Special edition paper

Overview of the ATACS Radio Train Control System

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JR East put the ATACS radio train control system into use on the Senseki Line (between Aoba-Dori and Higashi-Shiogama) in October 2011, and the system has been operating as planned since then. ATACS allows simplifying of ground equipment because train location recognition and train control are mainly done by onboard devices with this system. This is in contrast to traditional methods, which require ground equipment for train detection and control.

This article covers the development history and main features of ATACS as well as trends in radio train control systems.

●Keywords: Train control system, Radio communications technology, Recognition of train location, Track circuit, Moving block

1 Introduction

JR East put the Advanced Train Administration and Communications System (ATACS) radio train control system into use on the Senseki Line (between Aoba-Dori and Higashi-Shiogama) in October 2011.

Radio train control systems are being developed and introduced worldwide, but ATACS is the world's first system having functions such as level crossing control.

Traditional train control systems control trains using current in appropriately divided track sections (track circuits). When the track circuit is short-circuited by an axle of a train, the system detects the train and controls the train based on that information.

ATACS, however, uses onboard devices for recognition of train location. This system controls the train by exchanging information between ground equipment and onboard devices using radio communications.

In 1995, the Research and Development Center of JR East started development of ATACS, with the aim of putting into practical use the Computer And Radio Aided Train control system (CARAT) for which the Railway Technical Research Institute had been conducting basic research. We then carried out first and second phase development and test runs using prototype systems in stages. We also formed a system assessment committee, consisting of researchers and experts from inside and outside JR East, where the safety and other aspects of the system were evaluated and verified.

Based on the development and test results and the verification results from the assessment committee, we launched the ATACS project team (PT) in 2006 with the aim of putting ATACS into practical use on the Senseki Line. The ATACS PT has played a major role in consideration of functions ahead of practical use, planning and implementation of construction, performance checks, driving training, and more.

And finally, in October 2011, we successfully started operation of ATACS. This was later than originally intended due to two postponements, the Great East Japan Earthquake in March 2011 and a typhoon in September 2011. (Fig. 1)

Since the start of operation, ATACS has been working smoothly.

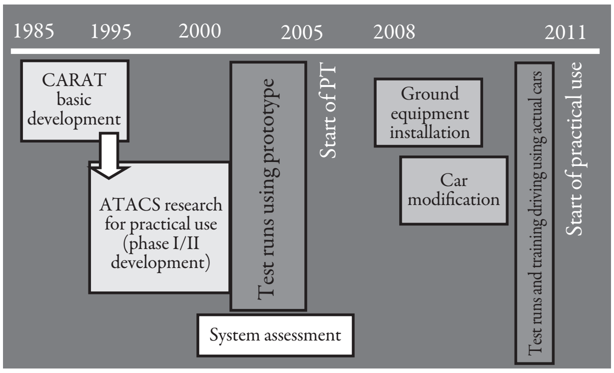

Fig. 1 History up to Start of ATACS Use

2 Background and Aims of ATACS Introduction

2.1 Background

Traditional train control systems need many devices along the track because train detection functions and signal display functions are handled by the ground equipment. Those devices are prone to breakdown due to severe installation conditions such as dust and vibration, and they require a large amount of labor and cost for maintenance. Moreover, such maintenance work could lead to labor accidents. In light of those circumstances, streamlining of ground equipment has been required.

In contrast, ATACS mainly uses onboard devices to detect train position and wirelessly displays signals in the cab, thus reducing ground equipment.

2.2 Aims

There were four major aims for introduction of ATACS, as shown in Table 1.

· Simplifying of ground equipment
· Further improvement of safety and reliability
· Improvement of follow-up to changes
· Function enhancement

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Table 1 Major Aims of ATACS Introduction

Streamlining of ground equipment	· Reduction of ground equipment such as track circuits · Reduction of maintenance costs by trimming the amount of equipment
Further improvement of safety and reliability	· Reduction of operation disruptions by trimming the amount of equipment · Reduction of wayside work by trimming the amount of equipment
Improvement of follow-up to changes	· Reduction of signal improvement work due to track equipment changes · Reduction of signal improvement work due to rolling stock performance improvement
Function enhancement	· Enhancement of support functions such as temporary speed limit restrictions and prevention of accidental failure to stop at stations · Improvement of appropriateness of duration of level crossing closing and warning

3 Main Features of ATACS

ATACS performs bi-directional communications between ground equipment and onboard devices. That allows ground equipment to receive detailed train location information and onboard devices to incorporate and reflect routing information, protection information, and the like to train control in real time. This enables the following.

· Efficient train interval control (moving block)
· Large-volume data transmission between ground equipment and onboard devices
· Improvement of efficiency of test runs using actual cars

Fig. 2 and Fig. 3 respectively show a comparison of traditional and ATACS train control and an overview of ATACS operation.

