ANNUAL REPORT 2024-2025

For the year ended March 31, 2025

Railway Technical Research Institute

Contents

Railway Technical Research Institute

Introduction	
3	Message from the President
Our Mission	
4	Management Vision “RISING”
6	Master Plan “RESEARCH 2025“
Major Results of Research and Development	
Ⅰ IMPROVEMENT OF SAFETY	
8	1. Performance Evaluation Method for Earthquake Early Warning Systems
9	2. Method for Setting Regulation Values for Operation Control Under Rainfall Using Radar Rain Gauges
10	3. Method for Estimating Track Buckling Risk Based on On-board Measurements
11	4. Method for Identifying Wheel Usage Limit Temperature and Evaluating Safety While in Service
12	5. Investigation of Front Rod Fracture Causes and Maintenance Methods to Prevent Fracture
13	6. Detection System for DC High-resistance Ground Faults by Utilizing the Current Data of Both Substations and Vehicles
14	7. Forward Obstacle Detection System for Trains in Preparation for Future Driverless Operation
15	8. Validation of the Long-term Effectiveness of Automatic Deer-deterrent Sound Devices
Ⅱ COST REDUCTION	
16	9. Design Method for Post-installed Anchor Joint Members in the Reconstruction of Concrete Structures
17	10. Reinforcement Method for Preventing Fatigue Cracks at Steel Girder Support Sections
18	11. Method for Identifying Potentially Critical Locations of Loose Bearing Based on On-board-measured Track Geometry
19	12. Extension of Rail Replacement Cycles Considering Fatigue/Soundness
20	13. Support Method for Extending Inspection Periods Based on Statistical Analysis of Equipment Inspection Records
21	14. Automated Visual Inspection System for Vehicle Underbody
22	15. Autonomous Train Operation System
23	16. General Purpose Real-time Algorithm for Generating Driving Curves for Driver Advisory System

Contents

24	17. Method for Updating On-board Databases Using Public Communication Networks
25	18. Labor-saving for Generating Crew Schedule to Enable Workforce Efficiency and Reduce Labor Burden
Ⅲ HARMONY WITH THE ENVIRONMENT	
26	19. Two-Step Cross-Sectional Tunnel Entrance Hood
27	20. Method for Detailed Prediction of Contribution of Each Noise Source on Wayside Noise Generated by Shinkansen Vehicles
28	21. Integrated Control Method for Railway Energy Storage Systems Enabling the Use of Renewable Energy
29	22. Development and Commercial Operation Demonstration of High-capacity Superconducting Feeding for Urban Commuter Lines
30	23. Safety Assessment of Hydrogen Fuel Cell Multiple Units
Ⅳ IMPROVEMENT OF CONVENIENCE	
31	24. Automatic Pantograph Drop System Using Real-time Abnormality Detection in the Current Collection System
32	25. Development of a Low-cost Primary and Secondary Vertical Semi-active Suspension System
33	26. Thermal Comfort Evaluation Method Using Air Conditioning Log Data from Commuter Trains
Ⅴ BASIC RESEARCH	
34	27. Method for Estimating the Density of Newly Fallen Snow Using Dual-polarization Radar
35	28. Prediction Method for Long-term Deformation Behavior of Concrete Bridges Considering Water Content Conditions
36	29. Non-contact Disc Brake Enabling Power Regeneration in Trailers
37	30. Method for Reducing Unstable Vibrations of Pantographs Caused by Sliding Friction
Public Relations	
40	News Release
42	Publications
Data	
44	Organization
46	Overview of RTRI
47	Master Plan
47	Compliance and a Better Work Environment
50	Historical Background

Introduction

Message from the President

Ikuo WATANABE
President of the Railway Technical Research Institute

It is with magnificent pleasure that I announce the publication of the Annual Report 2024 of the Railway Technical Research Institute (RTRI). This report, first published in 2009 (the report on fiscal year 2008), has been compiled to provide readers with a deeper understanding of our R&D efforts over the course of each year. We earnestly hope that by reviewing our activities for fiscal year 2024, you will gain further insight into the work and mission of RTRI.

While social and economic activities are gradually returning to pre-pandemic levels, the changes in the environment surrounding the railway industry are accelerating even further. Long-standing social challenges—such as recurring large-scale natural disasters, the goal of achieving carbon neutrality by 2050, and demographic changes including an aging population, declining birth rates, and a shrinking working-age population—have become increasingly urgent, apparent, and complex. Technological innovation to support the sustainable development of railways is now required more than ever.

Having entered fiscal year 2024 under these circumstances, RTRI accelerated its efforts to achieve the goals of the Master Plan RESEARCH 2025 across all business operations, with R&D taking the lead. Our R&D strongly advanced initiatives that contribute to improving safety particularly through strengthening railway infrastructure against natural disasters, promoting automation and labor-saving technologies via digital innovation, and decarbonizing railways towards the realization of carbon neutrality by 2050. In total, RTRI formulated 242 R&D projects and completed 91 of them. Furthermore, RTRI provided cross-sectoral technical support for disasters, accidents, and failures, promptly conducting damage assessment and cause investigation, as well as proposing recovery methods and recurrence prevention measures. In addition, RTRI resumed the Technical Forum after a five-year hiatus to disseminate its R&D outcomes. Concurrently, RTRI formulated the Master Plan RESEARCH 2030—Creating Sustainable Railway Systems—which will guide our strategic initiatives for the next five years starting from fiscal 2025.

Under our vision, “We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society,” and our new Master Plan RESEARCH 2030, we are committed to maximizing our capabilities as a comprehensive R&D institution and to striving for the creation of high-quality outcomes in response to the trust placed in us. We would appreciate your continued guidance and support.

Our Mission

Management Vision “RISING”

Management Vision “RISING”

Research Initiative and Strategy—Innovative, Neutral, and Global

Vision

“We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society.”

Mission

We will accomplish the following three missions:

- To intensify research and development activities so as to improve railway safety, technology and operation, responding to customers’ needs and social change
- To develop professional expertise in all aspects of railways and, as an independent and impartial research body, to fulfill our tasks using the best science available in an ethical way
- To pioneer cutting-edge technologies for Japanese railways and become a world leader

Strategies

We will accomplish the three missions using the Business Strategy and the Management Strategy.

Business Strategy

■ By pursuing excellence across all fields of activity and by conducting creative, innovative and high-quality research and development work:

- Addressing challenges that demand innovation
- Promoting research in fields where RTRI has significant advantages
- Exploring research frontiers
- Advancing interdisciplinary research projects and fundamental research
- Disseminating research outcomes
- Promoting highly market-oriented research activity to diversify and stimulate research
- Exploring visions of future railways

■ Acting as an independent and specialist organization, we will be conscientious and dependable, taking advantage of all available scientific knowledge:

- Investigating accidents and disasters, and proposing preventative measures
- Enhancing technical support activities
- Focusing on preparing railway technical standards
- Communicating information around the world in a timely and effective way

■ By accumulating knowledge and utilizing networks on a global scale, fostering technical progress which contributes to the development of railways around the world:

- Enhancing our global presence
- Encouraging our researchers' full commitment to global activities
- Supporting overseas deployment of Japanese railway systems
- Engaging actively in international standardization activities

Management Strategy

■ Strengthening our administration to support the Business Strategy, aiming to fulfill our missions.

