

Railway Systems

1 Future of Automated Railroad Operation Using On-board Passenger Information Display

In 2006, Hitachi began developing an autonomous decentralized on-board passenger information display (“this System”). This System has contributed to the realization of digital transformation (DX) for railroad operators through its high utilization rate, information displays for optimized user experiences, and three-screen display systems for enhanced representation of advertising displays.

As society faces a declining population, it is becoming increasingly difficult for railroad operators to acquire and train drivers and other staff, and this has led to a need to implement automated operation without staff in the lead car. Up to now, the linkage between the operation control center (OCC) operators and passengers was performed by the staff operating the train driver’s cab by guiding evacuations in the event of a vehicle breakdown or train fire, or displaying information for timetable changes, but for equipment to take on this role presents numerous challenges.

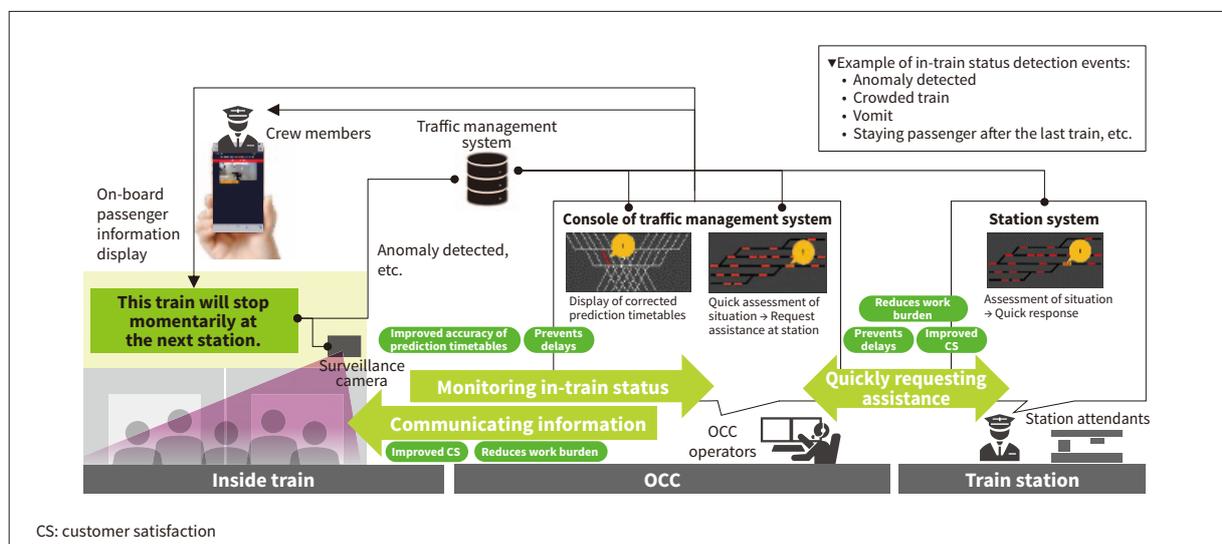
Hitachi is aiming to utilize the information and communication technology (ICT) of this System as a solution to these challenges. This includes detecting anomalies in

the train, such as train breakdowns, train fires, or passengers who are not feeling well, notifying OCC operators and station attendants, and providing evacuation guidance and information display for timetable changes from OCC operators to passengers. Hitachi will promote development of a system aiming to maintain safety and service quality in automated operation and reduce the workload of OCC operators and crew members.

