi provides broad support for advancement in railway systems that pushes into the next generation with the development of railway car systems, signal systems, and service solutions that employ IT.*

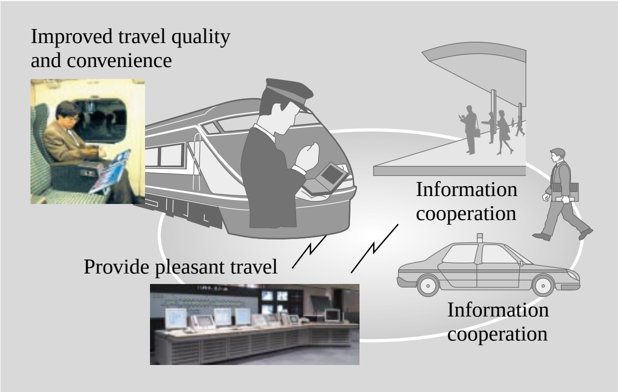


*Fig. 2—Requirements for Convenient and Easy to Use Railway System.*
*There are high expectations for railways as a safe and environment-friendly transportation system, and there is a demand for evolution of the system from the viewpoint of the user.*

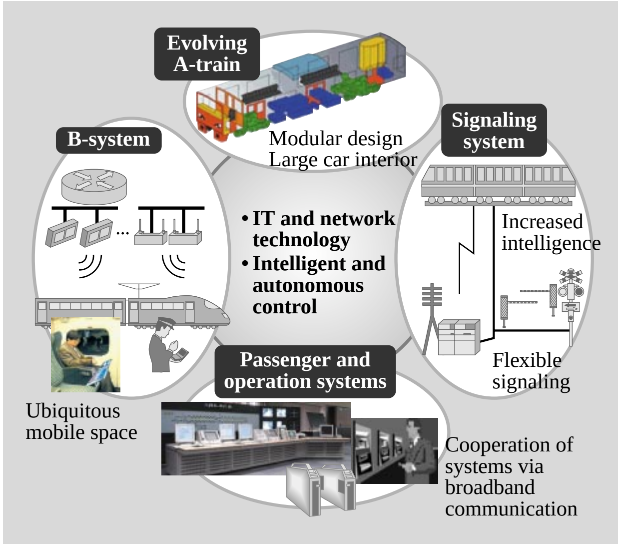


*Fig. 3—Development Concept for New Railway Systems.*
*Achieve higher quality and convenience by cooperation of on-board and track-side systems through IT.*

provides safe travel services. We will continue to strive for even more advanced systems through the development of information and device technology to achieve railway systems that are even more convenient and easier to use for passengers.

Improvement of the functions of railway systems has been a goal over the 180 years of railway history, which began in U.K. Now, the social role of rail travel is being reconsidered with hope for solutions to the global environment problem, traffic congestion in large urban areas and other such problems, and there is a demand for development of systems that even more people can use in comfort.

Here, we take up the development of Hitachi's proposed railway system and describe the most recent implemented solutions.

## NEXT-GENERATION RAILWAY SOLUTIONS

Hitachi began manufacturing electric locomotives in 1924. Since then, we have expanded the scope of our products to provide systems for various aspects of railway operation. We have developed systems for supporting passenger services through early adoption of electronic technology and network technology, including a large-scale on-line system for seat reservation and a traffic management system.

Regarding the train car, we have been working to improve comfort and other aspects of quality under the A-train concept. (The "A" here refers to the integration of the concepts of Advanced, Amenity, Ability and Aluminum.) Regarding the information and control system, we are advancing railway broadband services that integrate control and information under the B-system (broadband network system) concept, which makes use of a broadband network. In signaling, too, D-ATC (digital automatic train control) and electronic operation consoles, etc. are used to implement systems that make good use of IT.

The system solution concept to be developed in the future is the fusion of systems that have been developed with IT and network technology individually to provide new services such as those described below and to improve quality (see Fig. 3).

