In railway transport services, convenience and comfort must be improved from the viewpoint of the customer while also maintaining safety and stable transport. Signal control systems and transport operations systems are mechanisms that provide transport services. It is an important task for management to transform these systems in order to bring about changes in the railroad system.

This paper presents an overview of the research and development being conducted by the JR East Group as a part of the system transformation concerning transport services.

1 Introduction

Signal control systems and transport operations systems are indispensable mechanisms for safe and accurate operation of trains in railroad transport. In the long history of railroads, signal control systems used to maintain safety have developed together with the railroads. However, there is a need to solve as quickly as possible the various problems involving the equipment laid down along railroad tracks. In addition, improving transport operations systems to secure stable railway transport is also an important item from the viewpoint of management.

The JR East middle-term management concept calls for a change in railroad systems and research and development is to be promoted to that end. We are involved in research and development that will lead to transformation of systems that are related to transport services.

2 Mid-term Management Concept and Research & Development

The medium-term business plan, "New Frontier 2008," announced by the JR East Group in January 2005 has made the creation of customer value an important task for management. As a basic direction for management, the paper presents awareness reform, business reform, and management reform, and at the same time it indicates the six fields in Figure 1 as areas presenting new challenges. Based on this policy of promoting research and development, research and development themes have been established to secure safe and stable transport, reform signal systems, and allow early recovery to normal schedules after problems occur.

3 Problems with Present Systems and Research & Development Themes

3.1 Problems with Signal Systems

Although signal systems have a high level of safety because of accumulated technological improvements, there is a certain level of conservatism when it comes to changing equipment and reforming operations because it is a special field and this atmosphere is prevalent. However, the problems with current signal systems and operations were highlighted by the Chuo Line operation problems that occurred in September 2003, and those problems made it clear that innovative changes were needed immediately.
This background led to the Signal Innovation Project. In addition to developing a vision for future signal systems and creating a list of improvements required for future operations, this project has also started initiatives to bring these changes about.

3.2 Developments in the Signal Innovation Project
The Signal Innovation Project is based on the following five planks:

- Innovation in signal equipment
- Reduction of transport problems
- Improving work ability
- Development of human resources
- Strengthening partner companies

The main hardware measure with regard to innovation in signal equipment is the development and introduction of networked signal control systems. The introduction of optical fiber networks is aimed at reducing the use of multiple-core copper lines for signals, improving the ease of installation, and reducing the need for line checking and on-site tests.

Before the Signal Innovation Project was started, the radio-based train control system, ATACS, was developed. In this system, train location detection and train interval control functions were placed onboard to simplify wayside signal equipment.

3.3 Problems with Systems Concerning Transport Operations
With respect to improvements in transport operations mechanisms, instructions and station work have been modernized through the introduction of Centralized Traffic Control (CTC) and Programmed Routing Control (PRC). In recent years, large-scale systems such as ATOS and COSMOS that encompass transport planning, transport control, and traffic control have also been implemented.

However, there is still much room for improvement concerning support for train crew operations, further modernization of the work of on-duty assistant stationmasters for operations at crew district offices, and support for advanced operations organization (quick return to regular scheduling after problems that consider the use of crew and trains) for traffic dispatchers. Development of various systems is being promoted for the preceding aimed at improving operations and transport stability.

3.4 Positioning of Research & Development Themes

4 Development of Network Signal Control Systems

4.1 Background
In examining the various function areas of railroad signals in Figure 2, it can be said that there has been a lack of development in signal line routing.

4.2 Development of Station Systems
In large stations where there are many tracks and trains, a great amount of multiple-core copper wire cable must be used for signals. As Figure 3 shows, this can be replaced with optical fiber cable and a...
station network (LAN) can be configured for signal control information. By doing this, wiring checking that is required for signal construction with multiple-core copper wire cables can be replaced with simple checking of IDs assigned to control terminals, such as signals and electric switches.

By using such a network, installation of wiring can be greatly simplified because the quantity of multiple-core copper cable required is reduced, on-site equipment can be easily connected with connectors, etc. In addition, the wiring diagrams for multiple-core copper cable have been created as engineering work blueprints, so that a considerable amount of documentation can also be reduced. Furthermore, checking of wiring, on-site tests, and other work involved in construction can be reduced, and, as a result, this will help to prevent mistakes from being made.

Currently, a first-stage prototype system for stations has been developed and is undergoing monitor run tests at Tsuchiura Station on the Joban Line. After evaluating the test results, it is hoped that the system will be officially adopted in fiscal year 2006.