- Ensuring legal compliance
- Achieving a working environment in which all employees can be highly motivated
- Developing human resources with the resilience needed for global activities
- Further constructing, improving and updating test and research facilities
- Preparing and implementing a sound budget plan

Master Plan “RESEARCH 2025”

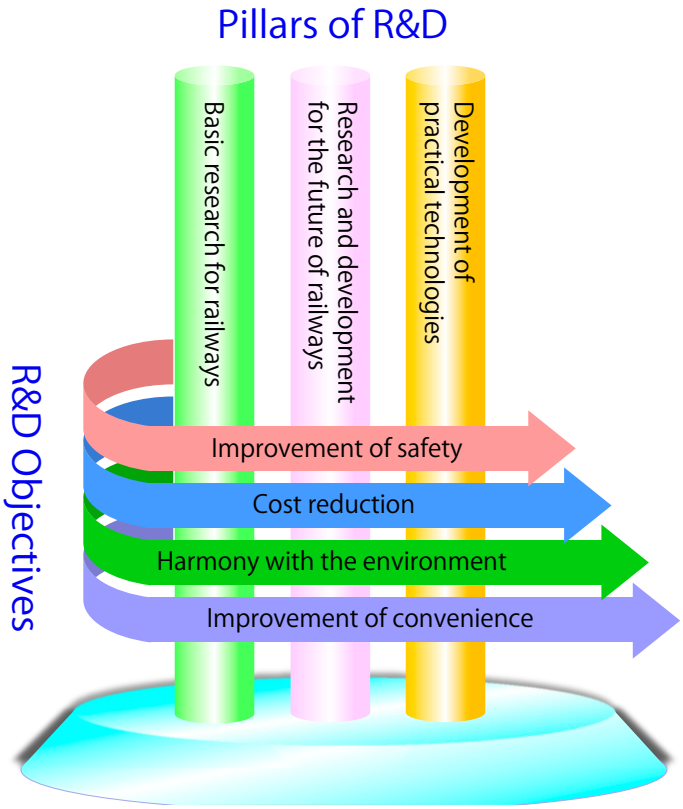
- Research and Development for Creating the Future of Railways -

The Master Plan is a medium-term action plan embodying the strategy to implement the vision.

Basic policies

- Enhancing safety with an emphasis on improving resilience to natural disasters
- Developing innovative railway systems based on digital technologies
- Creating high-quality results by taking advantage of our collective strength
- Enhancing international presence of the Japanese railway technologies
- Creating a motivating workplace where staff can demonstrate their abilities

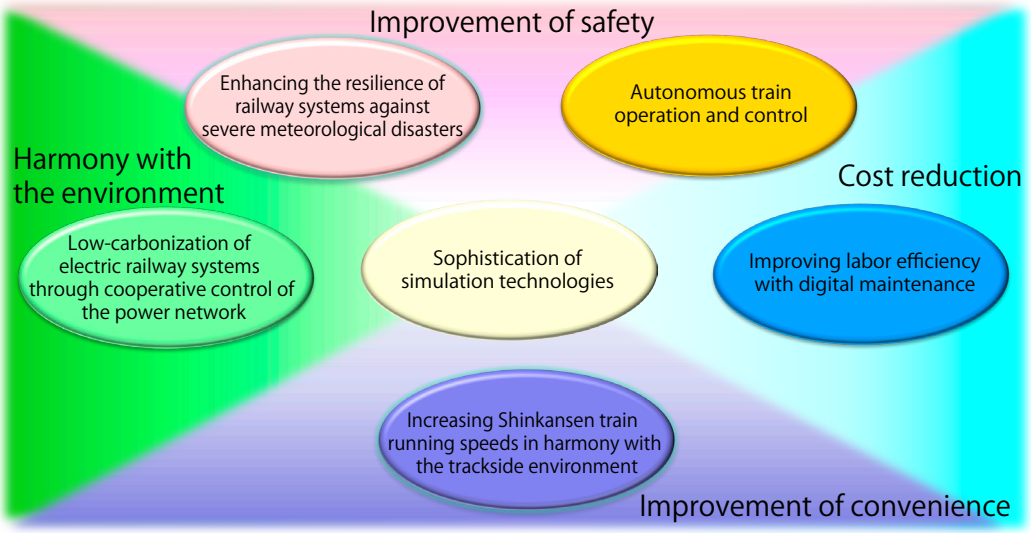
R&D objectives



Pillars of R&D

Research and development for the future of railways

In fiscal 2020, aiming to achieve practical application within about 10 to 15 years, we start the following six major research themes.



Development of practical technologies

In order to provide timely practical results, we are addressing topics with immediate relevance to the railway business.

Basic research for railways

To provide solutions to railway-specific issues and to incubate innovative technologies, we will actively engage in basic research as follows; forecast of meteorological disasters, running safety and stability of rolling stock, improvement to trackside environment, deterioration mechanism and inspection methods, human factors in error prevention, friction and wear impacting the service life of facilities, and exploiting the potential of artificial intelligence.

Major Results of Research and Development

IMPROVEMENT OF SAFETY

1. Performance Evaluation Method for Earthquake Early Warning Systems

- We have developed a performance evaluation method and simulator for earthquake early warning systems that can quantitatively assess the implementation effects and the transportation impact due to a new earthquake early warning.
- The results of the performance evaluation can be used to support decision-making when implementing a new warning method into an earthquake early warning system.

When a new warning method is implemented an earthquake early warning (EEW) system, faster warning issuance to enhance safety can be expected. On the other hand, the increased frequency of warning issuance may have an impact on stable transportation. Therefore, when implementing a new warning method to a railway under consideration, it is necessary to quantitatively assess both its implementation effects and its transportation impacts in advance.

We developed a performance evaluation method for earthquake early warning systems, using two indicators: the travel distance ratio, which quantifies the implementation effects based on the time difference between the initial warning issuance and the arrival of strong earthquake ground motion (representing the relative change in travel distance until running-train suspension after warning issuance), and the false warning issuance ratio, which assesses the transportation impacts based on the number of earthquake detection sites that issued warnings (representing the relative change in unnecessary warning issuances). As a tool for this evaluation, we developed a simulator for operation control after an earthquake (Figure 1).

To validate the performance evaluation method and the simulator for operation control after an earthquake, we conducted simulations using past earthquake records, comparing conventional warning methods for a virtual railway and earthquake detection sites. As a result, we confirmed that the implementation effects and transportation impacts of each method can be quantitatively compared (Figure 2). This enables quantitative evaluation of performance improvements in earthquake early warning systems prior to implementing a new earthquake early warning. This performance evaluation method can be used to support decision-making when implementing a new warning method into an earthquake early warning system.

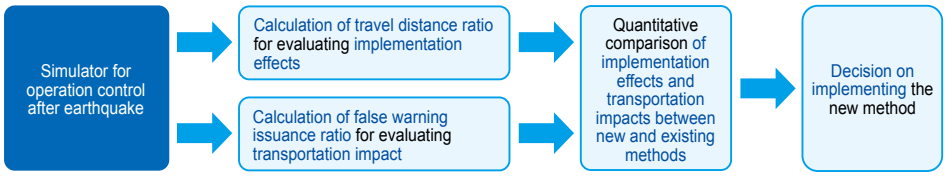


Figure 1 Performance evaluation process

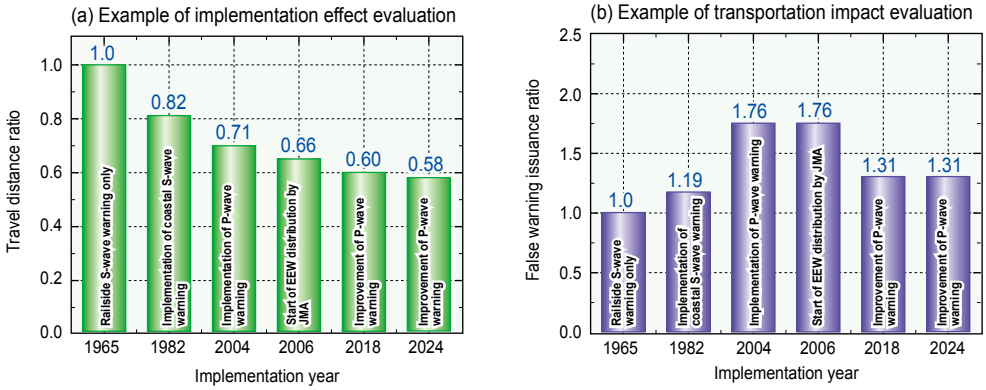


Figure 2 Example of performance evaluation (using the 1965 system as a standard)

2. Method for Setting Regulation Values for Operation Control Under Rainfall Using Radar Rain Gauges

- We have proposed a method for setting regulation values for operation control under rainfall using radar rain gauges by converting the regulation values of existing railway rain gauges.
- Although the regulation time increases slightly, more disaster events are captured, leading to improved safety.

