Latest Total Solutions for Railway Systems

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OVERVIEW: Throughout the world today, railway systems are being expected to play important transport roles and to develop further. To do so they must be punctual, provide high-density service, and be in harmony with the environment. In those circumstances, the safe and punctual railway systems in Japan are currently the focus of more worldwide attention than ever before. As a total system integrator, Hitachi provides a wide range of total solutions to meet railway needs, including new rolling stock, such as the A-train, and new signaling and power conversion systems. Among the recent issues concerning railway systems in Japan are environmental concerns, response to declining birthrates — i.e., fewer passengers — and an aging population, and the providing of information services fitting for the broadband age of communications. To respond to those issues, Hitachi provides a wide range of new solutions, such as its A-train rolling stock boasting of a recyclable modular structure and a new production system. Other solutions include a new energy train fitted with a hybrid power system, B (broadband network)-system as an information system for trains, an automatic operation support system for ensuring safe and efficient automatic train operation, traffic management systems, signaling systems, and a railway power conversion system that is environmentally friendly.

INTRODUCTION

IN the context of the attention being paid worldwide to environmental issues, railway systems have advantages in terms of punctuality and handling mass transport; at the same time, they consume less energy than airplanes (one-ninth) and passenger cars (one-sixth)[1], so they are expected to play an increasingly important transport role because they are environmentally friendly.

Roughly 160 million persons ride in trains each day around the world. The passenger utilization rate in Japan of 62 million passengers per day is equivalent to about 40 percent of that figure[2]. Two main reasons account for the high utilization rate in Japan: safety, and punctuality. Punctuality is proven by Tokaido Shinkansen (bullet train). Statistics show that the average time for all Shinkansen trains to be late is 0.3–0.6 minutes per train, including time lost because of typhoons or other natural causes[3].

Supporting the safety and punctuality of Japan's railways are the rolling stock, signaling and information control systems, transformers and other equipment, and the technology for maintaining the hardware and software.

Hitachi's beginnings in the transportation systems business trace way back to the first of a series of steam locomotives produced in 1920 (see Fig. 1), followed by an electric locomotive produced in 1924. Since then Hitachi has manufactured not only rolling stock and related electrical products for the Shinkansen, local lines, subways, linear subways, and monorails, but has also developed signaling systems to ensure safety, traffic management systems to support high-density train operation, support systems for driverless and one-person operation trains to increase the safety and efficiency of urban transport systems, power conversion systems, seat reservation and other sales-related systems, and new service systems using IC (integrated-circuit) cards. Hitachi also offers a range of solutions for ensuring the safety of railway systems, on-time scheduling, more efficient business management, and improved service to customers.

This article introduces some of Hitachi's new solutions for railway systems (see Fig. 2).

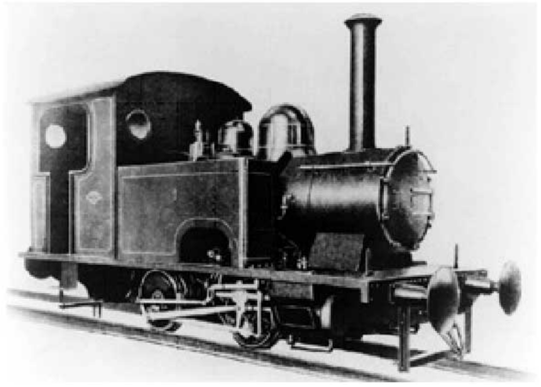

Fig. 1—First of Series of Steam Locomotives (1920).
Hitachi's beginnings in the transportation systems business trace way back to manufacture of its first steam locomotive in 1920.

NEW TOTAL SOLUTIONS FOR RAILWAYS

Included among the recent needs of railways are responses to environmental issues, improved business efficiency in line with Japan's trend toward declining birthrates and an aging population, greater comfort and improved service for customers, continued response to safe and punctual high-density traffic, and improved maintenance. Hitachi is responding to those various needs by providing the following solutions (see Fig. 3).

(1) Evolving A-train: next-generation rolling stock with completely new materials, structures, and production system.

