Featured Articles

Full Upgrade of Traffic Management Systems for Four Toei Subways Lines and Establishment of Integrated Control Center

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OVERVIEW: Coinciding with the establishment of a new integrated control center by the Bureau of Transportation, Tokyo Metropolitan Government, the traffic management systems for the Toei subway lines (Mita Line, Asakusa Line, Shinjuku Line, and Oedo Line) were progressively upgraded beginning in February 2013, with the last line being completed in February 2014. The upgrades involved the replacement of all systems, including the central controllers installed at each line control center, the traffic management and passenger information systems installed at each station, and the communications systems used for traffic management. It also included the consolidation of the central controllers for all four lines at the integrated control center. The upgrade improved passenger service by installing full-color displays for passenger information on the Asakusa Line, and also included measures to prevent delays from being compounded when schedule disruptions occur by integrating the operation of newly installed notification displays at all stations with an automatic rescheduling function.

INTRODUCTION

THE Toei subway lines (Mita Line, Asakusa Line, Shinjuku Line, and Oedo Line) are major transportation arteries used by large numbers of people in the Tokyo region. They run through central Tokyo and include services that share track with the Tokyu, Tokyo Metro, Keio, Keikyu, and Keisei lines (see Fig. 1). The train control systems (traffic management systems) manage and control the operation of all trains operated by the Toei subway. These important systems are essential for railway services that control the display and broadcast of information to passengers.

Because the previous traffic management systems on each line were supplied by different vendors, they included a mix of different techniques and screens for inputting control operations. They had also undergone system upgrades over their long operating lives to support expansion and other operational improvements, making the systems difficult to maintain.

The Bureau of Transportation of the Tokyo Metropolitan Government developed a plan to promote information sharing and facilitate response to schedule disruptions and other abnormal situations by consolidating the traffic management systems at a newly constructed integrated control center. The systems had previously been located at their respective line control centers, scattered across the city. To improve the ease of operation and maintenance of the upgraded systems, the Bureau also decided to use the same system configuration and core functions on all of the lines by upgrading all four of them together.

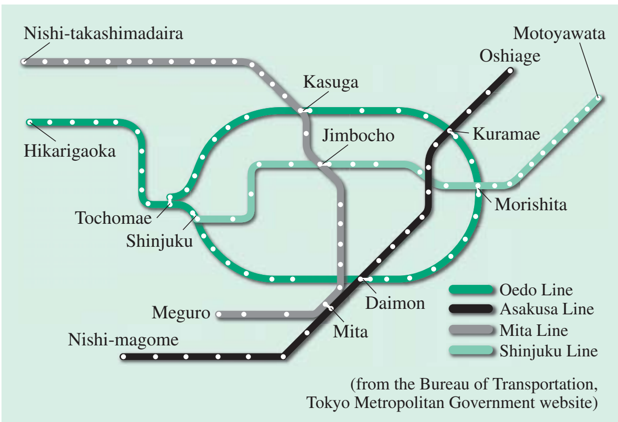

Fig. 1—Map of Toei Subway Lines.
The four Toei subway lines serve a total of 106 stations and move an average of 4.9 million passengers daily (2.45 million passengers boarding, 2.45 million passengers alighting between April 1, 2013 and March 31, 2014)[1].

Fig. 2—Control Room at Integrated Control Center.
Monitoring and automatic control of all trains on the four lines are performed by using the traffic display panels for each line, which are mounted side-by-side in the control room and at the supervisory control desks.

This article describes Hitachi's upgrade of the traffic management systems for the four lines. Switchover to the new systems was completed in February 2013 for the Mita Line, February 2013 for the Asakusa Line, November 2013 for the Shinjuku Line, and February 2014 for the Oedo Line (see Fig. 2).