Currently, railway rain gauges are installed at intervals of several tens of kilometers, and operation control under rainfall based on rainfall observed at these fixed points may fail to detect localized heavy rain occurring far from the gauges. To address this issue, the introduction of radar rain gauges, which can monitor rainfall over a wide area, is being considered (Figure 1).

In this study, we proposed an easy method to set regulation values for radar rain gauges based on the regulation values of existing railway rain gauges and information such as their installation intervals. Specifically, when an operation control is issued due to the radar-measured rainfall in any unit mesh within the operation control under rainfall section (Figure 1) exceeding the current regulation value, the rainfall observed by the radar rain gauge tends to be higher than that of the railway rain gauge (Figure 2, with the average increase factor denoted as rainfall conversion factor α). This may cause a significant increase in restriction issuance time, raising concerns about excessive protectionism. Therefore, the regulation value for the radar rain gauge is set by multiplying the rainfall conversion factor α by the existing railway rain gauge regulation value.

We also analyzed the relationship between the average operation control under rainfall section length L and the rainfall conversion factor α (Figure 3), enabling easy determination of α based on this relationship. The simulation results showed that in cases where the regulation values for radar rain gauges were set using this method (B and C in Figure 4), compared to the current case with existing regulation values set for railway rain gauges (A in Figure 4), the regulation time slightly increased while the number of captured disaster events also increased. This indicates improved safety without excessively extending the regulation time (D in Figure 4).

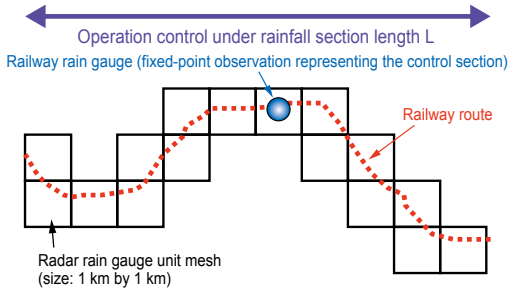


Figure 1 Conceptual diagram illustrating the relationship between railway rain gauges, operation control under rainfall sections, and radar rain gauges

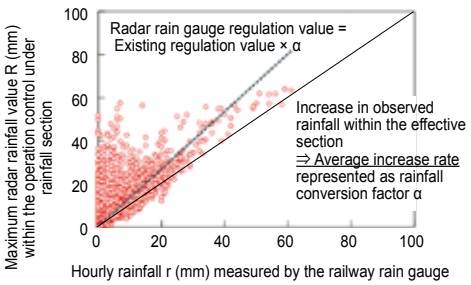


Figure 2 Concept of rainfall conversion factor

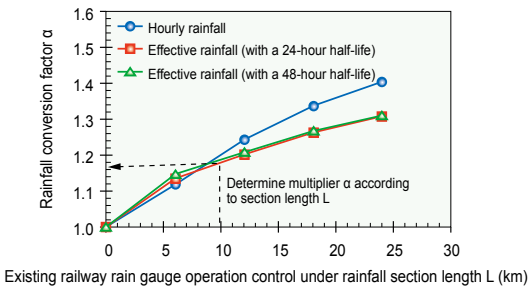


Figure 3 Relationship between operation control under rainfall section length and rainfall conversion factor

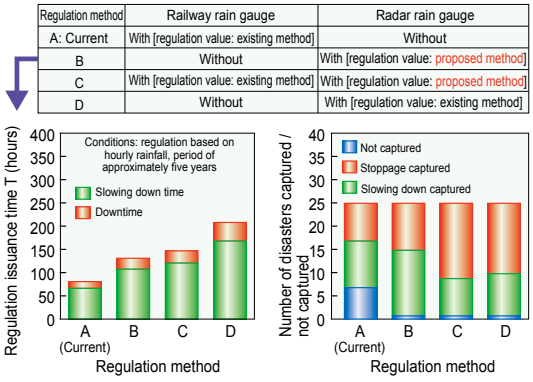


Figure 4 Estimated regulation time and disaster capture performance by method

3. Method for Estimating Track Buckling Risk Based on On-board Measurements

- We have developed a method to estimate the lateral ballast resistance using the gap between a sleeper and a ballast estimated from track measurements and ballast shape data obtained by on-board LiDAR.
- We have developed a system that identifies locations with potential risk of buckling on the track maintenance management database by using the estimated lateral ballast resistance and the maximum track curvature.

To prevent track buckling during extreme summer heat with a limited number of maintenance workers, it is essential to develop an efficient method for identifying locations where buckling is likely to occur. To address this, we developed a method to estimate buckling risk based on on-board measurements. Specifically, the buckling risk is assessed by combining the estimated reduction in lateral ballast resistance due to insufficient ballast at the track bed shoulder and unsupported sleepers together with the influence of track irregularity.

To identify areas with insufficient ballasts at the track bed shoulder, we developed a method to estimate the ballast shape using LiDAR sensors mounted on the train (Figure 1). The expected lateral ballast resistance based on the identified ballast shape is estimated using the limit equilibrium method. Model testing has confirmed that this method can predict the resistance with an error of approximately 10% for standard ballast shapes and about 20% for areas where sleeper ends are exposed (Figure 2). In addition, since no lateral ballast resistance is provided by the underside of sleepers in areas where unsupported sleepers are present, the estimated lateral ballast resistance is corrected based on the amount of hanging estimated from vertical level irregularity data obtained through track measurements.

As an indicator to identify locations with relatively high risk of buckling, we proposed a new metric called the “buckling risk index.” This index is calculated based on the estimated lateral ballast resistance and the planar curvature of the track. This processing method was developed using the command set of signal processing system for track maintenance and management (LABOCS), allowing the buckling risk index calculated from the rail temperature rise at which buckling may occur to be visualized on a chart for review (Figure 3).

This method enables the identification of critical locations where the buckling risk index exceeds 0.3 and facilitates the planning of maintenance activities prior to the peak heat season, when buckling is more likely to occur, thereby enhancing safety.