(2) B (broadband network)-system for broadband

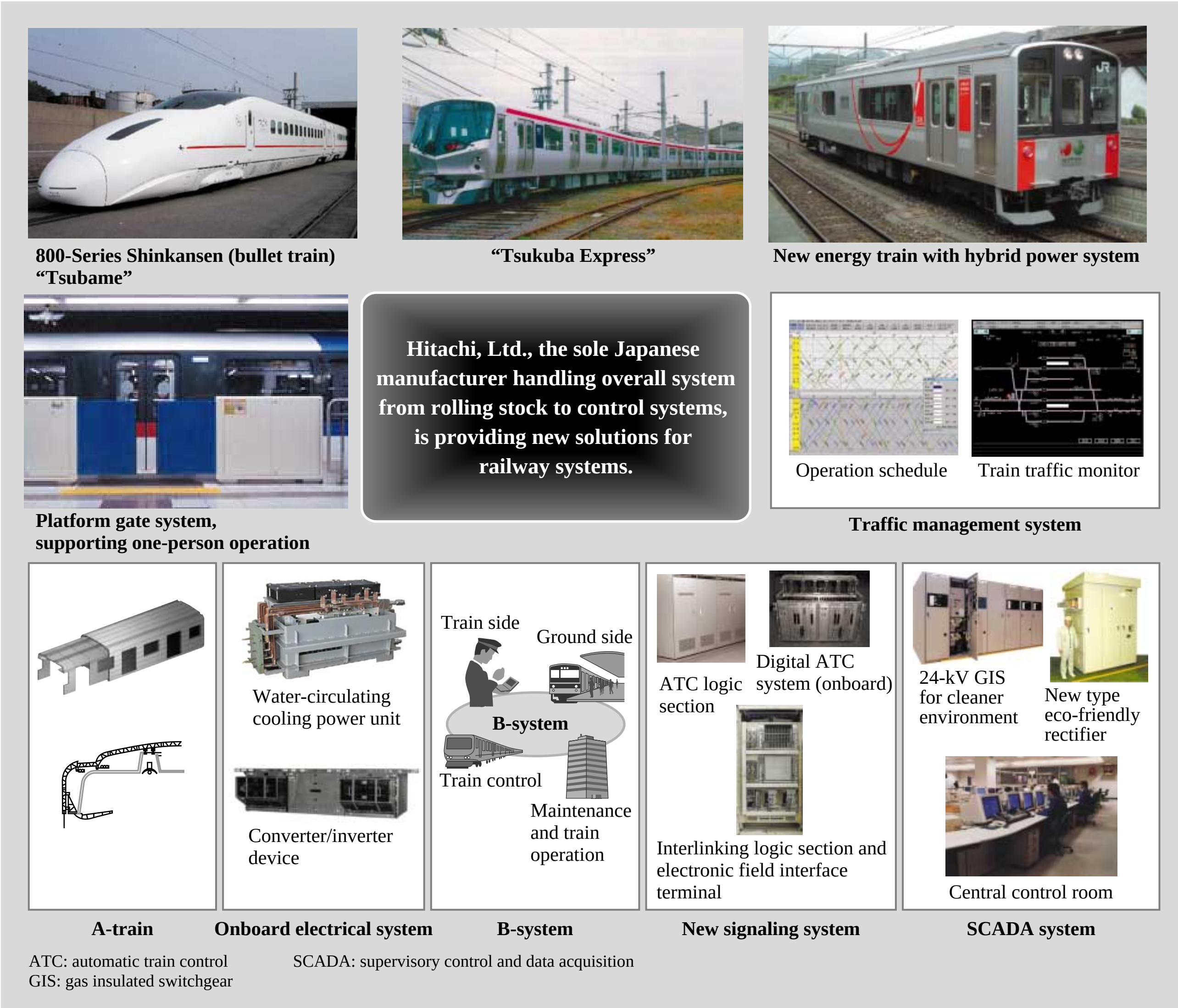

Fig. 2—New Total Solutions for Railway Systems Proposed by Hitachi.
As a total systems integrator, Hitachi proposes a wide range of solutions for railways, from rolling stock, signaling and traffic-management systems, power control and power conversion systems, to support for one-person train operation.