SYSTEM OVERVIEW

The project involved replacing the traffic management systems for the four lines (including the central controllers, station traffic management systems, station passenger information systems, and the communications systems used for traffic management) and consolidating all of the central controllers at the newly constructed integrated control center (see Fig. 3). The upgrade also provided passengers with easy-to-read information by replacing the passenger information displays on the Asakusa Line with new full-color light-emitting diode (LED) displays. New

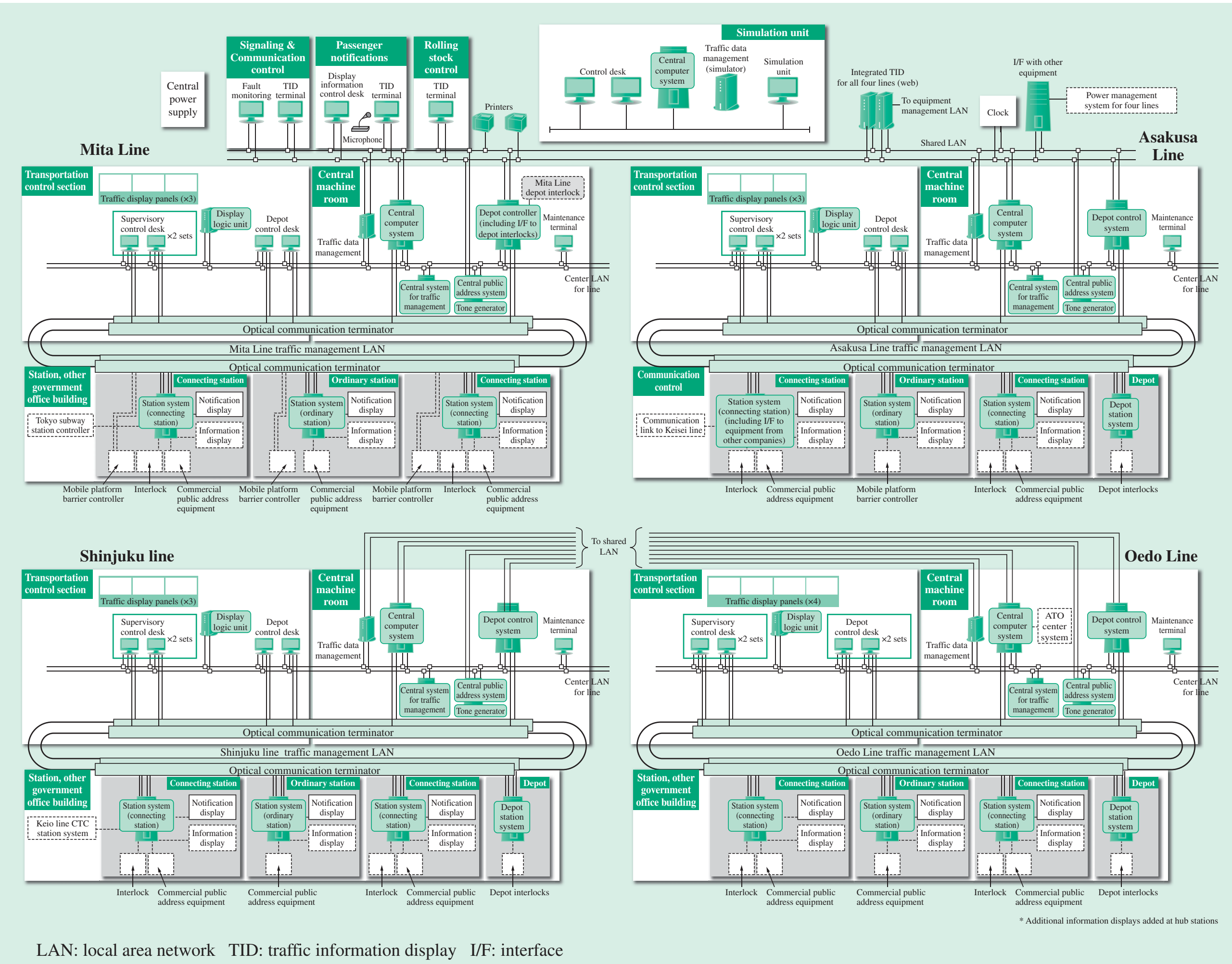

Fig. 3—System Block Diagram.
The central system consists of separate central systems for each line together with equipment shared by the four lines. The station systems, which consist of the station systems for traffic management and for information display, are connected to station equipment.

notification displays were also installed to provide an additional method for the delivery of operational instructions to train crew and station staff. Through interoperation with the automatic rescheduling function, these displays prevent lengthy delays when schedule disruptions occur.

