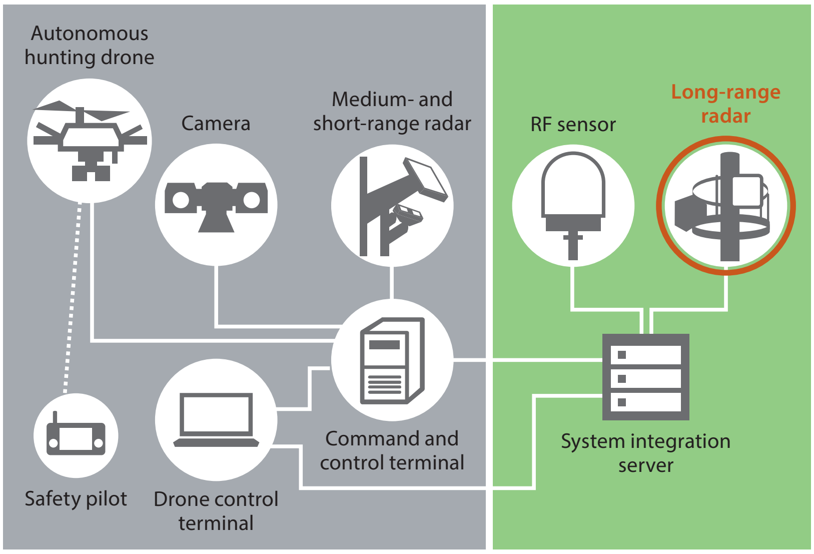
3. Infrastructure Solutions

3.1 Long-Range Radar for Counter-Unmanned Aircraft Systems

Long-range radar for C-UAS



RF: radio frequency

Overview of C-UAS solutions

The application of drones in logistics and infrastructure inspection has been advancing rapidly. At the same time, unauthorized drones have been used in attacks on critical facilities and airports, creating an urgent need for counter-unmanned aircraft systems (C-UAS) capable of detecting and mitigating such threats.

Against this backdrop, Toshiba Corporation has developed a long-range radar as a core sensor for such systems. This radar is capable of detecting drones at distances beyond human visual range, regardless of weather conditions or time of day. It employs a high-power pulsed Doppler radar architecture rather than a frequency-modulated continuous-wave (FM-CW) approach. As a result, long-range detection—previously achievable only with multiple units—can now be realized with a single unit.

Furthermore, the radar employs an active electrically scanned array (AESA) antenna, enabling simultaneous tracking of multiple selected targets. As a stationary radar with no rotating components, it requires minimal maintenance and is well suited for long-term operation.

In addition, to address the challenge of distinguishing drones from birds, we have newly developed an AI-based target classification function that focuses on temporal variations in the target's Doppler frequency measured by the radar. It is designed to achieve highly accurate target classification through the application of deep learning techniques. Field test results indicate that the proposed method achieves high classification accuracy.

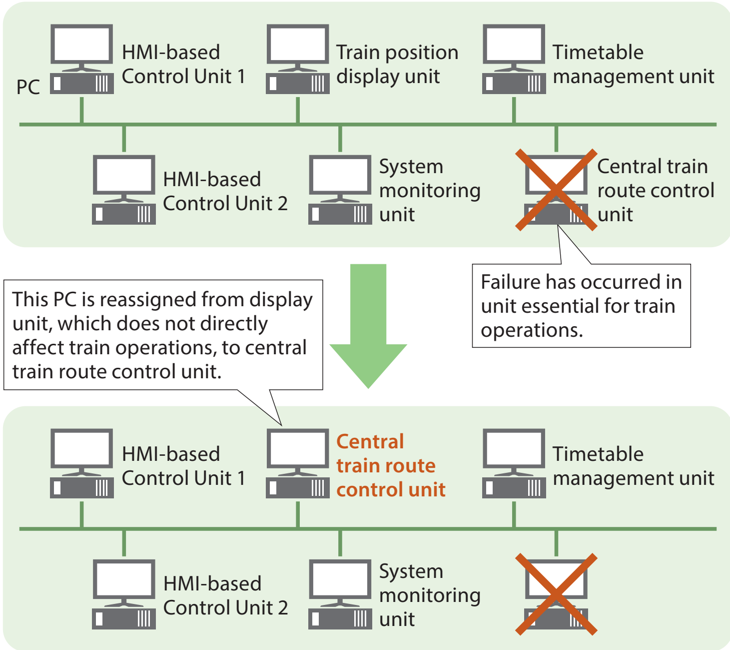
Through these capabilities, the new radar can detect distant targets and assess whether they pose a genuine threat, thereby reducing unnecessary responses and enabling operators to focus on priority targets.