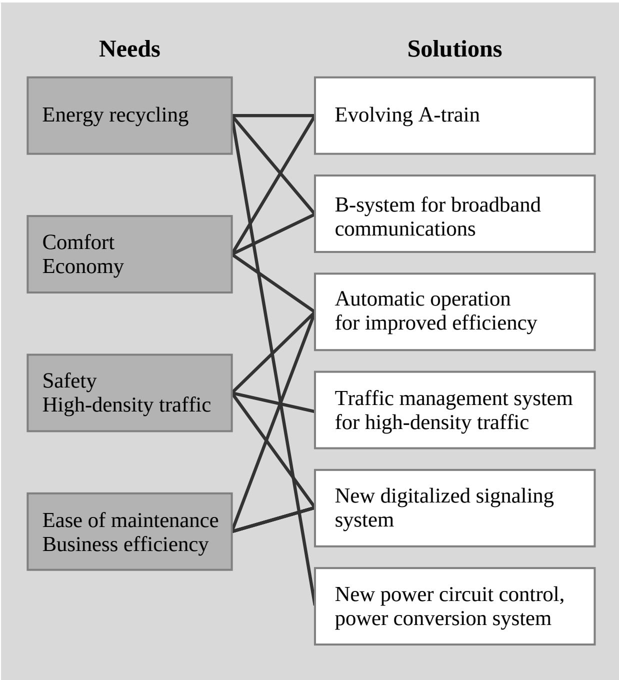

Fig. 3—Railway Systems Needs and Solutions.
Hitachi responds to various needs of railway systems by providing wide-ranging solutions from rolling stock to information services.

communications: linking trains to ground control via broadband networks to realize more efficient operation and maintenance, and improved passenger services.
(3) Support systems for automatic operation of trains to realize greater efficiency: support systems for automatic operation for one-person or driverless trains.
(4) Traffic management systems to support efficient line operations: integrated traffic management systems are spreading across urban transport networks to support high-density traffic sections.
(5) New signaling systems: newly developed signaling systems use digital technology to substantially reduce the size of equipment and realize onboard initiated semi-mobile blocking control.

A-TRAIN AND B-SYSTEM ADD UP TO MORE COMFORTABLE ROLLING STOCK

Evolving A-train

Hitachi's A-train is next-generation rolling stock manufactured using completely new materials, structures, and a new production system. The basic technology supporting the A-train includes a modular interior structure and an aluminum double-skin structure utilizing FSW (friction stir welding) to produce a high-precision car body (see Fig. 4). Hitachi has thus far received orders for over 1,000 A-train cars, and is now conducting research for improving the A-train's crashworthiness by securing safe space for passengers and absorbing in a crushable zone the energy generated in a crash.

Fig. 4—E257-Series Super Express DC Electric Train Produced for East Japan Railway Company.
Hitachi has received over 1,000 orders for the A-train, including those for the E257-Series super express DC electric train.

Hitachi's engineers also continue to make efforts to develop an onboard electrical system that is superior in ease of maintenance and reflects environmental concerns. In particular, the hybrid power system jointly developed by Hitachi and East Japan Railway Company, which applied technology for systems for electric rolling stock to the power system of railcars, is expected to provide substantial positive effects as a new solution for responding to environmental concerns.

B-system for Broadband Age

Recent years have seen a series of new services being provided as broadband network technology links together systems used in companies, homes, and urban centers. The application of broadband communications technology to railway systems is expected to link multiple systems for improved efficiency and convenience.

In order to respond to such needs, research is being promoted to provide more convenient and efficient railway systems by using broadband networks aboard trains to link onboard control devices as well as to link onboard systems with ground systems.

Hitachi is also developing an efficient high-speed, high-capacity railway system network called the B-system that will not only link the control devices