The traffic management systems are based on centralized control and achieve a high level of reliability by having a dual-redundant (hot standby) configuration for critical center and station systems. Although each line has its own traffic management system, they all have the same system configuration and software and a consistent user interface to facilitate traffic management operations and to make maintenance easier.

SYSTEM FEATURES

Central System

The overall system has a compact configuration. The equipment installed in the control rooms includes the traffic display panels, supervisory control desk, display information control desk, depot control desk, traffic information display (TID) terminals, simulation unit, and fault monitoring systems. The equipment installed in the hardware room includes line-specific systems such as central computer systems, central traffic control systems, public address systems, depot control systems, and maintenance terminals, and equipment common to all four lines such as TID central controllers and interfaces to other equipment (see Fig. 4). Traffic management operation has also been improved by having a common user interface, including the traffic display panels for each line that are installed side-by-side in the control room, and also the supervisory control desk screens and operating procedures (see Fig. 2). Having the same system configuration for all lines also simplifies maintenance by allowing the sharing of spare parts.

VoIP: voice over Internet protocol

Fig. 4—Line Center System.
The compact configuration includes the system that generates the passenger information audio for all stations on the line.
- *Central computer system (train traffic monitoring, route control, passenger information control, etc.): 1 cabinet*
- *Central traffic control system (exchange of information between central controller and traffic management systems at stations, etc.): 1 cabinet*
- *Public address system (management of passenger information audio, audio generation, VoIP, etc.): 3 cabinets*
- *Depot control system (tracking of rolling stock at depot, route control, etc.): 1 cabinet*

Station Systems

The station systems for traffic management are installed at connecting stations, and the station systems for information display are installed at ordinary stations. Also, a flexible configuration is achieved by adding units that work with interfaces such as electronic interlocks, relay interlocks, passenger information displays, public address equipment, and notification displays.

Networks

The networks [central local-area network (LAN) and shared LAN] that link central systems, and the network (traffic management LAN) that links central and station systems are conventional Internet protocol (IP) networks with a dual-redundant configuration and autonomous distributed communications middleware. Together, they comprise a system with high reliability and scalability.

Traffic Display Panels

Each line has three 60-inch liquid crystal display (LCD) monitors (four, in the case of the Oedo Line) that display information such as signal statuses and the identity and location of trains on the line. The system also supports reduced-size display to allow operation to continue on only one or two screens in the event of a fault in an LCD that takes it out of service.

Passenger Information Display

The display information control desks in the control room are used to enter messages for the passenger information displays on all four lines and to monitor information broadcasting. Control of passenger information displays and information broadcasting is performed by each line's central controller.

LED: light emitting diode

Fig. 5—Full-color LED Passenger Information Display for Asakusa Line.
These full-color LED passenger information displays were installed on the Asakusa Line. The displays provide passengers with easy-to-understand information by using color-coding to display a variety of train information.

Information broadcasting is performed by transmitting audio from the center, with the passenger information broadcasts for each station generated by the central public address system. Each generated message is sent as data via the traffic management LAN to the passenger information system at the intended station using voice over Internet protocol (VoIP), and then output as audio from the public address system.

Installation of Full-color Displays for Passenger Information (Asakusa Line)

The passenger information displays on the Asakusa Line were upgraded from the existing three-color LED displays to full-color LED displays (see Fig. 5). These displays provide passengers with easy-to-understand information on train services, using color-coded display for the various services on the Asakusa Line, which include a through-train linking Haneda Airport (Tokyo International Airport) and Narita International Airport.