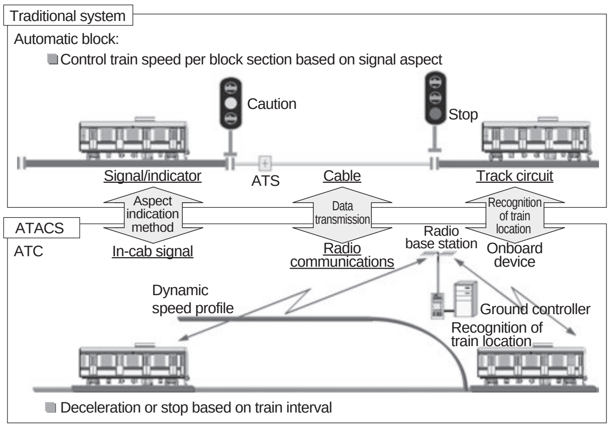

Fig. 2 Comparison of Traditional and ATACS Train Control

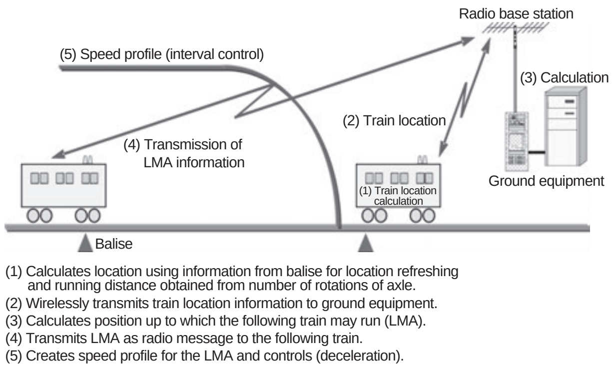

Fig. 3 Overview of ATACS Operation

(1) Efficient train interval control (moving block system)
With ATACS, the recognition of train location is done by onboard devices. The position to which the following train may run (LMA) is calculated based on the rear end of the preceding train (front end position + train set length), so the interval between the preceding train and following train can be efficiently controlled.

(2) Large-volume data transmission between ground equipment and onboard devices
With ATACS, train control information is exchanged by radio communications between ground equipment and onboard devices. Using radio communications allows bi-directional transmission of large volumes of data.

Onboard devices themselves calculate train locations and transmit that information to the ground equipment by radio communications. Ground equipment calculate the LMA based on the information on the location of the preceding train and transmit that information to the onboard device of the following train.

(3) Improvement of efficiency of test runs using actual cars
ATACS recognizes train locations based on a database shared by both ground equipment and onboard devices. Thus, by connecting the ground equipment and onboard devices in the manufacturer's factory and using simulated data of a running train, we can reproduce conditions similar to those of an actual running train.

In this way, we can carry out tests with ATACS in the manufacturer's factory to simulate conditions of a train running before test runs using actual trains and actually installed ground equipment and onboard devices. This improves the efficiency of the actual test runs.

4 Main Components of ATACS

ATACS is a system whereby running trains themselves detect their own locations and control train operation using bi-directional radio communications between onboard and ground equipment. It does not depend on train detection using track circuits, a method that has been utilized for more than 100 years.

ATACS is composed of ground equipment, onboard devices, and radio base stations that perform radio communications between ground equipment and onboard devices. An overview of each component is as follows.

4.1 Ground Equipment

(1) Ground controller (Fig. 4)
The ground controller is the core control unit of the ground equipment, and it has the following functions.

· Identification of train locations based on information from onboard control units
· Route control that safely creates the required routes
· Train interval control based on route and train location
· Boundary control whereby entry/exit of trains is controlled at the system boundary

(2) Train existence supervision equipment (Fig. 4)
Connected the ground controller, the train existence supervision equipment has a function to control line occupation of all trains within the ATACS area to secure safety in system failure and recovery.

(3) System supervision equipment (Fig. 5)
The system supervision equipment has functions including those for setting items such as temporary speed limit restrictions and for monitoring overall system operation.

Fig. 4

Fig. 5

(4) Field controller (Fig. 6)
The field controller is a device that connects a ground controller with field devices such as switches, level crossings and radio base stations.

(5) Balise for location refreshing (Fig. 7)
Installed every kilometer, a balise for location refreshing is a device that transmits kilometerage information to onboard controllers so as to enhance accuracy of recognition of train location by onboard controllers.

Fig. 6

Fig. 7

4.2 Onboard Devices
The onboard devices for ATACS on the Senseki Line are composed of the following in-cab units, with control units concentrated at the lead car in the direction to Aoba-Dori.
· Onboard control device that controls the train
· Cab display device that provides the driver with information
A configuration diagram and the appearance of the onboard device are shown in Fig. 8 and Fig. 9 respectively.

