Featured Articles

New Portable Radio Terminal for ATOS

—Development Based on Experience Design—

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OVERVIEW: The railways that form part of the transportation infrastructure of the Tokyo region operate with very high traffic densities, unmatched by anywhere else in the world. The traffic management system used on these Tokyo region railways handles not only railway operations, but also other functions such as enhancing services to passengers and improving safety for the maintenance workers responsible for maintenance and inspection of railway equipment. The lines controlled and functions performed by the traffic management system for the Tokyo region have been progressively expanded to the extent that the system now covers most lines in the region. However, because the architecture it is based on is now about 18 years old, support and maintenance of the overall system are becoming increasingly difficult. Accordingly, along with resolving problems that apply to the entire system, experience design has been utilized to undertake a major upgrade of the "portable radio terminal" used by maintenance workers with the aims of overcoming system aging and eliminating reliance on fixed-wire and wireless communications.

INTRODUCTION

RAILWAY services in the Tokyo region operate with very high traffic densities, unmatched by anywhere else in the world. The Autonomous decentralized Transport Operation control System (ATOS) that manages these services is a large autonomous and decentralized system that was installed to improve traffic management productivity, enhance services to passengers by providing realtime schedule information, and improve the safety of maintenance work. Having been expanded to cover 20 lines with an approximate total length of 1,270 km since it was first installed in 1996, the system is a vital part of the social infrastructure and is critical to the safe and reliable operation of transportation services (see Fig. 1).

Maintenance work on a railway covers such tasks as replacing parts and performing inspections of the equipment associated with the railway lines, signals, and other systems. Maintenance workers use information terminals and the "portable radio terminal" to perform their routine maintenance work. The information terminals are personal computers (PCs) installed at the maintenance center. They are used to download data to the "portable radio terminals" and to view information such as operating status and train schedules. The "portable radio terminal" is a small handheld device that can be taken to jobs and used to issue control requests such as "railway track closing" to prevent trains from entering a section of track being worked on, or to test signal equipment. Given the very high traffic density on Tokyo railways, the information terminals and the "portable radio terminal" are important systems for improving the productivity of maintenance work and the safety of maintenance workers.

With ATOS having been in service for approximately 18 years, this equipment is now aging, these maintenance support devices included. Furthermore, configuring the equipment has become progressively more complex and difficult to maintain as the system has been rolled out to new lines and its functions upgraded. Accordingly, a system-wide upgrade was undertaken based on the following requirements.

(1) Provide a network environment suitable for service expansion.

(2) Optimize the equipment configuration to enhance maintenance productivity.