Going forward, we will conduct demonstration experiments, enhance system functionality, and expand the range of applications.

3.2 Programmed Traffic Control System for Chita Area of Nagoya Railroad Co., Ltd.

PTC system for Nagoya Railroad Co., Ltd.
Tokoname Line, Airport Line, and Kowa Line

Functions assigned to individual PCs



Example of functional assignment to PCs within PTC system

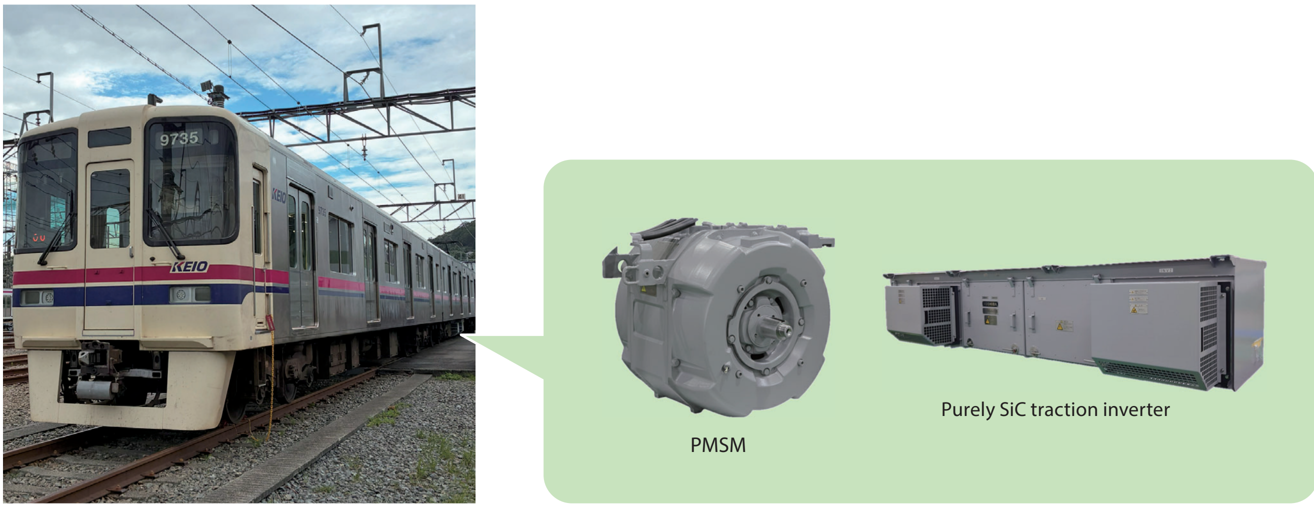
In May 2025, Toshiba Corporation delivered a programmed traffic control (PTC) system to the Chita area operated by Nagoya Railroad Co., Ltd. (hereinafter "Meitetsu"). The PTC system automates operations such as signal control, which have traditionally been performed manually by dispatchers.

Meitetsu is one of the largest private railway operators in Japan, with daily passenger volume of approximately one million. Its railway network is characterized by complex operational patterns, including high-density timetables and extensive interline services spanning multiple lines. Traditionally, such complex operations have relied on the flexible judgment of experienced dispatchers. However, anticipated labor shortages have highlighted the need for a sustainable operational framework, prompting Meitetsu to plan the introduction of a PTC system in the Chita area, including sections of the Tokoname Line, Airport Line, Kowa Line, and Chita Line.