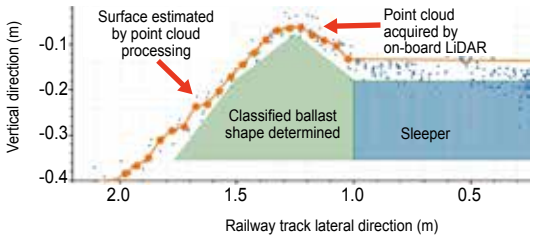
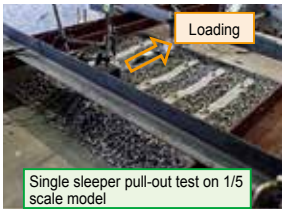


Figure 1 Estimation method for classifying ballast shape from point clouds obtained by on-board measurements



Ballast shape	Experiment (N)	Estimation (N)	Difference (%)
Standard	36.1	39.4	+9
Exposed end	34.7	30.1	-13

Figure 2 Verification of estimated lateral ballast resistance

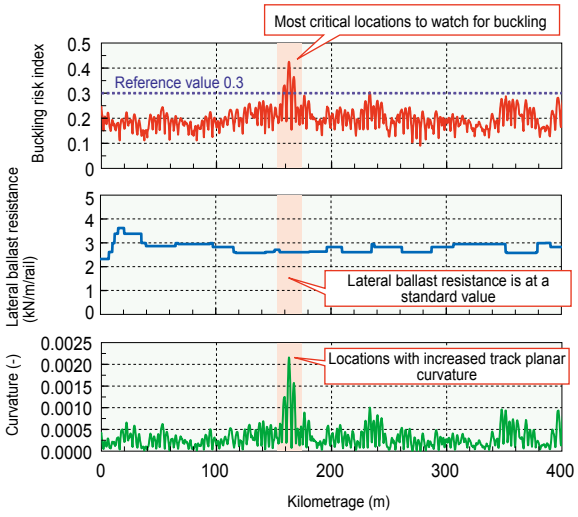


Figure 3 Example of extracted locations with estimated buckling risk index and potential buckling concerns

4. Method for Identifying Wheel Usage Limit Temperature and Evaluating Safety While in Service

- We have developed a method to identify the safety limit temperatures for various types of wheels when abnormal overheating occurs and to easily estimate the resulting residual stresses based on the deformation amount specific to each wheel type.
- As a more accurate method to assess wheel safety while the vehicle is in service, we have developed a residual stress estimation technique using an ultrasonic measurement device.

Wheels generally have sufficient thermal capacity to handle normal tread brake heat loads. However, in cases of abnormal overheating caused by failures such as tread brake air valve malfunctions, tensile residual stresses can develop in the wheel, which may lead to cracking or breakage in the worst cases. In such situations, the condition of the wheel has traditionally been qualitatively assessed based on deformation or paint peeling. However, because the limit temperature and deformation behavior vary among different wheels, there has been a demand for more quantitative evaluation criteria.

Therefore, numerical analyses were conducted on various wheels used for tread brakes to clarify the relationship between temperature rise and the limit temperature at which the wheel undergoes plastic deformation. Additionally, a method was developed to easily estimate the residual stress generated beyond the limit temperature based on the wheel's deformation amount (Figure 1). Furthermore, as a method applicable even to wheels with minimal deformation, we developed a residual stress estimation technique using an ultrasonic (acoustoelastic) device. This method determines the stress state based on differences in measurements between wheels of the same type and diameter within the same train set, according to the measurement principle (Figure 2).

These methods enable high-precision assessment of wheel stress conditions non-destructively and without disassembly while the vehicle is in service when abnormal wheel overheating is detected. This allows for rapid decision-making regarding continued operation, wheel replacement, or vehicle deadheading, ensuring safety is maintained.

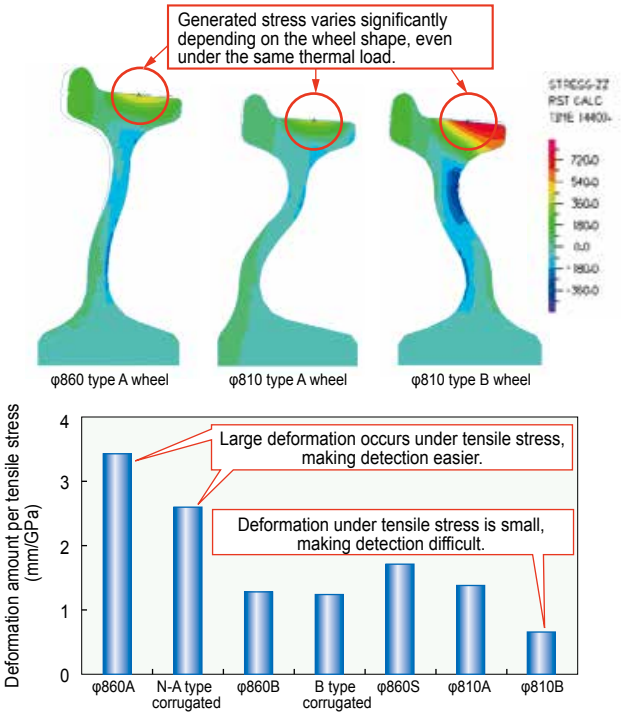


Figure 1 Examples of stress distribution after abnormal overheating by wheel type and deformation amount per stress

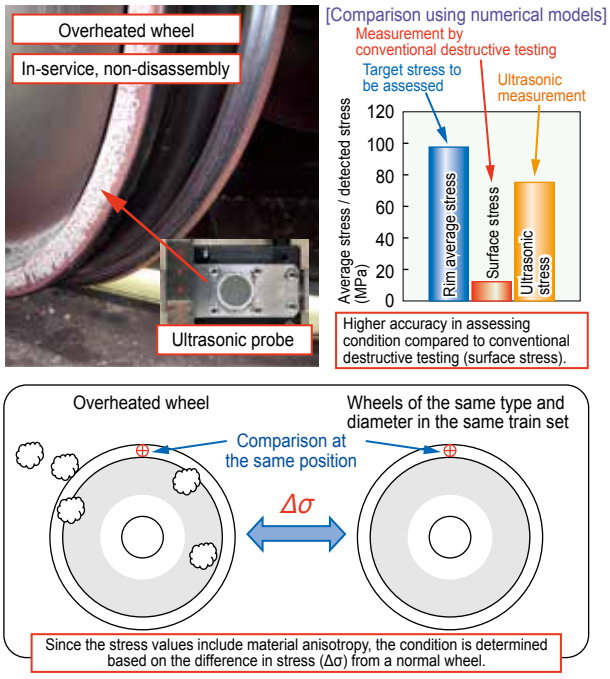


Figure 2 Overview of ultrasonic stress measurement and diagram of non-disassembly, in-service condition assessment

5. Investigation of Front Rod Fracture Causes and Maintenance Methods to Prevent Fracture

- We have identified the causes of fractures of front rods, which are part of the switch and lock movement, through both experiments and analysis, and found that they are caused by impacts during vehicle passage and improper lateral length adjustment.
- We have proposed inspection items, adjustment methods, and evaluation criteria necessary to prevent fractures of front rod L type connection devices during inspections conducted by railway operators.

Fractures of front rods can cause switching failure, leading to major transport disorders. Even today, transport disorders involving train delays, including those over 30 minutes, continue to occur almost every year. Efforts to deal with front rod issues, such as reviewing and improving the design and materials, and investigating causes, have been made, but they have been limited to addressing individual cases. As a result, the fundamental causes of fractures had not been fully clarified, nor had generalized countermeasures or key inspection points been established.

To address this, through field investigations, measurements, and a newly developed numerical analysis method, we demonstrated that fractures in front rods primarily occur at the L type connection device, a component of the front rod, and that the risk of damage is high at the stress concentration area of the L type connection device slotted hole due to torsion and bending deformation. We also showed that impacts during vehicle passage caused by equipment conditions, such as vertical steps at the heel of tongue rail, and improper lateral length adjustment of the front rod are causes of fractures.

Based on these causes, we proposed maintenance methods to prevent fractures, highlighting key points to check during visual inspections and adjustment guidelines that can be determined from appearance inspection (Figure 1). Furthermore, we also proposed example descriptions to assist railway operators in creating maintenance manuals.