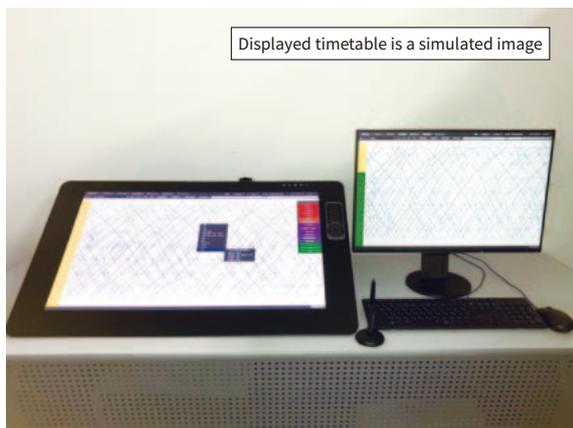
2 Safer and More Stable Transportation with the Updated ATOS Joban Line and Joban Local Line

In the Autonomous decentralized Transport Operation control System (ATOS), a large-scale autonomous decentralized train operation control system of the East Japan Railway Company, the central equipment and network equipment of the Joban Line and Joban Local Line were upgraded in May 2021.

In this project, the development and implementation of tablet graphic display (GD) was carried out to improve the efficiency of command operations along with the equipment upgrades. In the past, when replanning was needed, OCC operators made an adjustment plan on paper timetables and input this plan into the train



1 Image of linkage between OCC operators, station attendants, and on-board passenger information displays when an anomaly is detected in a train carriage



2 Operation adjustment input terminal for the ATOS Joban Line and Joban Local Line

graph console (GD) by mouse operation. Therefore, the development and implementation of tablet GD project developed a new tablet terminal (tablet GD) to input the adjustment plan, and it was installed for the first time in the ATOS line zone. This terminal enables adjustment input using a stylus, and soon, the tablet GD will be able to perform the entire process from preparing of adjustment plans to their input for improving the work efficiency of the OCC operators in their replanning work.

Hitachi will continue to contribute to even safer and more stable transportation in the Tokyo metropolitan area by upgrading equipment and implementing new functions.

3 Update of PTC Completed for Metropolitan Intercity Railway (Tsukuba Express)

The Tsukuba Express, operated by the Metropolitan Intercity Railway Company, had switched over from its existing traffic management system, which had been in operation since the railway's inception in 2005, to a new system in February 2021. It was a phased system switchover, beginning with the upgrade of some station equipment in June 2019.

For the system configuration, the number and types of hardware making up the station equipment have been reduced, thereby reducing the running costs for maintenance. Also, the control functions were integrated into the central equipment room so that the traffic management system for station control, such as information broadcasts and linked devices, could be upgraded from this room. This system configuration also considers reducing the number of workers required for upgrades.

For greater functionality, a multi-monitor system was installed. By increasing the amount of information that can be displayed at once without changing the number



3 Operation display panel and operation command console for Tsukuba Express traffic management system

of hardware in the control unit, Hitachi sought to both streamline the system and improve the efficiency of command operations.

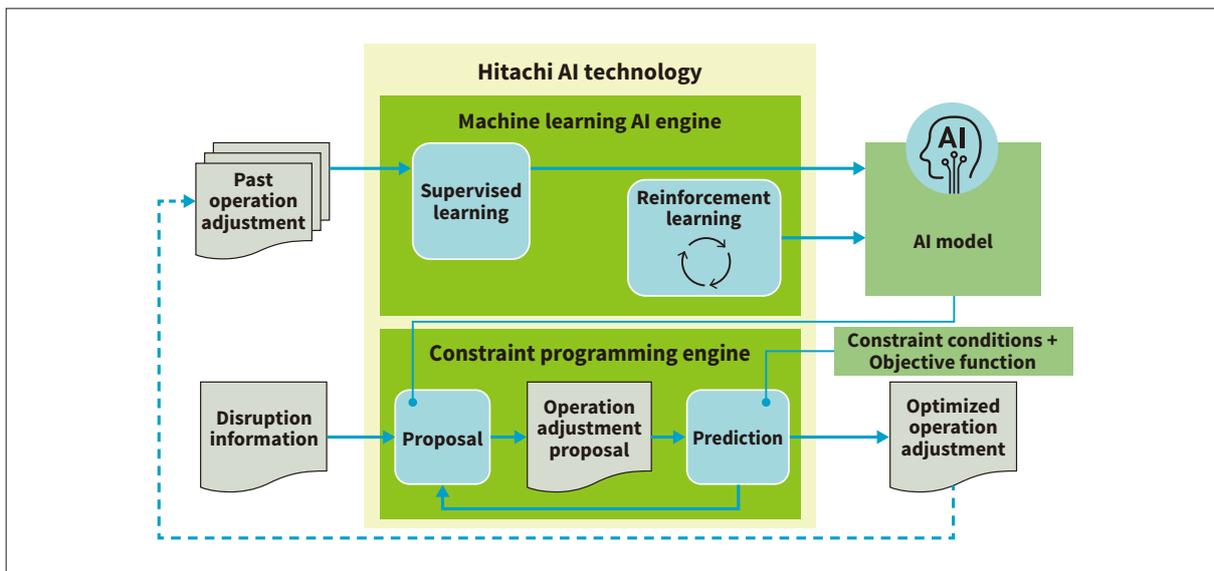
Hitachi will continue its efforts to improve the command environment and ease of maintenance by implementing improvements to the system in line with customer requests.