Against this backdrop, we developed a PTC system tailored to Meitetsu's complex operations, leveraging more than 50 years of expertise. To ensure high system reliability, the PTC system adopts a redundant architecture consisting of multiple interconnected subsystems, including central train route control units, control units equipped with a human-machine interface (HMI), timetable management units, train position display units, and system monitoring units. Unlike conventional systems, in which a failure in a single component can affect overall operations, the new PTC system adopts a flexible multi-PC configuration in which each PC is assigned specific functions. In the event that a unit fails, its functions are reassigned to another PC handling less critical tasks, thereby enabling continued train operation.

In this project, the PTC system was tailored to accommodate Meitetsu's complex operational requirements. By leveraging cyber-physical systems (CPS), such as the PTC system, we will continue to address the challenges faced by railway operators and create new value for society.

3.3 PMSM Drive System and Traction Inverter for Keio 9000 Series Trains



PMSM drive system for Keio 9000 series trains

Toshiba Corporation has received orders from Keio Corporation for electrical equipment for refurbished 9000 series electric multiple units, including permanent magnet synchronous motor (PMSM) drive systems, and has been delivering these systems sequentially. The refurbished trains commenced commercial service in March 2025.

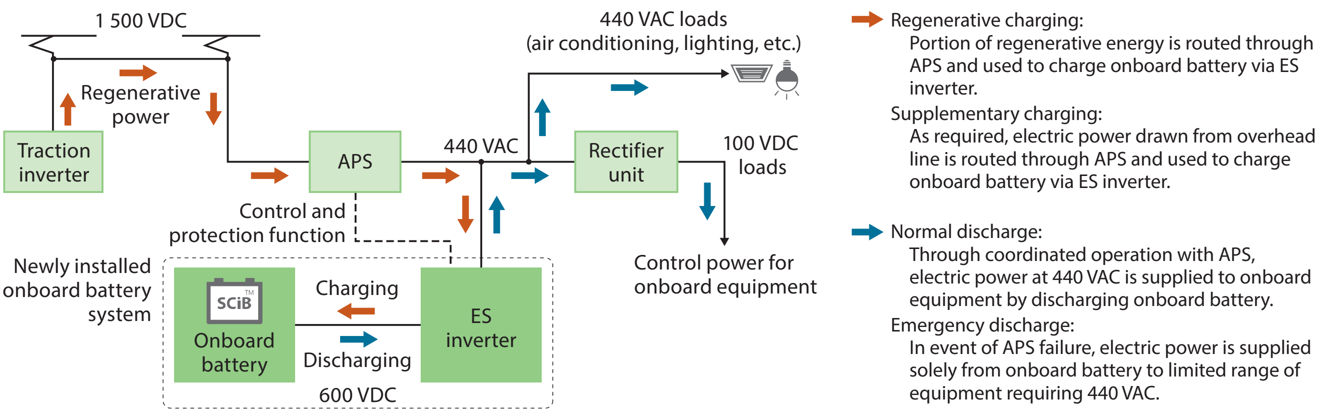
Compared with the PMSM drive system previously delivered for eight-car 8000 series trains, the new system incorporates a traction inverter using purely silicon carbide (SiC)–metal-oxide-semiconductor field-effect transistor (MOSFET) devices. These devices enable higher-temperature operation and exhibit lower conduction and switching losses than conventional silicon (Si)–insulated-gate bipolar transistor (IGBT) devices. The traction inverter is designed to take full advantage of the high-current capability of SiC devices.

In addition, the PMSM reduces the quantities of iron core material and permanent magnets relative to conventional designs, thereby suppressing the induced voltage. Furthermore, it exhibits lower iron and copper losses, including those associated with flux-weakening current, particularly in the high-speed operating range. Furthermore, the adoption of a frameless structure and a modified cooling design has reduced the temperature rise by 40% while enabling higher-current operation and weight reduction.