(1) The evolving A-train and B-system: providing a large and high-quality car interior at low cost, with information services provided through cooperation with the B-system to provide a ubiquitous space

(2) Signaling system: in addition to adding intelligence to on-board control, achieve a signaling system that is both safe and flexible by strengthening the cooperation between on-board and track-side systems.

(3) Passenger and traffic system: promotion of greater system intelligence, such as selectively offering information that is appropriate for individual passengers and responses that are prompt and appropriate according to traffic conditions

By developing such capabilities, we aim to achieve pleasant, economical, and safe high-density traffic operation and to improve business efficiency and maintainability.

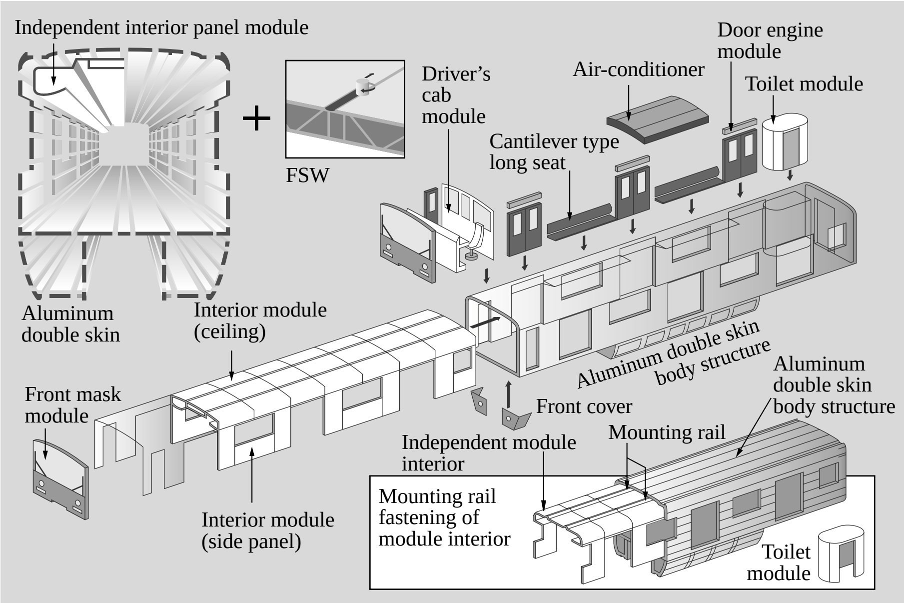


*Fig. 4—Overview of 3000 Series (A-train) Cars for Nanakuma Line of Fukuoka City Transportation Bureau.*
*Progression from aluminum double-skin body structures to triple-skin structures and modular design that extends as far as to electrical products are features of this system.*

## NEW SOLUTIONS CONCERNING TRAIN CARS

### The Evolving A-train

Hitachi has already received orders for over 1,000 cars that are extended according to the A-train proposal, and we have taken on the challenge of developing the latest technology. We are aiming to achieve a thinner structure that insulates against noise and heat with aluminum double-skin body structures constructed by FSW (friction stir welding), which produces high-precision car body structures, and triple skin, which evolved from the basic concept known as module fitting (see Fig. 4). We have also given attention to structures that are installed beneath the floor, which are largely neglected in conventional car body construction, and considered the structure of the inverter, moving forward with development oriented to solutions needed for next-generation cars.

We have also concluded formal contracts with HSBC Rail (UK) Ltd. for the supply of A-train cars, and we are proceeding with development of cars that can also fully conform with international passenger car standards. Examples include conformance with standards for improvement of collision safety, guaranteed survival space, and crushable zone impact energy absorption structures.

We have also begun improvement of inverter technology as part of the car electrical system, and in collaboration with East Japan Railway Company, have moved forward with research on hybrid propulsion technology in which diesel engines and secondary cell batteries are used. That technology is generating great expectations, because steam powered locomotives are still common worldwide.