Simulation Unit

Hitachi configured a simulation unit that can be used for all four lines. This saves space by allowing the user to specify which line to simulate when they start the unit.

The functions of the simulation unit include simulating operation based on train schedule data, recreating previous conditions based on historical data collected online, and training control center staff in how to perform traffic management, for example.

Depot Control System

The Toei subway has five rolling stock depots. The depot control desks in the control rooms and depot control system in the central hardware room are used, respectively to display the trains on each line and to control depot entry and exit. They also improve the efficiency of traffic management by automating depot entry and exit based on a predefined depot schedule, and by coordinating control of depot entry and exit with the actural traffic on the line during schedule disruptions.

TID Terminals

The TID central controller performs web-based distribution of information relating to traffic on the four lines that can be displayed on the network-connected TID terminals (general-purpose personal computers). Using a newly developed function for exchanging information between TIDs, the traffic control center and station staff can also enter information such as details about delays or train congestion into their own TID terminal and broadcast it as messages to all the other TID terminals.

Interoperation with Other Systems

The traffic management system improves the efficiency of traffic management by coordinating operation through connections to other systems, including power management systems, equipment management systems, rolling stock control systems, train radio systems, overnight work systems, and the traffic management systems for through-train services.

NOTIFICATIONS DISPLAYS THAT PROVIDE NEW METHOD FOR COMMUNICATING WITH TRAIN CREW AND STATION STAFF

The project included the installation of new notification displays on all platforms to provide a new method for

Fig. 6—Notification Display (Vertical).
These are installed for each platform ahead and to the side of the train driver's cab to provide operating instructions to the driver.

Fig. 7—Notification Display (Horizontal).
These are installed between the middle and far end of the platform to provide operating instructions to the conductor and station staff.

the delivery of operational instructions to train crew and station staff.

The notification displays are produced in two versions, consisting of vertical (see Fig. 6) and horizontal (see Fig. 7) displays respectively. A high-brightness version was also produced to make the display easier to read at above-ground stations. Which version to use was chosen based on the environment at the station where it was to be installed, with most being installed ahead and to the side of the driver's cab (for the driver) or between the middle and far end of the platform (for the conductor and station staff).

When a control center staff member selects "command type," "departure prohibition," "departure signal," "schedule adjustment time," "notification of workers on premises," or "departure instruction issued by station staff" from a supervisory control desk, the notification display lights up the corresponding Japanese symbol ["指," "抑," "出," time interval (digits such as 0:10 indicating the schedule adjustment time in minutes), "作," or "合", respectively]. The newly developed automatic rescheduling function prevents delays from being prolonged when a schedule disruption occurs by automatically calculating the train headway from the relative difference between the train's own delay and that of the following train, and automatically determining the schedule adjustment time at each station.

The installation of the notification displays has improved efficiency by making it possible to issue instructions to the stations on the notification displays when a schedule disruption occurs instead of continuing with the past practice, which required issuing departure prohibitions, departure instructions, time adjustments, and other commands while simultaneously using the train radio, command telephone, or some other method to communicate with each train.

CONCLUSIONS

This article has described a traffic management system upgrade and given an overview of the system. The upgrade to the new system was completed without incident on all lines despite involving a switchover from systems supplied by different vendors. The Great East Japan Earthquake, which struck during the development phase of this project, was a major disaster of a sort that does not occur frequently and served as a reminder of the importance of measures for dealing with disasters. In the future, Hitachi intends to undertake development in collaboration with the Bureau of Transportation, Tokyo Metropolitan Government to make the traffic management system for the Toei subway, a major transportation artery in the Tokyo region, even more resilient to disaster.

ACKNOWLEDGEMENTS

Finally, the authors would like to express our deepest thanks to everyone who worked so hard on this long-running system upgrade project.

REFERENCE

(1) Bureau of Transportation, Tokyo Metropolitan Government, http://www.kotsu.metro.tokyo.jp/subway/kanren/passengers.html in Japanese.

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