As a result, the PMSM drive system is well suited to the 9000 series trains, which operate under a wide range of conditions, including through-service operation to subway lines and express services. The refurbished 9000 series trains are expected to achieve an approximately 20% reduction in energy consumption compared with the pre-refurbishment 9000 series trains.

3.4 Onboard Battery System for Tobu 60000 Series and 80000 Series Train Cars

Tobu railway 80000 series cars



Configuration of onboard battery system

Toshiba Corporation has received orders from Tobu Railway Co., Ltd. for electrical equipment, including onboard battery systems, for its 60000 series electric multiple units and the new 80000 series cars, and has been delivering these systems sequentially. The 80000 series trains commenced commercial service in March 2025.

The onboard battery system consists of an onboard battery incorporating our SCiB™ lithium-ion rechargeable cells and an energy storage (ES) inverter. The ES inverter captures regenerative energy during braking and uses it to charge the onboard battery. In addition, it supplies power stored in the onboard battery to onboard equipment such as lighting and air-conditioning systems, thereby offsetting a portion of the power otherwise supplied by the auxiliary power supply (APS). This contributes to improved energy efficiency and reduced greenhouse gas emissions.

Furthermore, in the event of an APS failure, the onboard battery system can supply power to essential equipment required for train operation, including the air brake compressor, thereby enabling continued operation.

Going forward, we will continue our efforts to develop railway equipment and systems that contribute to the realization of carbon neutrality, while enhancing safety and convenience and promoting co-creation aligned with the concepts and needs of individual railway operators.

3.5 Commencement of Battery Post Operation at Hiroshima Station by Hiroshima Electric Railway Co., Ltd.

Nighttime test run at Hiroshima Station

Hiroshima Electric Railway Co., Ltd. commenced operation of the Ekimae-Ohashi Route on August 3, 2025. As part of this new line, the Hiroshima Station stop was newly constructed on the second floor of a new station building to improve access to the Sanyo Shinkansen, and the section between Hiroshima Station and Ekimae-Ohashi Bridge was elevated. Within this elevated section, the maximum gradient reaches 48‰ (equivalent to a 48 m rise per 1 000 m of horizontal distance). As there were concerns that voltage drops caused by uphill operation could affect train operation, the construction of a new traction substation was initially considered. However, it was found that constructing a new substation would be difficult due to constraints such as limited space for installing the required equipment.

As a countermeasure, Toshiba Corporation proposed adopting a traction energy storage system (TESS) that enables charge and discharge control using lithium-ion secondary batteries, and applying it as a battery-post-type traction power supply system instead of constructing a new traction substation. The introduction of TESS was determined based on the evaluation of three key benefits: (1) voltage compensation to prevent voltage drops on uphill gradients, (2) absorption of surplus electricity generated by regenerative braking on downhill gradients, and (3) emergency operation capability enabling continued train operation during power outages. The system has a rated output of 400 kW, a rated voltage of 600 V, and a rated energy storage capacity of 198 kWh. It began operation concurrently with the opening of the new line.

3.6 Completion of Power Supply Control and Relay Panel Replacement Project (Package 1) for Taiwan High Speed Rail

New control and relay panel for Taiwan High Speed Rail

More than 15 years have passed since Taiwan High Speed Rail commenced full-line operation. In response to the aging of power supply equipment, the control and relay panels at each electric post were identified as the initial priority for replacement. Toshiba Corporation completed the replacement of control and relay panels at seven of the total 30 electric posts—starting from the southernmost location—as Package 1.

Control and relay panels are critical components of the power supply system, responsible for the monitoring, control, and protection of power supply facilities. Accordingly, their replacement must be carried out without disrupting train services. As train operations are prioritized, installation and testing activities were restricted to limited nighttime hours when services were suspended. The existing panels were required to remain in continuous operation until the new panels were fully installed and tested; therefore, switching between the existing and new panels had to be performed within these nighttime windows.