### Broadband Era B-system

Through e-Japan and u-Japan Strategies and other such programs promoted by the Japanese government, broadband information technology is being established as a fundamental technology for ordinary society. u-Japan in particular plans for various social services to be implemented with information communication technology for social life in 2010.

Information communication technology has begun to be employed in train control and signaling as well as for use in passenger information services, on-board mail access, and other such services. Taking train control as an example, broadband communication makes it possible for advanced control signals, which have up to now used physically different communication lines, to be sent and received over the same line as the large quantities of information involved in information services. In addition, communication between systems on the track-side and on-board systems on a moving train has, in the past, supported only the minimum communication required for the task. Now, however, the wireless LAN technology and moving vehicle communication technology that has been developed in recent years is being applied to construct an environment that allows access to high-quality communication services even from within a moving train. Hitachi has been developing the B-system, an efficient railway system in which control data and information are integrated by connecting various

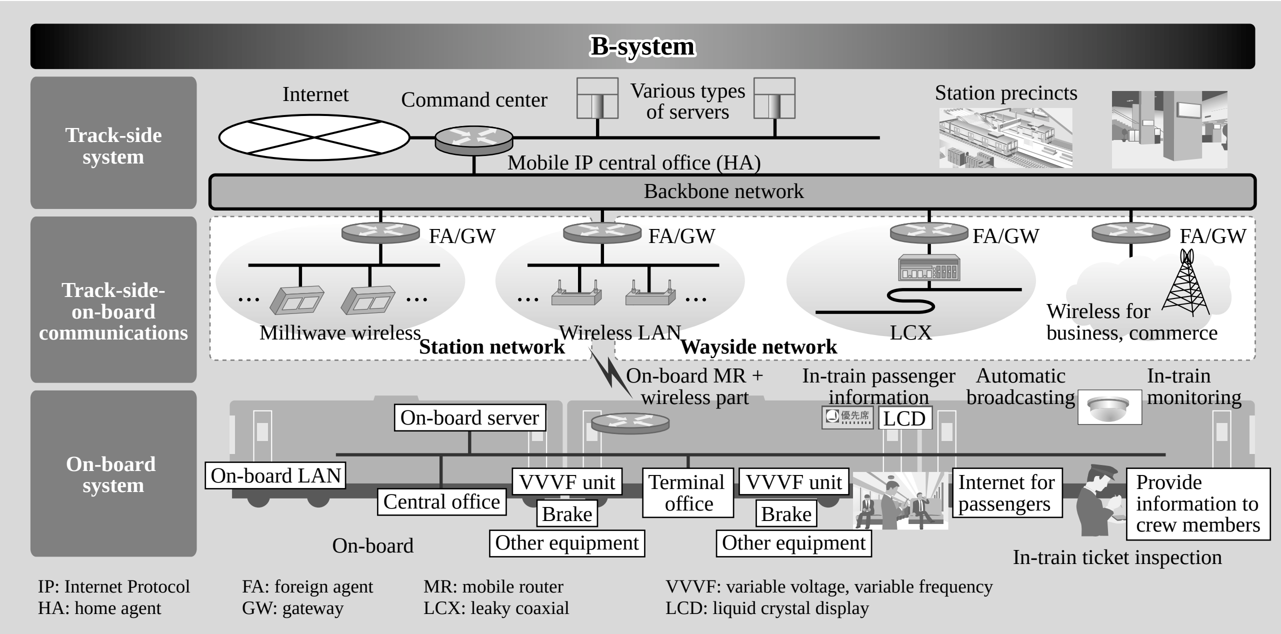


*Fig. 5—Example of Broadband Communication Application (B-system).*
*Linking track-side systems with on-board systems via a broadband communication network strengthens cooperation between those systems and provides pleasant information services within the passenger cars.*

on-board devices and track-side systems via a high-speed, large-capacity communication network (see Fig. 5).