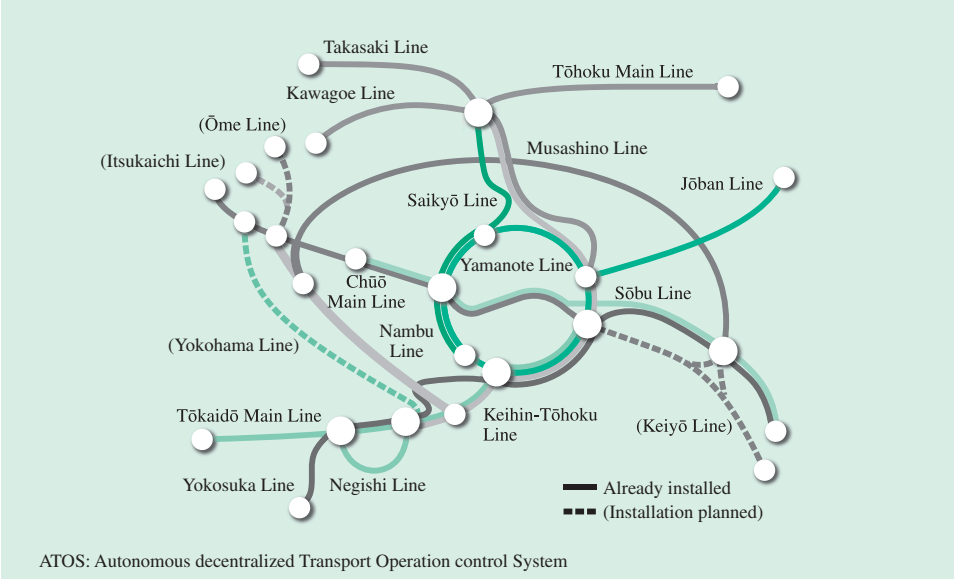

Fig. 1—Lines Controlled by ATOS.
ATOS has been progressively deployed to key railway lines in the Tokyo region, beginning with the Chūō Main Line, where it commenced operation in 1996.

(3) Upgrade the human machine interface (HMI).

This article describes the development of a new "portable radio terminal" that was significantly upgraded to satisfy requirement (3).

CHALLENGES AND SOLUTION DURING DEVELOPMENT OF NEW PORTABLE RADIO TERMINAL

Eliminating Reliance on Fixed-wire and Wireless Communications

With the aging of the overall system, eliminating reliance on fixed-wire and wireless communications has become an issue because it has become progressively more difficult to obtain spare parts for the fixed-wire and wireless access points used for communication between the "portable radio terminal" and station control systems.

The new portable radio terminal eliminates the need for fixed-wire and wireless communications by switching instead to accessing a central system via the standard mobile phone network rather than connecting to the station equipment as in the past (see Fig. 2). By transmitting from the central system to the station control systems, this eliminated the need for fixed-wire and wireless access points. Furthermore, continuity with previous services was maintained by having the new device incorporate the functions of both the information terminals and the existing portable radio terminal.

Challenges Associated with Incorporating Information Terminal Functions

Extending ATOS to cover additional lines led to more information terminals and portable radio terminals being used, and was accompanied also by an increase in maintenance and support costs. Currently, there are about 500 information terminals and about 3,000

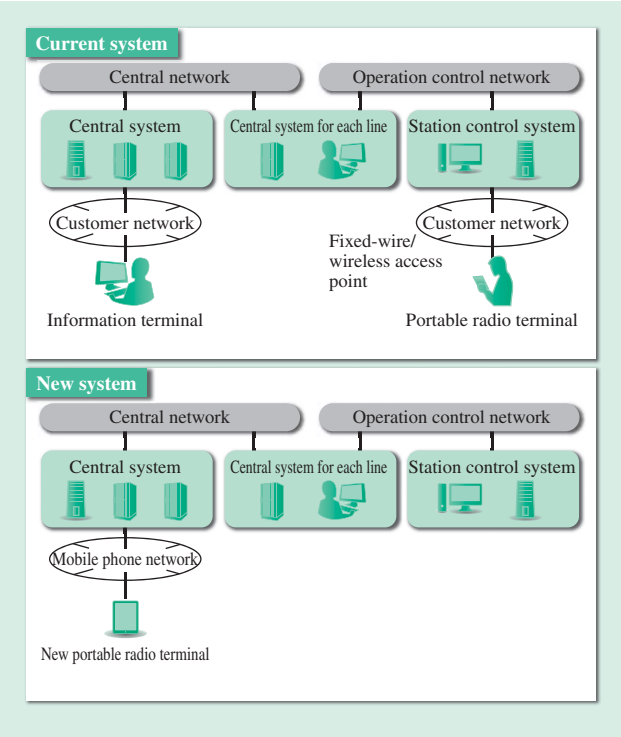

Fig. 2—System Block Diagram.
Use of fixed-wire and wireless communications was eliminated by having the portable radio terminal connect instead to a central system.

portable radio terminals in use. To reduce maintenance and support costs, it was decided to incorporate the functions of the information terminals into the portable radio terminal.

As described above, the information terminal is a PC, whereas the existing portable radio terminal is a handheld device. Because of the many differences, including screen size and operating procedures, one of the challenges was to develop a new user interface.

Accordingly, experience design was adopted for the development of the new portable radio terminal to ensure that it would be easy to use.