4 Application of Machine Learning to Traffic Management Systems

Recently, the increasing number of interconnected train services across the multiple railroad lines has improved convenience, but at the same time, it has increased the range of impact of train service disruptions caused by accidents and other incidents and has complicated the work of replanning timetables to cope with abnormal weather conditions and other situations. Also, due to the worker shortage caused by the declining birthrate, aging population, and other factors, an important issue for railroad operators has become how to pass on their expertise in recovering from schedule disruptions.

For this reason, Hitachi developed a new artificial intelligence (AI) operation adjustment function combined with machine learning to further improve the operation adjustment function, which is one of the functions of the traffic management system.

In this development, the AI learns the characteristics of past adjustment content that was implemented by the OCC operators during train service disruptions, and verifies them by constraint programming, thereby enabling the automated proposal of timetable equivalent to the adjustment implemented by the OCC operators for train service disruptions. This has reduced the burden on OCC operators when adjusting operation and enables rapid timetable replanning.



4 Conceptual diagram of AI rescheduling function

Hitachi will conduct further verification with the aim of commercialization of this function and contribute to even safer and more stable transportation by railroad operators.

5 Tokyo Metro Fukutoshin Line 17000 Series High-efficiency 8-pole PMSM Drive System

Tokyo Metro Co., Ltd. and Hitachi have developed a high-efficiency 8-pole permanent magnet synchronous motor (PMSM) drive system and installed it in the new 17000 series cars (8-car configuration) of the Fukutoshin Line for achieving further energy savings for rolling stock.

Because of the short distances between stations on the Tokyo Metro lines, the cars running on the lines often use the low and medium speed ranges. Copper loss of the main electric motor occurs predominantly in the low and medium speed ranges, and so Hitachi examined how to reduce copper loss (improved efficiency) by using a multi-polar design for the main electric motor. Most

conventional induction motors (IMs) have four poles, and the recent PMSMs have six poles, but Hitachi has developed an 8-pole PMSM to attain further energy savings. Also, full silicon carbide (SiC) elements were used to handle the increased switching frequency by the multi-pole main electric motor and to reduce the size and weight of the inverter system.

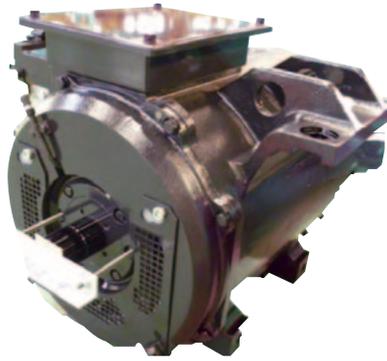
This system was tested for about one year on a 07 series train on the Tozai Line, and a 29% reduction in power consumption was confirmed compared to a conventional system using an IM. Soon after, Hitachi delivered the product for a new 8-car train of the Fukutoshin Line 17000 series.

6 Mumbai Metro Line 2 and 7 in India

As the increase of the rapid growth of population in India has led to the enlargement of the transportation, the demand in mass transit has risen in the market.