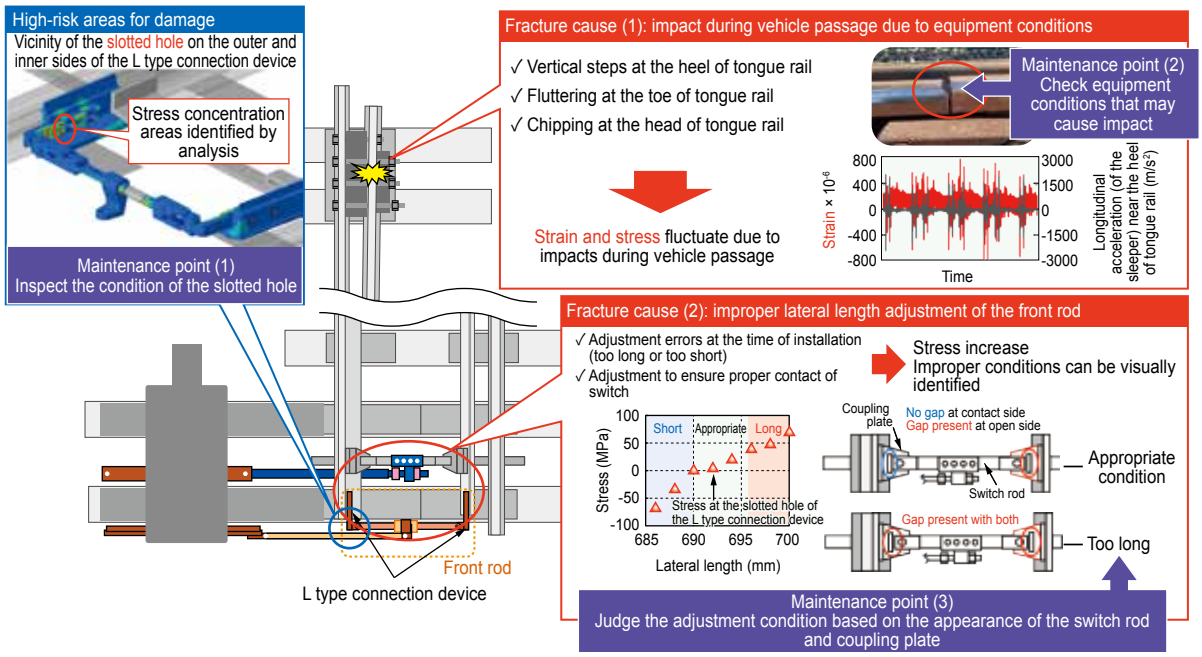


Figure 1 Locations with high front rod damage risk, causes of fractures, and maintenance methods

6. Detection System for DC High-resistance Ground Faults by Utilizing the Current Data of Both Substations and Vehicles

- We have developed a system capable of detecting high-resistance ground faults by utilizing the current data of both substations and vehicles simultaneously, while taking into account the position of trains within the feeding sections.
- The system is compatible with configurations involving multiple trains and multiple feeding section, and is capable of detecting ground faults of several hundred amperes that are difficult to detect with conventional protection systems.

One of the challenges in monitoring the integrity of overhead contact line equipment in DC traction system is the difficulty in detecting high-resistance ground faults, in which current leaks to the ground through supports of contact line or other paths due to causes such as flying debris. A well-known detection method is adding protective discharge gaps or similar voltage-limiting devices to the contact line system, however, this faces challenges such as the need for maintenance of additional devices. In contrast, methods based on monitoring feeder current only at substations have detection difficulty on small fault current with about hundreds of amperes, which is much less than current consumed by trains in normal operation. To address this, we developed a system that detects high-resistance ground faults utilizing the current data of both substations and vehicles and comparing the difference of the total feeding currents from substations with the total traction loads (collected current of all trains), taking the position of trains within the feeding sections into account (Figure 1).

In this system, measurement devices installed at substations and on trains continuously transmit current data with high-precision timestamps of every sample point, along with train position coordinates and other relevant information, to a data server. Next, the system links coordinate of train to the relevant feeding section. For each section, the system calculates the total feeding currents and the total traction loads present in the relevant section. It then compares the current between the substations and the trains, and when the accumulated value of the current difference exceeds a predefined threshold, a high-resistance ground fault is determined.

We built a prototype system as a module utilizing data integration and kilometrage conversion functions from the previously developed integrated analytics platform for railways. Verification tests conducted on the test track at the Institute confirmed that the system can detect ground faults of approximately 50 amperes under a traction load of about 160 amperes (Figure 2). In future, by applying high-precision current sensors, the system can detect ground faults of several hundred amperes even on commercial lines where traction loads reach several thousand amperes.

Based on the verification results, we compiled the basic specifications and design guidelines for implementing this method in substations and trains. This method can be implemented in environments where train position and current data can be collected and can be transmitted to a data server.

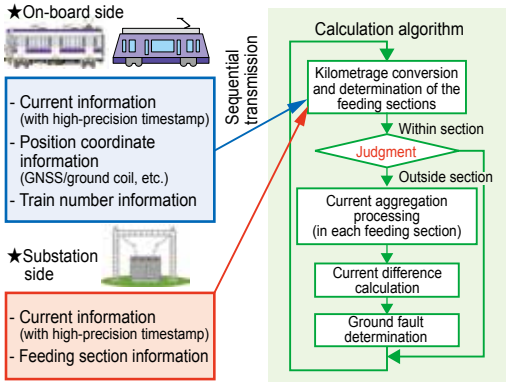


Figure 1 Overview of the developed DC high-resistance ground fault detection system

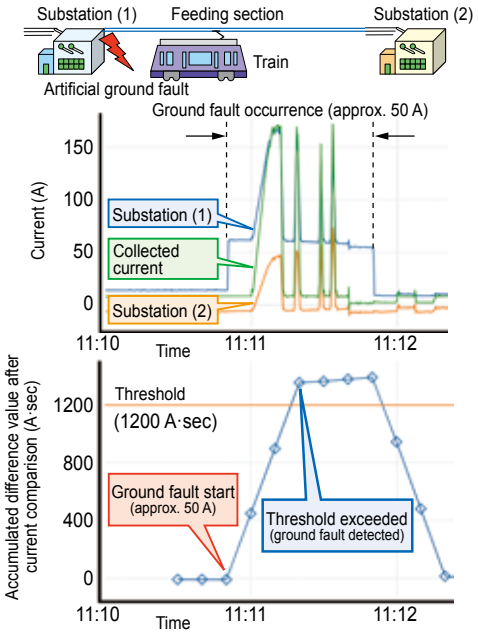


Figure 2 Example of accumulation processing during artificial ground fault occurrence

7. Forward Obstacle Detection System for Trains in Preparation for Future Driverless Operation

- We have developed a forward obstacle detection system for trains in preparation for future driverless operation on lines with level crossings and similar features.
- Using railway-specific information for calibration, high-precision sensor fusion of multiple sensors can be achieved without the need for special adjustments.

Obstacle detection ahead of the train using on-board cameras and sensors is considered one of the most promising technologies for ensuring railway track safety when introducing future driverless operations on general railway lines, such as those with level crossings. To achieve this, a system that integrates multiple sensors is required, including capabilities to detect obstacles at night and respond to incidents such as wayside fires.

To address this, we developed a forward obstacle detection system for trains using sensor fusion. This system integrates a visible light camera, a LiDAR sensor, and a far-infrared camera. It uses AI to extract the railway track area from visible light camera images, detects objects that have entered the railway track area, measures distance using LiDAR, and detects temperature using the far-infrared camera. On the other hand, integrating multiple sensors requires calibration (correction and adjustments) of each individual sensor, a process that can be complex and time-consuming. To address this, we developed a method for collectively calibrating various sensors using railway-specific rail information (Figure 1).

In verification tests conducted on actual straight railway tracks, the system was able to detect wildlife (deer) at up to 376 meters, wayside fire flames at up to 502 meters, people at up to 556 meters, and automobiles at up to 614 meters (Figure 2).

The insights gained from developing this system can be used to determine specifications of forward obstacle detection system for trains tailored to railway operators' line conditions. Additionally, they will be applied as foundational technology for the currently in-development "automatic train operation system utilizing existing railway system." Furthermore, the calibration method can be utilized as a core technology for various forward obstacle detection systems.