DEVELOPMENT OF NEW PORTABLE RADIO TERMINAL

Use of Experience Design

Experience design[1] is about imbuing products and services with the potential for users to obtain rich experiences by identifying users' explicit and implicit requirements and then presenting them in real terms. Specifically, one of the main approaches adopted is based on a human-centered design process[2] and aims to work through an iterative process that involves (1) understanding the users, (2) identifying what they want, (3) building a prototype, and (4) evaluating how well the users are satisfied.

The following sections describe the process followed during development of the new portable radio terminal (studying how the devices will be used, identifying the issues, working on the graphic design, and conducting a user evaluation).

Study of How Devices will be Used and Identification of Issues

In developing the new portable radio terminal, Hitachi accompanied the maintenance workers engaged in overnight maintenance work to observe their use of the existing information terminals and portable radio terminal, and to hold consultations. To make the most of this valuable opportunity to observe these workers, a careful preliminary analysis was conducted that included determining how the equipment was operated and looking at previously collected user comments. Consultations were also conducted with railway company staff to ascertain the relevant operational rules.

This workplace study obtained a list of 15 issues. The following sections describe three of these in particular.

(1) High level of demand for monitoring functions

The maintenance center for the line being studied had three information terminals, which the maintenance workers used to perform different functions at the same time by displaying different screens on each device (data acquisition screens and operating status and train schedule display screens). Furthermore, the procedure for calling up each screen was time consuming, requiring the workers to return to the top menu and re-enter the data they wanted to monitor.

Based on this, Hitachi inferred that there would be cases in which a user engaged in one particular function would want to access different functions at the same time. In particular, there was a high level of demand for monitoring functions and requirements for being able to call up monitoring screens from other functions as well as for minimizing the amount of re-entry required to switch between screens (as described above).

(2) Improvement to ease of viewing and operating

Because the maintenance workers have to look up and fill out a variety of paper documents as they perform their work, rather than holding the portable radio terminal in their hand, they would place it on a desk or on the floor while working. Because the maintenance workers also used the devices at night, in direct sunlight, and while wearing gloves, the graphic design needed to be easy both to view and to operate while performing maintenance work in difficult environments.

(3) Consistent graphic layouts

The information terminals are Windows* PCs, with initial development done on the MS-DOS* operating system. Subsequent development to improve or upgrade functions, however, took advantage of the functions of the operating systems available at the time. Accordingly, it was found that there is a lack of consistency in the graphic layouts used on the current information terminals, and that inexperienced users find them difficult to operate. The graphic layouts of the information terminal and current portable radio terminal are also significantly different, with a landscape screen orientation on the former device and portrait on the latter.

As a result, there was a need to adopt consistent graphic layouts not only for the information terminal screens but also for the integration of the two types of devices.

* Windows and MS-DOS are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

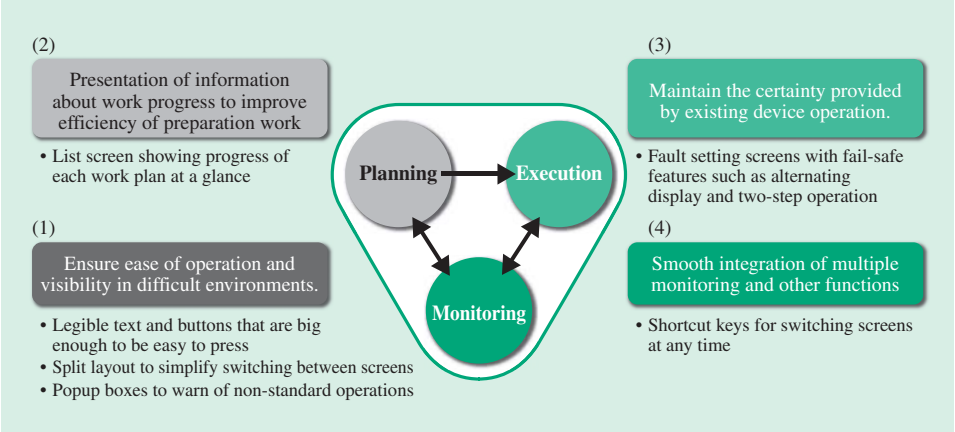

Fig. 3—Design Concepts for New Portable Radio Terminal. Four design concepts were considered in terms of the three main tasks performed during maintenance work: planning, execution, and monitoring.