## SIGNALING SYSTEM

### Development of an On-board Main Signaling System

IT is also being introduced to the signaling system in the form of digital ATC, etc. The digital ATC system maintains an on-board line database and protection patterns, and generates on-board protection patterns based on the limit of movement authority signal from the track to protect the train. This can be seen as a leading-edge system that is moving towards adding intelligence to on-board and track-side systems. Train location is detected from the track circuit and the limit of movement authority for which safe running is possible is calculated on the track side. The information is then passed to the train through the track. In the train, a running pattern is generated on the basis of the received limit of movement authority and the train then moves autonomously (see Fig. 6).

In the future, we expect the trend towards on-board autonomy to continue with even further increases in the intelligence of on-board systems. The functions will be divided between track-side train control systems for overall safety management and on-board systems for autonomous train operation within the scope of guaranteed safety. Communication between the on-board and track-side systems will allow cooperation between them.

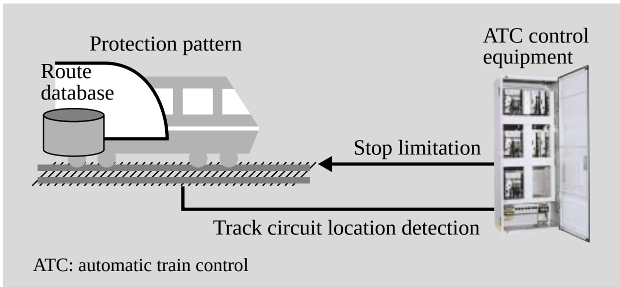


*Fig. 6—D-ATC Control Concept.*
*With D-ATC, the train receives stop limitation signals from the track circuit for safe autonomous running.*

In a typical basic system configuration, the results of on-board train location detection are sent to the system on the track side, where the information is processed. Track-side equipment sends to each train limit of movement authority positions for the routes on which operation is safe as well as timely information. The objective is to implement a system that allows the various trains that have received the information to run safely and autonomously, achieving safe and flexible train operation based on the operations schedule, the current operation situation and the needs of passengers. That requires improvement

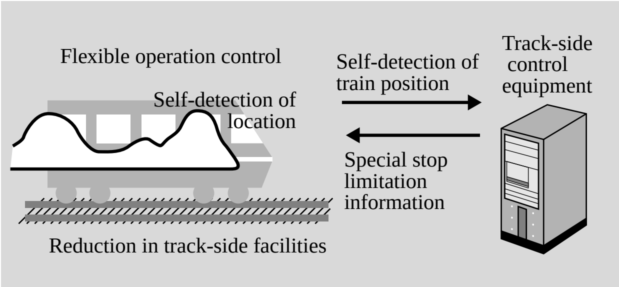


*Fig. 7—Signaling System with Cooperation between On-board and Track-side Systems.*
*The train detects its own location on board and operates safely and flexibly according to signal information received from a track-side system.*

of mobile communication technology and the establishment of safe on-board location detection technology. Hitachi is pushing forward with development of that technology. We also believe that proceeding with this technological development will allow reductions in track-side facilities and cost, as well as proposals for signaling systems of higher quality (see Fig. 7).

### Networked Station Signal Control

We are developing a control method that employs network communication for point control and signal control at stations. Conventionally, the control functions are centralized in the fail-safe devices that reside in the machine rooms of stations. The local control devices are connected to the machine room individually by control lines for control of train course changes and signal lamps. The very large amount of wiring between the machine room and the controlled equipment on the station premises that is required by this system causes problems in construction and maintenance. To deal with that problem, Hitachi has collaborated with East Japan Railway Company to develop a system in which the machine room and the controlled devices are connected by a network. Specifically, fail-safe terminals are installed at the site of each controlled device and the communication with the control room required for control is done via the network. This is expected to greatly reduce the number of above-ground control lines, including power lines, that are laid at times of repair or new construction at stations. We are moving forward with continuous development of smaller and less expensive terminals that can be used in common by various types of stations (see Fig. 8).