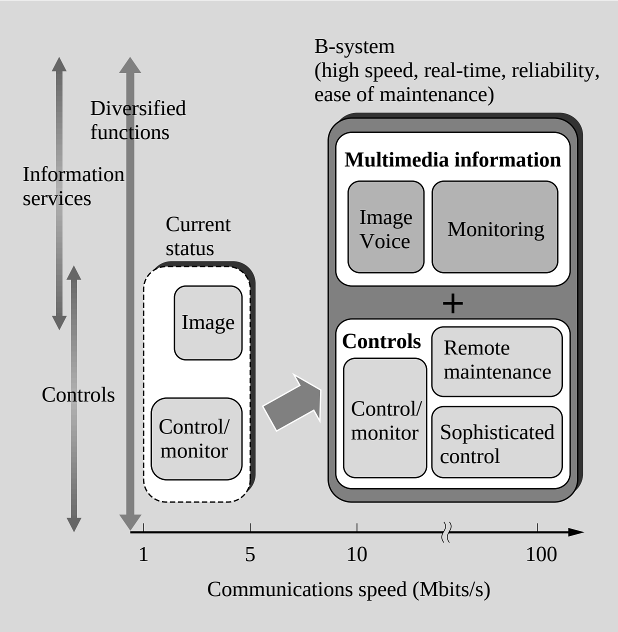

Fig. 5—Outline of B-system Functions.
A high-speed, high-capacity network integrates functions such as control, remote maintenance, and onboard monitoring.

Fig. 6—One-person Operation of Trains on Tokyo Monorail Line.
One-person operation on the existing Tokyo Monorail Line was realized by adding functions such as platform monitoring, including placing a monitor in the operator's cabin.

aboard trains but will also link the onboard and ground systems.

Through the use of broadband network technology it will be possible to transfer control and monitor data as in the past as well as various other types of information in an integrated manner, such as maintenance information, more sophisticated control data, and images (see Fig. 5). It will also become possible to offer new control and information services, including:
(1) more efficient control of onboard equipment linked together more closely,
(2) collection of large volumes of sensing data, and realizing more efficient maintenance by transmitting data to ground stations, and
(3) providing information services to railway personnel and passengers through the linking of control and ground station systems.

SOLUTIONS FOR URBAN TRANSPORTATION

Automatic Operation for Greater Efficiency

As Japan moves into a period that sees declining birthrates and an aging population, there will be a decrease in the overall number of railway passengers, an increase in the number of elderly passengers, and a decrease in the number of skilled workers in the railway industry. Expectations are thus great for developing more efficient business operations. In that backdrop, there is a growing trend toward introducing one-person operation of trains in urban transport systems. To support one-person operation, it is important to build an overall system that combines the following subsystems:
(1) Support systems for driver operations, including ATO (automatic train operation) and information control systems.
(2) A platform monitoring system comprising station monitors and onboard monitors for ensuring the safety of passengers alighting and boarding trains.
(3) Platform gate systems to prevent passengers from falling off the platform, and gap fillers to block the gaps between the train and the curved section of platforms.

To realize improved safety and more stable business operations, new urban transport systems can be designed from the start for one-person operation. Also, existing lines that did not consider one-person operation when they were opened for business can be retrofitted to one-person operation. A good example is Tokyo Monorail Line that serves Haneda Airport from Hamamatsucho Station, and that has been in operation since the Tokyo Olympics of 1964. Prior to one-person operation being introduced from September 2002 (see Fig. 6), various analyses were conducted so that the three subsystems mentioned above could be added to the existing systems to build

Fig. 7—Central Command Center of Teito Rapid Transit Authority.
Teito Rapid Transit Authority is moving its integrated traffic management system away from surveillance of all lines via monitors and toward providing functions such as control information services and cooperative control among lines.

an overall system with integrated functions.

With ATO, meanwhile, the introduction of new technology provides the technological foundation for driverless operation. For the first time in Japan, Hitachi has developed an automatic operation system for commercial-basis monorails that does not require a driver to be aboard.

In driverless operations, it is necessary to provide not only for normal operations but also automatic or remotely controlled operations to avoid hazardous situations and initiate restoration procedures when a train stops because of a malfunction. Also, automatic safety gates on train station platforms are linked with the train's operation so that they open and close together with the doors of the train when it arrives and leaves the station.

Traffic Management Systems for Urban Transport

In recent years, urban railway systems have come to comprise finely meshed networks, providing greater convenience to passengers. Hitachi had previously installed systems for managing the traffic of separate railway lines, and is now integrating those systems at single locations. Integration of systems allows speedier responses for issuing instructions, greater efficiency, and the assurance of improved safety and stability in providing on-time transportation.