(1) Onboard control device
The onboard control device is a device with which a train itself detects its position, transmits that position information to ground controllers using a radio base station, receives LMA information from ground controllers via a radio base station, and creates a braking pattern taking into account track gradient, speed limit and the like to perform speed check and braking control.

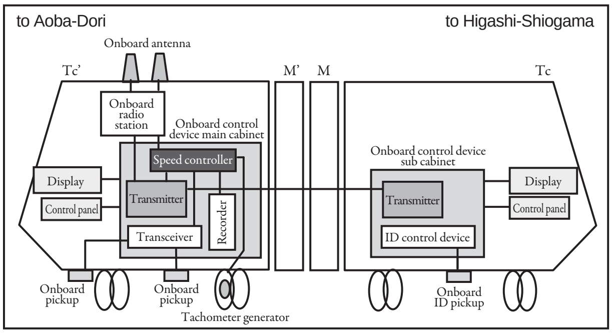

Fig. 8 Image of Configuration of the Onboard Device

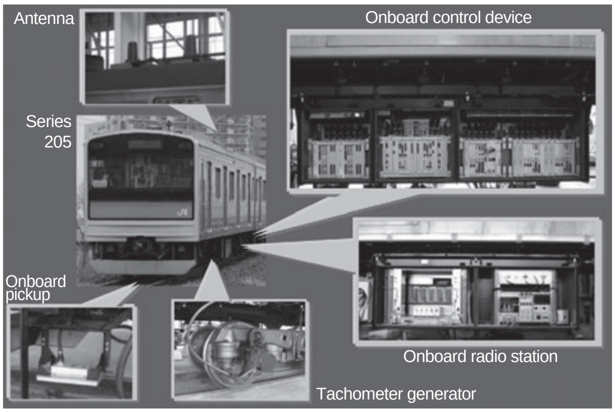

Fig. 9 Appearance of Onboard Devices

(2) Cab display device
The cab display device is a monitor in the cab that displays information required for driving. Its appearance is shown in Fig. 10.

Fig. 10 Appearance of the Cab Display Device

4.3 Radio base station

The radio base station is composed of the following components, both being duplex.

· Radio base station (connected to a ground controller)
· Onboard radio station (connected to an onboard control device)

Conforming to the narrow band digital radio standard stipulated by Japan's Radio Law, the radio base station basically employs the four-frequency reuse to protect from interference between base stations and efficiently use radio signals. The radio base stations are placed at intervals whereby one stations controls an area of 2 to 3 km.

The image of the placement of radio base stations is shown in Fig. 11.

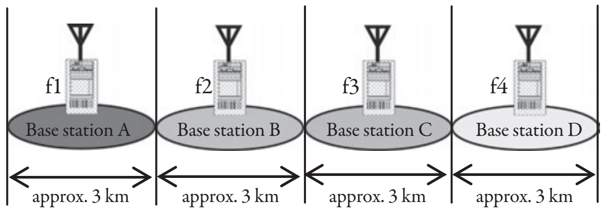

Fig. 11 Image of Placement of Radio Base Stations

5 Trends in Radio Train Control Systems

Previously, when applying radio communications technology to train control, transponders and the like were used to a limited extent since their quality and transmission capacity was insufficient. However, advancements in mobile radio communications technology and radio communications digitalization technology have come to allow practical application of radio communications technology to train control. Specifically, the following radio train control systems have been put into practical use in Europe and North America.

· European Train Control System (ETCS)
· Positive Train Control system (PTC)
· Communication-Based Train Control system (CBTC)

As explained above, a train control system using radio communications can help keep facilities and equipment to a minimum. Such systems thus have been more often adopted by urban railways, particularly to those in Asia and South America, where new lines have been increasingly constructed.

Introducing a radio train control system can make unifying different train control methods used in different countries easier. An effect is thus anticipated in Europe whereby introduction of a radio train control system facilitates standardization of operation procedures for international high-speed trains (interoperability).

6 Conclusion

ATACS for the Senseki Line has started with the following basic functions as the first step.

· Function whereby the train recognizes its own location
· Route control function to safely create train routes
· Train interval control function to prevent train collisions

As the second step, a temporary speed limit restriction function was put into use in December 2012. We are now carrying out tests of the level crossing control function and discussing with people concerned on the required functions and the optimal system configuration in view of early introduction of ATACS to the greater Tokyo area as well.

In Japan, the introduction of ATACS on the Senseki Line was the first example of application of radio communications to a routinely operated train control system. We hope that this example will spread the introduction of radio train control systems in Japan.

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