In addition, development of new functions and devices to increase the number of stations at which this system is used (second stage development) will be started.

4.3 Towards the Development of Between-Station Systems

When the future updating of old ATS-P equipment along the main lines in greater Tokyo is considered, there is a need to develop the network signal control systems between stations.

In addition, when the expansion of network signal control systems is considered, connecting crossing safety equipment to network signal control systems should be given as the next theme for between-station systems.

Furthermore, the logic equipment at stations that connects all of these functions must also be reconsidered in the future, and measures shall be taken after considering the overall concept.

5 Development of ATACS

5.1 Overview

Development of wireless train control systems (ATACS) has been based on the significant development of mobile telecommunications technology, computer technology, and software technology in recent years.

As Figure 4 shows, automatic train control devices (ATC) and wireless train equipment is changing from analog technology to digital. It is easy to see that the onboard signal system used for automatic train control will change from track circuit transmission to wireless transmission.

5.2 Development Results

Development of ATACS started in fiscal 1995. Testing of the first stage basic functions was conducted from September 1997 to February 1998. Testing of the second stage applied functions was conducted from October 2000 to February 2001. (See Table 2.)

The prototype system was developed from fiscal year 2002, and prototype testing was conducted on the Senski Line (18 km of double track) from October 2003 to the end of fiscal year 2004. Figure 5 shows an overview of the overall functions of ATACS.

ATACS is a train location detection system that does not use conventional track circuits. Because it was a train control system that
was based on new concepts, such as the use of wireless communications for transmission of control information, an objective assessment of its train control mechanism and safety was required. Therefore, in parallel with the prototype tests, an ATACS system evaluation committee made up of external scholars and experts was established in fiscal 2004 to assess the technology based on the prototype tests. As a result, this system presented an assessment report stating, “This system has the performance required of signal safety equipment and is at a level where it can be introduced in practical systems.” In addition, in the same fiscal 2004 we started considering the various tasks in using the system and the measures to be taken in an in-house committee.

5.3 Future Developments
The scheduled test evaluation data was acquired after completing prototype testing over about one year and a half, the ATACS system evaluation committee determined that the technology was at a practical level, and the system had been further examined in-house. Thus, after top management had made their deliberations, a project team was established in June 2005 to consider specifics towards implementing a practical system. This project team shall conduct further deliberations for a practical system, eventually create a final draft plan for adoption by the company, and introduce a practical system along the chosen first line.

6 Development of Systems for Transport Operations

6.1 Overall Development of Improvements in Transport Operations
Improvements in transport operations mechanisms have changed from the modernization of instructions and station operations to date. Today, from the viewpoints of supporting train crew operations, further modernization of the work of on-duty assistant stationmasters for operations at crew district offices and support for transport dispatchers in advanced operations organization, the improvements have been expanded to research and development for everyone that is involved in transport operations.

6.2 Research & Development Results
An example of a mechanism that has already been adopted is the operational changes transmission system. In this system, when a dispatcher inputs operations organization information into the Tokyo area transport control system (ATOS), the information is automatically displayed on the monitor of the driver's cab on the appropriate train. In order to assure that information has been sent and received, the dispatcher waits for receipt confirmation from the crew for a certain period so as to make sure that the transmitted information has been received. (There is a warning function for information if a receipt confirmation is not received.) Figure 6 shows an overview of the operational changes transmission system.
train use. Depending on how these train operation changes are made, return to the regular schedule may be delayed and reorganizing train operations may take more time. Therefore, a system that supports the appropriate reorganization of train operating after a transport problem occurs has been developed. This system provides dispatchers and personnel in charge of districts with the information necessary for creating train operation plans, and it presents a train operation organization proposal. An overview of this system is shown on the left side of Figure 7.

The train operation organization and support system has been in use on the Chuo/Sobu local line since April 2005.

6.3 Progress of R&D and its Future

In railroad transport, the drivers and conductors who are to board trains is scheduled, and this is referred to as crew deployment or crew assignment. When train schedules are changed because of transport problems, this crew deployment plan will change. When a train delay or other problem makes it impossible for a crew to board a given train, the dispatcher in charge of crew deployment or the on-duty assistant stationmasters at crew district offices must order crew changes, such as assigning different crews. A system is being developed that checks to make sure that there are no missing assignments, provides the changed information to the personnel in charge, and proposes a reorganization plan. This system is entering the final stages of development, and plans call for confirmation tests to be conducted for the early adoption. An overview of this system is shown on the right side of Figure 7.