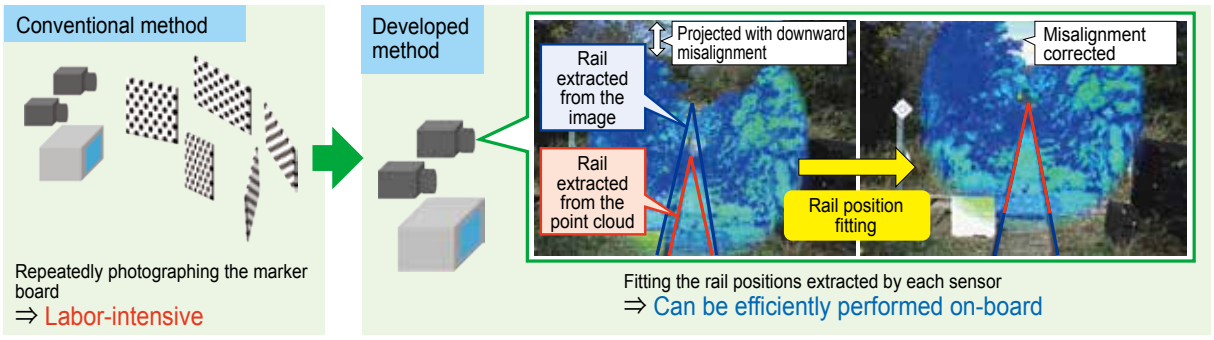


Figure 1 Calibration method for enabling sensor fusiont

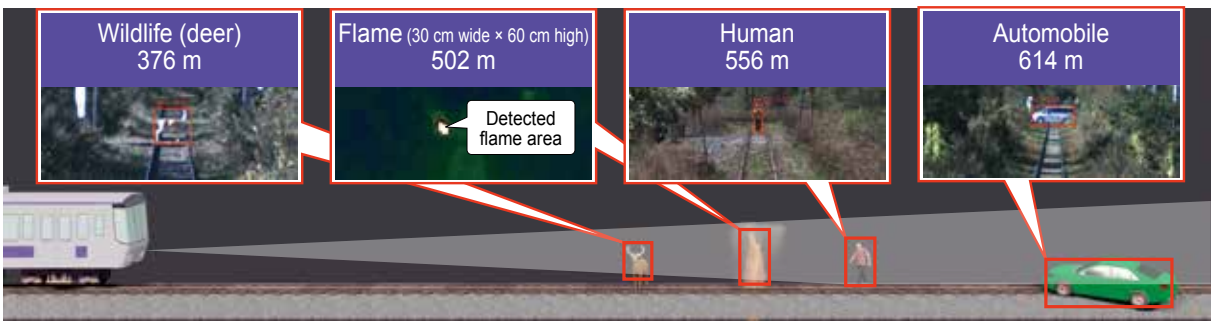


Figure 2 Detection distances of the forward obstacle detection system for trains using sensor fusion

8. Validation of the Long-term Effectiveness of Automatic Deer-deterrent Sound Devices

- The installation of automatic deer-deterrent sound devices was found to reduce collisions between trains and deer by approximately 30 to 40%, and this reduction was confirmed to be statistically significant.
- A validation test conducted over 2 years and 9 months confirmed that the above effect is sustained over the long term.

Despite the high and stable deer population, their habitat is expanding every year, resulting in an annual increase of approximately 10% in collisions with trains. To address this issue, the Railway Technical Research Institute developed a device that automatically emits deer-deterrent sounds combining the deer's alarm calls to warn others and dog barks that deer dislike from trains within preset sections (Figure 1, "deer-deterrent sound device"). While its effectiveness in preventing collisions with deer had been confirmed, verifying the long-term sustainability of this effect remained a challenge.

From April 2022 to December 2024, a validation test on the sustainability of the effect was conducted over 2 years and 9 months by gradually installing the deer-deterrent sound device on 12 of the 39 operational vehicles running on the target line section. As a result, the number of collisions with deer per thousand kilometers was approximately 0.26 for vehicles without the device and approximately 0.16 for vehicles equipped with the device. This confirmed that the installation of the device leads to a long-term reduction effect of approximately 30 to 40%, which was also verified to be statistically significant (Figure 2).

The deer-deterrent sound device is expected to be an effective long-term measure for reducing collisions between trains and deer.

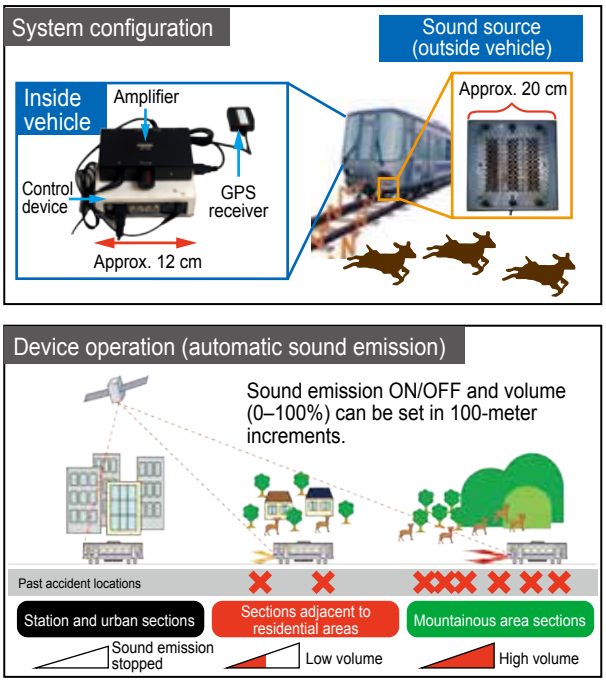
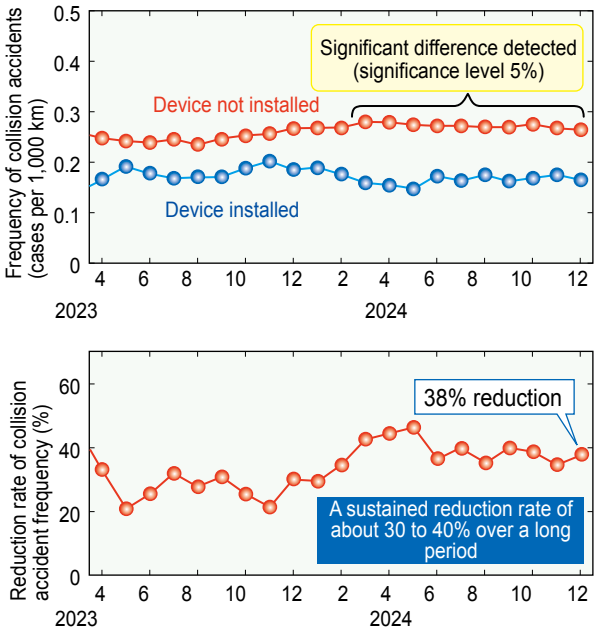


Figure 1 Overview of automatic deer-deterrent sound devices



*Test started in April 2022. This figure shows data from April 2023 onward.
*"Collision frequency": Frequency of collisions with deer per 1,000 km traveled (calculated from cumulative travel distance and cumulative number of collisions since April 2022)

Figure 2 Results of the long-term verification test

9. Design Method for Post-installed Anchor Joint Members in the Reconstruction of Concrete Structures

- We clarified the stiffness and capacity of the joint surface according to the quantity and drilling positions of post-installed anchors, as well as the shear transfer capacity based on the treatment method of the joint surface, and developed a design method for joint members.
- Compared to conventional methods, the amount of post-installed anchors can be reduced by approximately 30%, making construction and quality assurance easier for existing structures with overcrowded reinforcement.