Integrated traffic management systems are tending to develop from merely having functions for managing the traffic of a number of railway lines to being linked with related systems and with corporate intranets and also to being fitted with functions for providing information services. Efforts are thus being made to develop traffic management systems for providing cooperative control among railway lines and providing control information services. A good example is the traffic management system of Teito Rapid Transit Authority in Tokyo (see Fig. 7).

TRAFFIC MANAGEMENT AND SIGNALING SYSTEMS RESPOND TO VARIOUS NEEDS

Traffic Management Systems Support Railway Traffic

Up to now, traffic management systems for use with conventional railway lines were aimed mainly at raising the efficiency of traffic management operations by controlling trains in the context of changes such as more trains running on the same line and becoming more diversified, and lines of different companies mutually connecting to make their service more attractive. In recent years, stronger calls have emerged for introducing control systems at large railway stations for overall control of entire lines rather than blocks of lines as well as for the integration of networks, improved information services, and greater efficiency of a wide range of operations.

Utilizing leading-edge IT and expertise it has accumulated up to now, Hitachi developed a system for conventional railway lines that it expects to become a new model of railway traffic control. The system has numerous options for responding to the needs of railway companies, depending on the length of the railway block, the density of traffic and the transport format. Using autonomous decentralized system technology, it is possible to build the system step by step to fit a company's plans.

The subsystems in Hitachi's traffic management system include planning, traffic control, transmission, power, interlocking, and passenger guidance. The subsystems are joined together in a building block system and can also function independently. That arrangement allows the introduction of individual subsystems or of the overall system in stages in line with plans for equipment renewal. A total system integrating several subsystems will be seamless and will not appear to be comprised of subsystems (see Fig. 8).