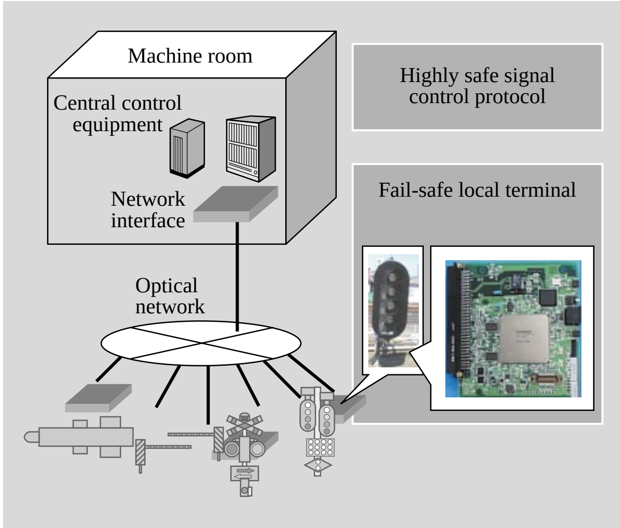


*Fig. 8—Example of Networked Signaling System Configuration.*
*Safe ways to use optical passive networks and small fail-safe terminals to greatly reduce wiring at stations are developed.*

## INFORMATION AND CONTROL SYSTEM AND PASSENGER SYSTEM FOR EXPANDING COOPERATION

### Information and Control System for Expanding Cooperation

The systems described below were introduced in transportation control systems and automatic operation systems for newly constructed lines:

(1) The transportation management system was implemented for the Kyushu Shinkansen which began operation on March 13, 2004. In addition to the traffic management system, which handles mainly dispatching, we were responsible for the development of the system for transportation planning and management, passenger information system and other such systems. For high reliability, the traffic management system employs an FTC (fault tolerant computer) for train number comparison and track circuit tracing.

A special feature of the Kyushu Shinkansen operation is a passenger transfer to an older express line that occurs at the Shin-Yatsushiro Station. To conduct this transfer in a way that does not inconvenience passengers requires close cooperation concerning the operating information of the Shinkansen line and the older line. To achieve that cooperation, we developed an interface and implemented a connection control and connection information system. We thus were able to improve the quality of passenger information services through the

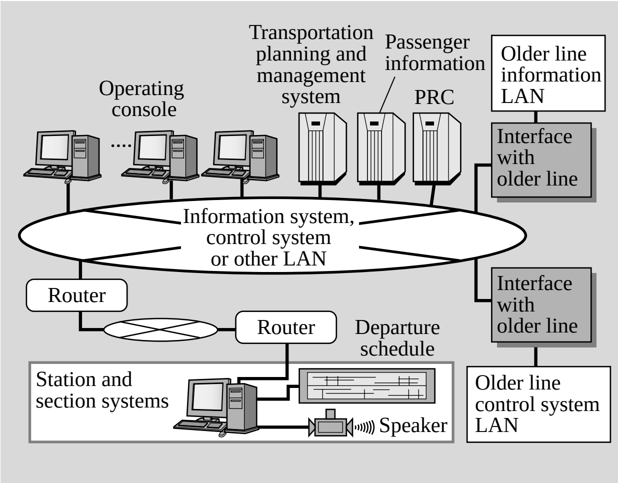


*Fig. 9—Overview of Kyushu Shinkansen Transportation Management System.*
*Cooperation between the new Shinkansen transportation management system and an older system was achieved with minimum modification of the existing transportation management system by developing an interface for the older rail line.*