To improve convenience at stations and other areas, there has been an increasing number of cases where additional members are installed on existing cut and cover tunnels and rigid-frame viaducts using the post-installed anchor method (Figure 1). However, a rational design method for member joints has not been proposed, and considering it from the safety measures side, cases of using an excessive number of anchors can be frequently seen. In such cases, it has sometimes been difficult to perform anchor installation and ensure quality in existing structures with overcrowded reinforcements.

To address this, a design method was developed that accounts for the type of joint members, the quantity and positions of anchors, and the roughening of the joint surface. For corner joints, a method was proposed in which the opening of the joint surface caused by the pullout of anchors from corner is modeled as a rotational spring, and the stiffness of the joint member is calculated based on the quantity and positions of the anchors (Figure 2). For wall joints, a shear capacity calculation method was proposed that considers the effects of friction and interlocking of aggregates at the joint surface. Trial calculations for cut and cover tunnels showed that the amount of post-installed anchors could be reduced by approximately 30% for both beam-to-column connection joints and wall joints (Figure 3).

These design methods are reflected in the guidelines for post-installed anchors and can be applied in the reconstruction of concrete structures. This design method enables rational structural planning and selection of joint members, allowing for greater design flexibility in accommodating various structural forms and spatial requirements.

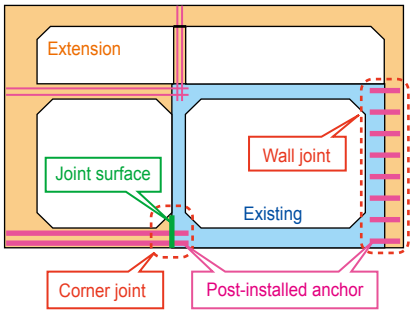


Figure 1 Example of reconstruction in a cut and cover tunnel

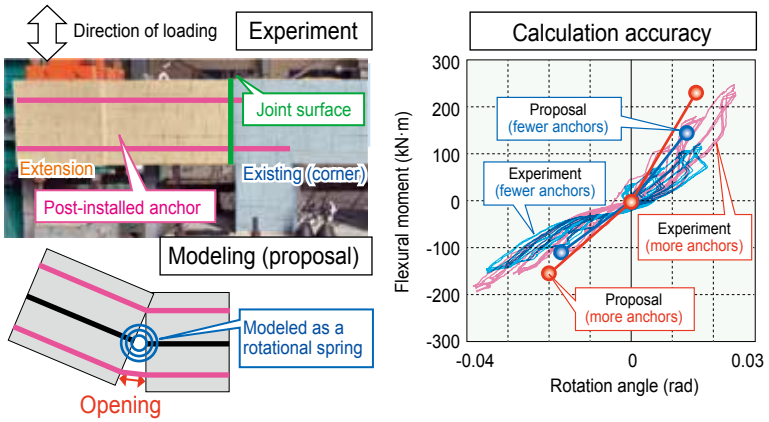


Figure 2 Stiffness calculation for corner joints

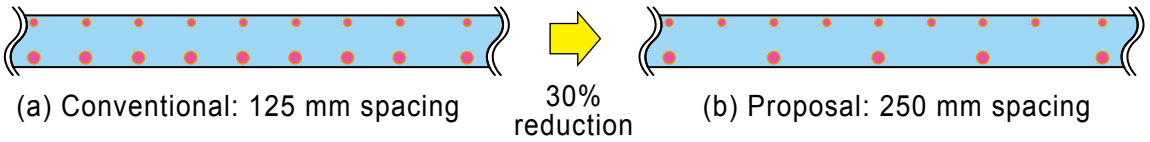


Figure 3 Example of anchor quantity reduction (joint surface in the “corner joint” shown in Figure 1)

10. Reinforcement Method for Preventing Fatigue Cracks at Steel Girder Support Sections

- We have developed a reinforcement method that prevents fatigue crack occurrence at steel girder support sections without the need for temporary girder supports.
- By driving in bearing bolts to press the backing plate against the bottom flange, the plate efficiently shares the load, reducing stress concentration at the lower end of the edge stiffener where fatigue cracks tend to initiate.
- This reinforcement method can be implemented in a short time at less than 10% of the cost of conventional methods.

At the support sections of welded steel girders, improper installation of bearings can cause inadequate support of the girder, leading to stress concentration in the welds at the lower end of the edge stiffeners during train passage, which may result in fatigue cracks (Figure 1). To prevent fatigue cracks, it is necessary to improve the bearing installation condition. However, this requires temporarily supporting the girder, which entails considerable costs for installing temporary supports and related work.

Therefore, we developed a reinforcement method that reduces stress concentration at the welds and prevents fatigue cracks by reinforcing the lower end of the edge stiffener with the backing plate (Figure 2). Simply connecting the backing plate to the edge stiffener does not ensure a firm fixing with the bottom flange on the bearing, so it does not share the load during train passage and therefore does not provide effective reinforcement. In this method, the backing plate is pressed and fixed firmly against the bottom flange on the bearing, allowing it to share the load and provide reinforcement. The pressing of the backing plate is performed manually in a short time by shifting the plate toward the bottom flange by driving in bearing bolts, making it applicable even in the confined construction environments around the bearing sections. Since this method allows construction without temporarily supporting the girder, it can prevent fatigue cracks at less than 10% of the cost of conventional methods. The method was applied to an actual bridge, and it was confirmed that the stress at the lower end of the edge stiffener during train passage decreased by approximately 60% after construction (Figure 3).

This method can be utilized as a low-cost preventive maintenance measure for welded steel girders. Specifically, it can be applied in cases such as improper bearing installation, presence of small gaps difficult to adjust, predicted fatigue crack occurrence due to aging, or situations where temporary support of the girder is difficult.

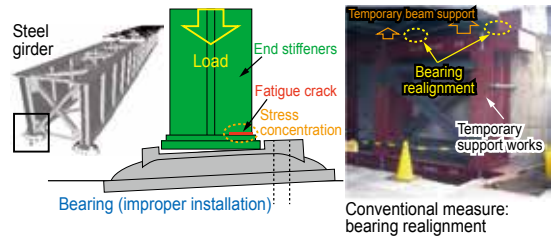


Figure 1 Fatigue cracks at the lower end of the edge stiffener and conventional countermeasures