A portable digital assistant (PDA) for crew that will notify each member of the crew of modification proposals that the crew deployment organization support system has created is also being developed.

With respect to crew management by on-duty assistant stationmasters at crew district offices, a system is also being developed that supports the work of tracking crew from the time they come on duty to the time they go off duty. Figure 8 shows an overview and images of this system. Furthermore, a system that creates an operation organization proposal that coordinates usage is also being developed (Figure 9). When train schedules are changed because of transport problems, etc., this system will propose both train operation and crew deployment changes.
7 Development of Individual Equipment and Devices Related to Signals

With respect to the development of individual equipment and devices related to signals, the various parts of the Research and Development Center JR East Group (Advanced Railroad System Development Center, Safety Research Center, Technical Center) are cooperating with the various user departments within the company for development.

7.1 Development of Switching Devices

After the official adoption of the next generation electric switch, development of the steady state monitoring processing unit for the next generation electric switch was completed. In the future, we shall be working on the development of the next generation electric switch for multiple branching, development of low-maintenance electric switches for use in stations, and making the next generation electric switch compatible with the network signal control system.

7.2 Development of Station Safety Equipment and Crossing Safety Devices

7.2.1 Development of Falling Detection Devices and Crossing Obstruction Detection Devices

As a way to improve safety in stations, we have developed a device that detects when a passenger has fallen off a platform onto the tracks and takes action to stop any incoming trains. This new fall detection device based on image processing was installed at some of the platforms at Shinjuku station last year, and it will continue to be installed according to the safety plan. Figure 10 shows an overview of the device.

In order to improve the safety at crossings, we have developed a large obstruction detection device using image processing. This unit is for use at crossings that do not currently have large obstruction detection devices and is a low-cost device. This device is currently undergoing final on-site tests. Figure 11 shows an overview of this device.

7.2.2 Development of Lightweight Crossing Barriers

We are currently developing crossing barriers that are lightweight and easy to work with. We plan to conduct onsite tests this year.

7.3 Research & Development Concerning Maintenance Work

With regard to securing safety for railroad maintenance work, we have developed and implemented a track closing procedure support system that prevents procedural mistakes when conducting construction work along tracks and a maintenance car route configuration system that maintenance workers handle themselves. In order to prevent collisions between trains and maintenance cars, we have completed development of the maintenance car short-circuiting running system (warnings at crossings are remotely controlled by personnel on the maintenance car or by assigning a crossing monitor at the crossing) that turns on the stop signals for the section in which the maintenance car is located.

Figure 12 shows an overview of the maintenance car short-circuiting running system.

Fig. 10: Overview of the Fall Detection Device Using Image Processing

Fig. 11: Overview of the Large Obstruction Detection Device Using Image Processing

Fig. 12: Overview of the Maintenance Car Short-Circuiting Running System
running system.

**8 Conclusion**

8.1 Importance of Research & Development

It is said that research and development is an important management task for companies. Research and development at the JR East group is conducted according to management policy. Specifically, the Technology Development Committee and other groups deliberate the direction of research and development and the themes to be approached.

The goal of research and development is to change the railroad systems. The relation between this and the five main planks of research and development are shown in Figure 13.

The individual research and development themes concerned with the signal control systems and transport operations systems mainly come under the top three categories (safety and stability, convenience and comfort, cost reduction). However, depending on the viewpoint or slant, it can be said that they are related to all categories.

In the future, we shall conduct individual research and development on signal control systems and transport operations systems while evaluating the technological trends in information technology and other fields.

Furthermore, the demands from customers will become more advanced and diversified.

Because of such projections, the JR East Group made the following statement in its new medium-term business plan, "New Frontier 2008,"

"In order to continue to be a trusted, lifestyle services creating group, we must have customers choose the JR East Group by providing higher quality services." Also, as a basic direction of management, "Placing emphasis on research and development," has been included in the six challenges.

In order to follow that management policy, not only those who work in the research and development department, but all JR East Group employees will cooperate to contribute to "new creation and development."

In order to continue to be a vital company looking to the future and in order to lead the times by combining the knowledge of our companies, the JR East Group will continue to meet the challenges to realize the expectations of our customers.

![Fig 13: Five Goals of Research & Development](image)

**References:**


8.2 For the Future

Because Japanese society is rapidly aging, the railroad business cannot expect an increase in passengers in the future. Because of this, there will be increased competition in the transportation market and the management environment will be even more severe.