TABLE 1. Functions Required of Fully Automated Subway System
*We are implementing these required safety functions to realize full-automatic train operation.*

| Functions required |
|---|
| (1) A means to prevent the stopping of a running car between stations and a means to make it possible for a car to move to the next station even in the event of a stopped train |
| (2) A redundant system or two-unit equipment configuration for equipment that is directly related to car running so that the function is maintained even if one system or unit stops working. |
| (3) The running function, the function for communication with the dispatcher, and the functions for prevention of passenger anxiety of the principle devices shall not be lost when the auxiliary power source stops working in trains that have stopped between stations because of loss of power from aerial power lines, etc. |
| (4) On-board security equipment shall have a redundant configuration of main components and a fail-safe mechanism for the system as a whole. |
| (5) Cars shall be equipped with a system for rapid evacuation guidance etc. when an abnormality arises in a car. |

sharing of schedule information and operating information with minimum effect on existing systems (see Fig. 9).

(2)We developed a full-automatic operation system for Nanakuma Subway Line of the Fukuoka City Transportation Bureau, which started operation on February 3, 2005. This was the first full-automatic operation of a subway in Japan. The main factor that has prevented this in the past is believed to have been concern over coping with abnormal situations in mass transit and subway tunnels. To achieve full-automatic operation requires that there be no stopping of trains between stations, no cause of concern to passengers, and a guarantee of safe train operation. The basic functions required to meet these conditions are listed in Table 1.

For that purpose, a function for two-way information transfer between on-board and track-side systems is prepared. That allows monitoring of status of the devices on the train and detection of device failures, abnormal vibration and other such states and fast transmission of the data to the dispatcher. For the on-board systems, we also developed technology that contributes to safe, fully automatic operation, including improved reliability through redundant configuration, running back-up, and instruction from the dispatcher.

(3)Monorail system

Hitachi has accumulated much experience as a total supplier of straddle-type monorail systems. Hitachi has manufactured and supplied cars, electrical products and other components for China's first urban monorail, which started operation in Chongqing City in June 2005 (see Fig. 10).

*Fig. 10—Monorail in Chongqing, China.*
*China's first urban monorail began operating on June 18, 2005.*

We plan to actively expand these systems, including the track-side traffic management system and substation system, which have been built up from many years of development, to overseas markets.

(4)The newest Tsukuba Express railway system

For the Tsukuba Express, which began operation in August 2005, Hitachi has supplied TX-2000 Series cars and was involved in the construction of movable platform gates, traffic management systems and other such work (see Fig. 11). The cars use the latest aluminum double-skin body structures for increased quietness and strength to achieve a safe and pleasant


*Fig. 11— Tsukuba Express Car and Platform Gate.*
*TX-2000 series cars (left) and platform gates to support safe driver-only operation (right).*

passenger environment. Our objective was to achieve pleasant, high-quality passenger transportation by implementing driver-only operation, movable platform gates and an ATO (automatic train operation) function that increased stopping position accuracy, and a better passenger broadcasting and information service to improve passenger services.

## Convenient Passenger Systems

### Passenger information services

Railway transportation services are changing from simply being a means of transportation to being a system for supporting the daily life of customers by constructing a pleasant living space on the lines of flow that connect the places in which railway users engage in their lifestyles.

Among the passenger services, the gaze rate of passengers is high, so the value of various kinds of information provided inside the train car is high for both the provider and the user. We are therefore setting up an organization to develop LCDs for use within the train cars and plasma displays for use in stations and to provide them as a system. On the Nanakuma Line described above, effective advertisement information is presented via in-car displays.

### Future development of the passenger sales system

As a pioneer in passenger sales systems, Hitachi has developed various kinds of leading-edge technology in the time since the JR Group's reservation system "MARS (multiple access reservation system)" was made practical. One example of that is the development of an electronic ticket ID (identification) management system. The ubiquitous information society is arriving and, for railways too, the use of ID boarding tickets is expanding and compatibility with mobile devices equipped with IC card functions is continuing to progress. We are steadily moving forward with the use of open platforms for implementing those functions.

Hitachi will continue to take up the challenge of proposing total system solutions, drawing on expertise in the construction of information systems for passenger sales and operation and management systems (see Fig. 12).