5 Inverter system (left) and main electric motor (right) used on the Fukutoshin Line 17000 series



6 Mumbai Metro Lines 2 and 7 traction motor (left) and traction converter (right)

In 2019, Hitachi has been awarded to the Project of Mumbai Metro Line 2&7 (MRS1) for the supply of Propulsion System, Auxiliary Power Supply (APS), and Train Control Management System (TCMS), where the revenue operation is aimed to commence within FY2021 currently in the midst of Test and Commissioning.

The MRS1 Project is planned to introduce the unattended train operator (GoA4) operation, with high level technology and safety. As Hitachi, we are executing the Project with the collaborations of designs of Mito Factory, Hitachi Industrial Products, Hitachi Rail, as well as localized Hitachi ABB Power Grids from Swiss (Company name was changed to “Hitachi Energy” in October 2021), maximizing the synergy effect and realizing the system integration at rolling stock level. Hitachi has succeeded in emerging as the first of Propulsion System, APS, and TCMS in the Indian market.

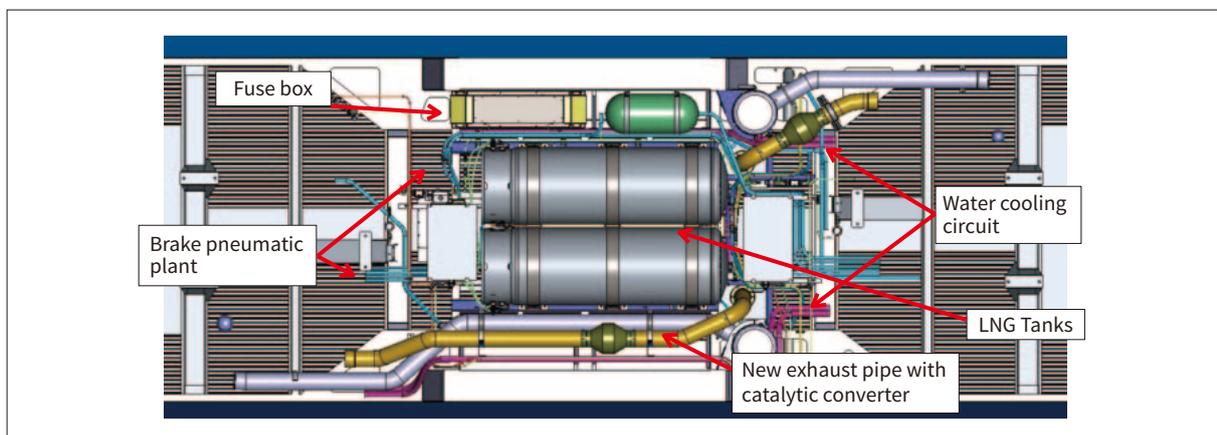
solutions. One example is the refurbishment of the historic Italian ALn 668 trains from diesel to liquid natural gas (LNG), with Hitachi Rail S.p.A. delivering the refurbishment design and negotiating its acceptance with Trenitalia S.p.A. This project demonstrates LNG’s sustainability potential, particularly for the refurbishment of existing trains or shunting locomotives. LNG is cost-effective and can enable a sustainable lifecycle through the use of recycled bio-LNG fuel.

The refurbishment of two ALn 668 trains has been completed for tourist service, including replacement of the fuel tank to support LNG, diesel motor transformation to the Otto cycle, re-design of all interfaces between the LNG tanks and the motor, and homologation of the train by national safety railway authorities. Refurbishment of this type ensures the continued value of assets through adaptation to support a low-carbon future.

The LNG ALn 668 debuted in January 2021 across the “Transiberiana Italiana” tourist line, characterised by steep slopes through the Apennines mountains. Successful completion and running of this prototype will see the technology roll-out to a further 20–50 trains, demonstrating a future commitment to green technology. (Hitachi Rail S.p.A.)

7 OS&M Green Refurbishment: Converting Diesel Trains to Liquid Natural Gas

Development of the Operation, Service and Maintenance (OS&M) sector presents opportunities to focus on green



7 Re-design of the ALn 668 from diesel to LNG