Work on Graphic Design

Before beginning work on the graphic design to resolve the issues described above, Hitachi used the issues identified by the workplace study as a basis for establishing the design concepts for the new portable radio terminal that would combine the functions of the information terminals and existing portable radio terminal (see Fig. 3).

Next, based on these design concepts, Hitachi utilized rough sketches and real-size mock-ups when considering the graphic design. The following sections describe the work conducted for the four design concepts.

(1) Ensure ease of operation and visibility in difficult environments.

Hitachi considered new graphic layouts for consolidating the existing information terminal (with a landscape screen) and the portable radio terminal (with a portrait screen) to identify their various advantages and disadvantages. During discussions, Hitachi also provided simple models and actual-size screen samples to give an idea of how the devices would be used in practice. From these comparisons, Hitachi decided to use a portrait screen orientation to satisfy users who wanted to maximize the number of data items that could be displayed on the screen at one time.

Hitachi also looked at which font sizes would provide the best visibility under different scenarios such as the device being held in the hand or placed on a desk.

(2) Presentation of information about work progress to improve efficiency of preparation work

A new two-column layout was adopted for the new portable radio terminal. This layout splits the screen into left- and right-hand frames such that, when performing list entry, data can be entered on the right while viewing the data items available for entry on the left. Also, when displaying in list format, various operations can be performed by using the right side to view details of the data items shown on the left.

This allows the same screen to be used for both display and entry of required input data (see Fig. 4).

(3) Maintain the certainty provided by existing device operation.

When performing maintenance work, before going onto the track and starting work, the maintenance workers first use the portable radio terminal to set a block that prevents trains from entering the section of line being worked on. Accordingly, Hitachi looked at how the reliability of this prevention of train entry could be enhanced. Based on this, it adopted a layout

Fig. 4—Two-column Layout.
This format allows a large number of data items to be displayed on a single screen, with required inputs able to be viewed and entered on the same screen.

Fig. 5—Shortcut for Calling Up Monitoring Functions. Shortcut keys have been assigned to almost all screens to facilitate switching to monitor function screens.

tailored specifically to performing work that is closely associated with maintaining the safety of maintenance workers and added a prompt to remind workers to do a final check on the check screen provided for that purpose after requesting that trains be prevented from entering the section of line.

By differentiating the screens used for performing work from other screens, this provides a high level of certainty in device operation that reinforces to users the importance of maintenance work requests.

(4) Smooth integration of multiple monitoring and other functions

Shortcut keys were assigned to almost all screens to facilitate switching to commonly used monitoring function screens (see Fig. 5).

OUTCOMES INCLUDING USER EVALUATION

To date, 17 user evaluations of the newly developed portable radio terminal have been completed. This has included repeatedly obtaining feedback (comments and suggestions) regarding things like changes to coloration and button layout, resulting in the development of a new device that is easy for users to operate.

In the future, Hitachi intends to make further improvements to the new portable radio terminal based on user evaluations obtained during presentations and training for maintenance workers, and to utilize this information in subsequent development.

CONCLUSIONS

This article has described the development of a new portable radio terminal that helps make maintenance work easier for maintenance workers and contributes to higher productivity.

In the future, Hitachi aims to develop systems that are easy to operate for use by a wide variety of railway workers and that help provide safe and reliable transportation.

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REFERENCES

(1) K. Kashimura et al., "Experience Design: Theory and Practice," Hitachi Review **62**, pp. 293–301 (Sep. 2013).

(2) "Ergonomics of human-system interaction Part210: Human-centered design for interactive systems," ISO 9241-210.

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