Occasionally it is difficult to introduce a new high-

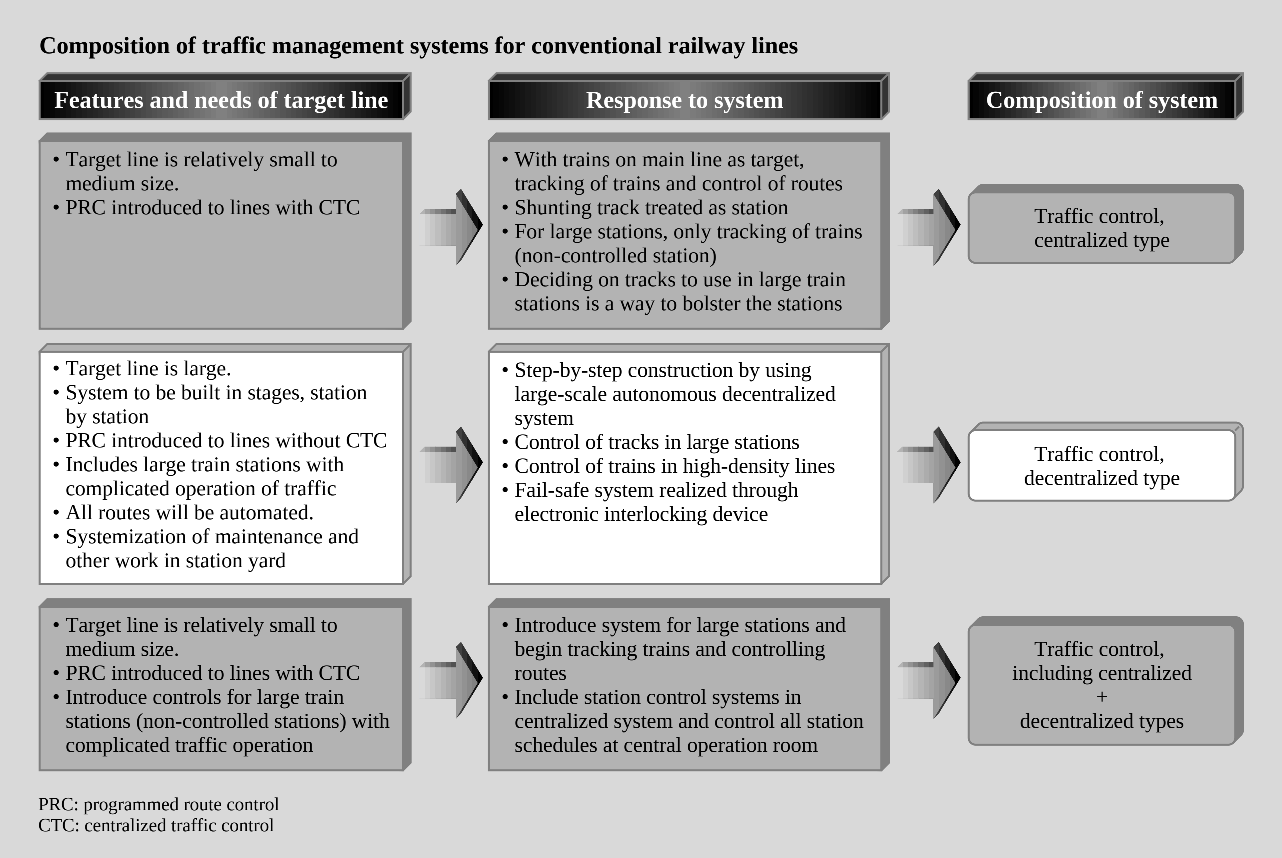

Fig. 8—Features And Needs of Systemization, and Composition of Traffic Management Systems for Conventional Railway Lines.
Traffic management up to now was divided into concentrated and dispersed systems. In recent years, however, the need has increased for traffic management that combines concentration and dispersal.

speed network to some railway sections. For the traffic management system of Shin-etsu trunk line, for example, a new transmission system was introduced that used metal circuits for realizing high speed and high reliability. The system was actually an information transmission system for train operation. In that system, a current status connection that existed as an independent circuit was systematized by integrating it into the transmission system. Moreover, without having an exclusive terminal for monitoring the status of train operations, if a business-use personal computer loaded with an Internet browser is connected to the exclusive JR (Japan Railway) telecommunication lines, it is possible to display information about existing railway lines, scheduling information, and information on accidents.

As seen thus far in this article, Hitachi offers sophisticated products ranging from systems for conventional lines in outlying districts to small systems for individual train stations.

New Digitalized Signaling System

Hitachi is developing diverse types of new signaling systems. One is a digitalized ATC system that allows high-density traffic with an assured braking system. Another is the ADX2000 series dual-system electronic interlocking device that fits the interlocking logic section in the same rack frame as the electronic terminal, thus requiring less space and providing greater ease of maintenance. In addition to above is integrated interlocking/ATC equipment, which, by combining ATC theory and interlocking theory, allows space savings and low cost. These signaling systems are aimed at improving railway services in the near future.

The digitalized ATC system was developed with three main points in mind: (1) to respond flexibly to transport needs, (2) to reduce the cost of equipment, and (3) to improve ease of maintenance (see Fig. 9).

(1) Responding flexibly to transport needs

By using an onboard control device to control assured brakes to closely fit the rolling stock's