To address this requirement, changeover panels were adopted in the Package 1 project to enable efficient switching from the existing to the new panels, thereby reducing changeover time and securing sufficient working time. In addition, a newly deployed server was introduced into the communication system between the supervisory control and data acquisition (SCADA) system and each electric post to interface with both the existing and new panels. This approach minimized the impact on existing systems.

The use of the changeover panels and the newly deployed server enabled the successful completion of the four-year Package 1 project in July 2025 without disrupting train services.

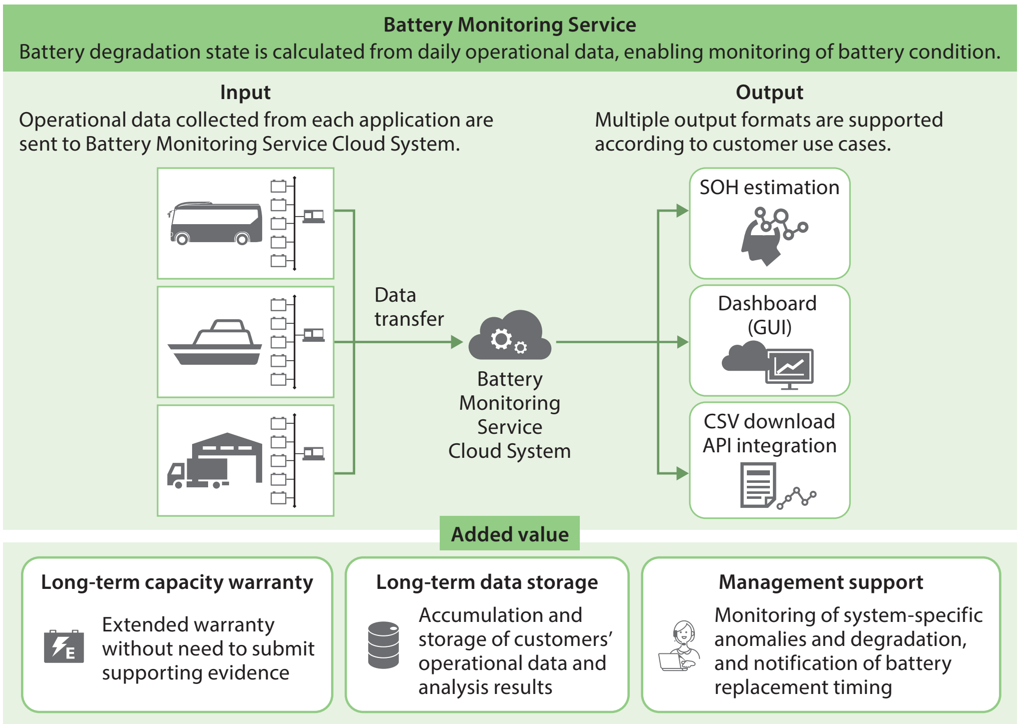
3.7 Battery Monitoring Service for Estimating Battery Degradation from Operational Data

In recent years, the deployment of electric mobility and renewable energy systems has been accelerating toward the realization of a carbon-neutral society. In this context, ensuring the long-term stable operation and reliability of storage batteries has become essential for the sustainable development of social infrastructure. In particular, accurate assessment of battery degradation, together with the promotion of planned maintenance and the reuse and recycling of used batteries, represents a critical challenge directly linked to both economic efficiency and environmental sustainability.

To address these societal needs, Toshiba Corporation has developed a "Battery Monitoring Service" that estimates battery degradation states based on operational data and has completed preparations for its launch. This service collects battery operational data via a cloud-based system and analyzes them using proprietary algorithms, such as a voltage standard deviation method, to enable daily estimation and monitoring of the state of health (SOH), a key indicator of battery degradation (capacity retention rate). Conventionally, SOH evaluation required dedicated facilities, specialized personnel, and system shutdowns. In contrast, this service enables diagnosis using only daily operational data, thereby reducing operating costs and minimizing system downtime. Furthermore, it enables rapid and cost-effective diagnosis at the module level, contributing to early detection of abnormalities and preventive maintenance.