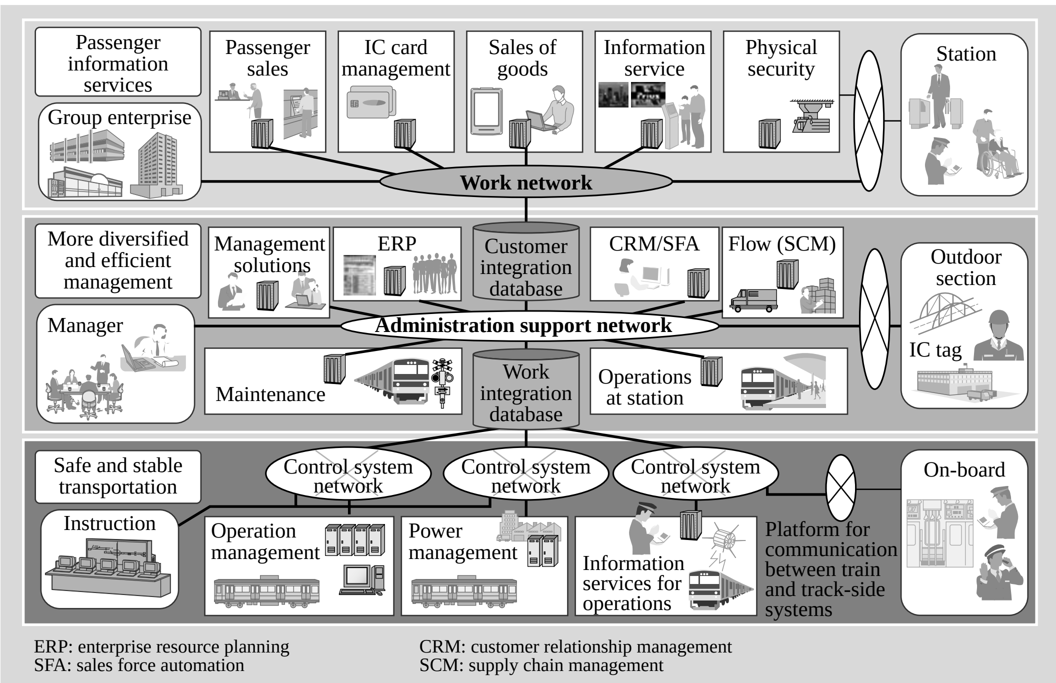


*Fig. 12—Overview of Total System Concept for Passenger Sales System.*
*Hitachi is taking up the challenge of constructing a total system for the passenger sales and operation system and the management system.*

**(a) Regenerative energy absorbing equipment**

**(b) Dry-air insulated switchgear**

*Fig. 13—Example of Substation Equipment that is Friendly to the Environment.*
*Achieving effective use of regenerated power and $SF_6$ gasless equipment implements a typical environmentally-friendly substation.*

## ENVIRONMENT-FRIENDLY SUBSTATION SYSTEM

The most recent railway substation systems emphasize the need for environment-friendliness, low-loss, compactness and low maintenance. To meet those needs, products such as environment-friendly $SF_6$-gasless switches, silicon-filled transformers, and low-loss eco-rectifiers are being developed. We have also developed a storage battery regenerated energy absorption system that employs the same lithium ion batteries that are used in hybrid automobiles to make effective use of regenerated power. Field experiments that are currently in progress point to the practicality of this system (see Fig. 13).

## CONCLUSIONS

We have described systems that have been implemented by Hitachi, focusing on the direction of the development of Hitachi's new railway total solution proposal.

In the future, it will be necessary to implement passenger services of even higher quality so that even more people will be able to use railways in comfort, in addition to providing a safe and punctual railway system. Taking a world-wide view, Japanese technology is attracting more attention from other countries in Europe and Asia and beyond, creating expectations for steady global expansion.

Hitachi, as a railway total system integrator, will continue to propose solutions for even higher levels of quality in the future.

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