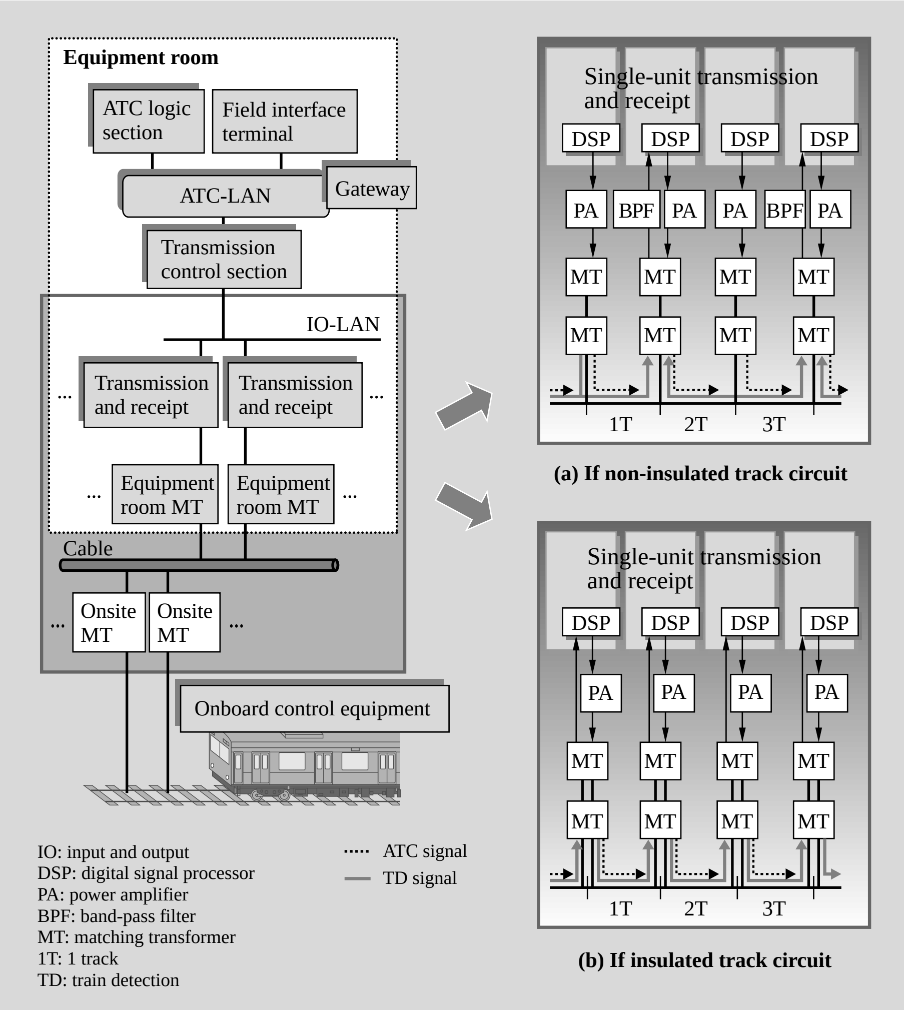

Fig. 9—Composition of ATC System. Functions such as sensing the location of trains and calculating their stopping points were previously carried out using hardware but in the ATC system they are carried out using software. The software is loaded into the transceiver located in the ATC logic section.

performance, it is possible to reduce the headway between trains and shorten the travel time. As well, the use of pattern tracing control can reduce the number of times a train is unnecessarily accelerated or decelerated. Other positive effects that can be expected are enhanced riding comfort and more efficient electromotive force.

(2) Reducing cost of equipment

One positive result from utilizing the assured braking system for digitalized ATC is the reduction of onsite facilities (number of track circuits). Also, logic processing in the ATC can be concentrated by using software and digitalized signal processing technology, leading to size reductions and lower equipment costs. Smaller size reduces the space required for equipment by 60% compared to previous equipment. And because the ATC signals and TD signals can be transmitted superimposed from one transmitter, the length of external cable and machinery room cable is reduced.

(3) Improving ease of maintenance

Besides constant diagnosis of the completely duplicated functions of all parts of the system, except for the protectors, a shunting function operates once a day at a set time to diagnose the shunting circuits. For the onsite equipment as well, including the track circuits, the current status is monitored and statistics are computed for the immediate past year. Warnings can then be issued before irregularities occur, thus also promoting maintenance. Based on these diagnostic and other functions, there is no need for regular maintenance to support operability.

NEW POWER CIRCUIT CONTROL AND POWER CONVERSION SYSTEM

Hitachi provided Tohoku and Joetsu Shinkansen Lines with a new power circuit control system called the COSMOS-SCADA (computerized safety, maintenance, and operation systems for Shinkansen—supervisory control and data acquisition) System. This system concentrates in a control center the monitoring and control functions previously dispersed to separate train sections. COSMOS-SCADA is a new-generation power circuit control system that allows labor savings on maintenance. The existing systems were divided into five sections and replaced step by step with the new system.

Calls have become stronger in recent years for railway power conversion systems to harmonize more closely with the environment, have a low loss rate, be compact, and require less maintenance. To comply with those calls, new systems use a silicon transformer, SF_6 GIS for meeting environmental considerations, cumulative-type SWGR (switchgear), and an eco-friendly rectifier for reducing loss.

CONCLUSIONS

This article introduced some of Hitachi's total solutions for railway systems.

Hitachi is Japan's sole overall systems integrator for railway systems. It will continue to use its over 80 years of experience with railways to provide new solutions for railway systems and contribute to the further development of Japan's railways.

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