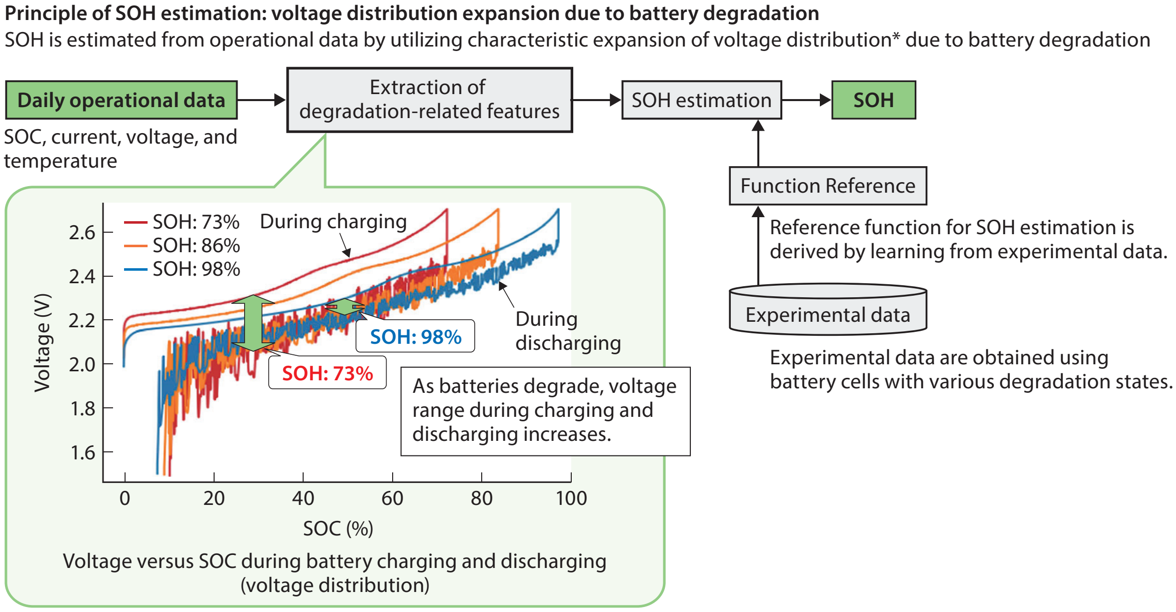
This service supports multiple usage scenarios, including dashboard visualization via a graphical user interface (GUI), diagnostic result export in comma-separated values (CSV) format, and application programming interface (API) integration. It is applicable to a wide range of use cases, including electric buses, marine vessels, and industrial battery energy storage systems.

Going forward, we will proceed with proof-of-concept (PoC) demonstrations on electric buses and expand the application of the service to construction machinery and other fields. We will also develop the service into a data platform supporting the entire battery lifecycle—including battery passports, operations and maintenance (O&M) services, and reuse and recycling support—while flexibly adapting to changes in customer needs and regulatory requirements, such as the European Union (EU) Battery Regulation. In doing so, we aim to contribute to improving the safety and reliability of battery operations and to the realization of a sustainable society.



: Toshiba SCiB™ lithium-ion battery

Battery Monitoring Service overview



SOH: ratio of measured capacity to rated capacity at given charge/discharge rate and temperature
SOC: state of charge, an index indicating ratio of current battery capacity to maximum capacity
* When battery is new, internal voltage is maintained at nearly uniform level; however, as degradation progresses with continued use, internal state becomes non-uniform, resulting in increased voltage variation, referred to as "voltage distribution expansion."

Battery SOH estimation using voltage deviation method