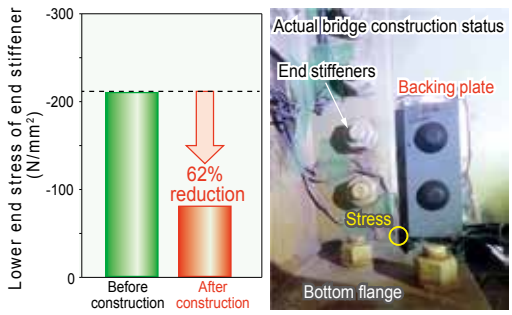


Figure 3 Stress reduction effect on the actual bridge

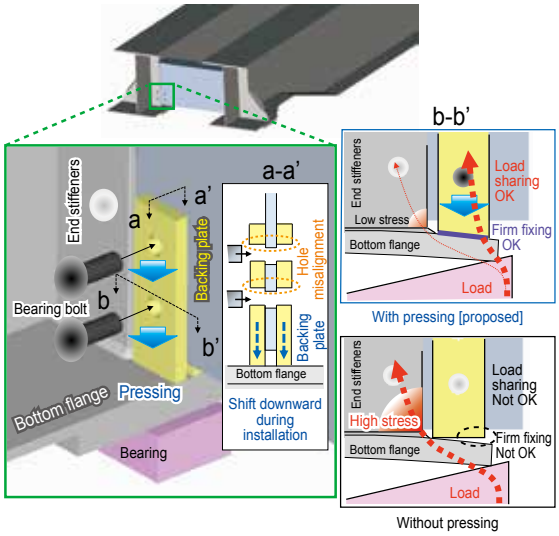


Figure 2 Outline of reinforcing construction method

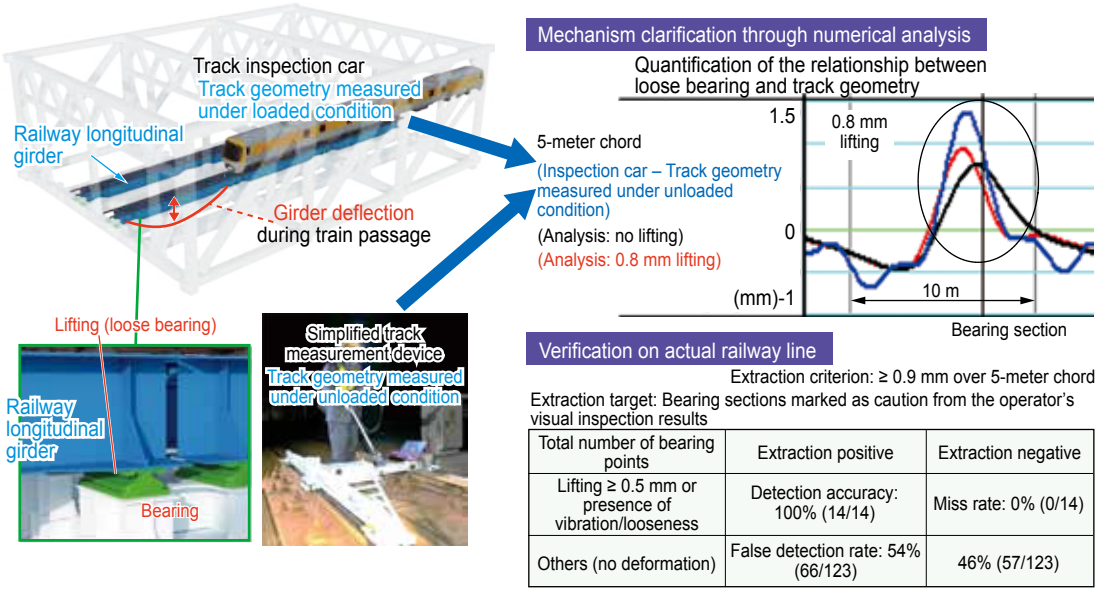
11. Method for Identifying Potentially Critical Locations of Loose Bearing Based on On-board-measured Track Geometry

- We have developed a method for identifying bridge loose bearing locations by utilizing the difference between track geometry measured under loaded conditions obtained from a track inspection car and track geometry measured under unloaded conditions obtained from a simplified track measurement device.
- This method enables the high-accuracy identification of loose bearing locations with vibration or with an uplift gap of 0.5 mm or more in sections where steel bridges with ballastless tracks are continuous.

In steel railway bridges, loose bearing accompanied by vibration at the support points may occur when trains pass. Since loose bearing can lead to issues such as fatigue cracks, engineers have traditionally conducted periodic on-site inspections, visually checking each bridge one by one. This process has required a significant amount of manpower. Therefore, if loose bearing locations can be identified using track geometry measured on-board, it would be possible to narrow down the inspection targets and significantly reduce the workload. However, it has been difficult to extract subtle displacements caused by loose bearing from on-board-measured track geometry, and no effective method had been developed to achieve this.

To address this, we first developed a numerical analysis method and clarified the characteristic increase in track geometry amplitude at locations with loose bearing. Based on this property, we developed a method for identifying loose bearing locations by using the amplitude of track geometry obtained by subtracting the track geometry measured under unloaded condition (recorded by a simplified track measurement device) from the track geometry measured under loaded condition (recorded by a track inspection car) as a detection indicator. This method was applied to 137 bearing points along an actual railway section with multiple consecutive simply supported steel bridges with ballastless steel tracks. As a result, all 14 bearing points that had previously been identified as critical by the railway operator were successfully detected due to vibration or due to an uplift gap of 0.5 mm or more observed during visual inspections (Figure 1).

This method is applicable to sections with consecutive steel bridges with ballastless steel tracks, such as long-span bridges, and enables the screening of loose bearing locations that require visual inspection, thereby contributing to a reduction in inspection workload. It is also planned to be used as a subsystem of the integrated analysis platform.



Total number of bearing points	Extraction positive	Extraction negative
Lifting ≥ 0.5 mm or presence of vibration/looseness	Detection accuracy: 100% (14/14)	Miss rate: 0% (0/14)
Others (no deformation)	False detection rate: 54% (66/123)	46% (57/123)

Figure 1 Bridge loose bearing detection method using on-board-measured track geometry and verification on actual railway

12. Extension of Rail Replacement Cycles Considering Fatigue/Soundness

- Fatigue tests conducted on rails that had reached their replacement cycles while remaining in sound condition revealed little to no reduction in fatigue strength, indicating that periodic replacement may no longer be necessary.
- To identify locations where rail defects are likely to occur, we have developed a method for evaluation of health using track measurement data and implemented it in the track maintenance management database system.

Although rail replacement cycles are set based on the fatigue test results targeting bending fatigue at the base of rails, rails that remain in sound condition are considered to have the potential for much longer service life.

To address this, both fatigue tests of actual rails and rotating bending fatigue tests with 500 million load cycles, equivalent to approximately 5 billion passing tonnages, were conducted on aged rails including welded joints, non-welded rail sections, and expansion joints that had reached approximately 1 billion passing tonnages, which is the current replacement threshold. The results showed minimal reduction in fatigue strength compared to new rails (Figure 1), suggesting that continued use beyond 1 billion passing tonnages is feasible and that fixed replacement cycles could potentially be eliminated.

On the other hand, fatigue damage at the base of rails can occur before reaching the replacement cycle in areas where hanging sleepers or localized irregularities on the top surface of rails are observed. Stress measurements conducted at such locations, along with numerical analysis simulating track conditions, revealed that the stress generated in the rail during train passage can reach several times that of those in sound conditions, exceeding the fatigue limit and causing damage (Figure 2).

Based on these findings, we proposed a method for quantitatively evaluating the possibility of rail failure by estimating fatigue due to stress through numerical analysis, using the amount of hanging sleepers and rail surface roughness calculated from track measurement data. This method was implemented in the LABOCS track maintenance management database system (Figures 3 and 4).

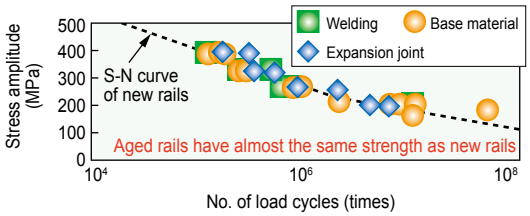


Figure 1 Fatigue test results of aged rails

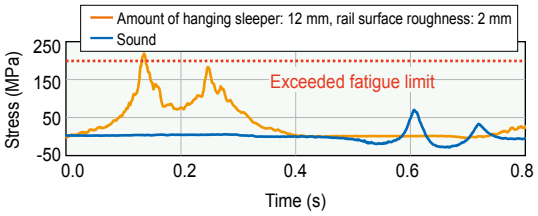


Figure 2 Stress waveform during train passage (2 wheelset)

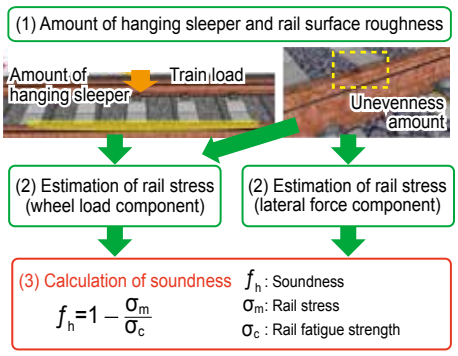


Figure 3 Rail soundness estimation flow

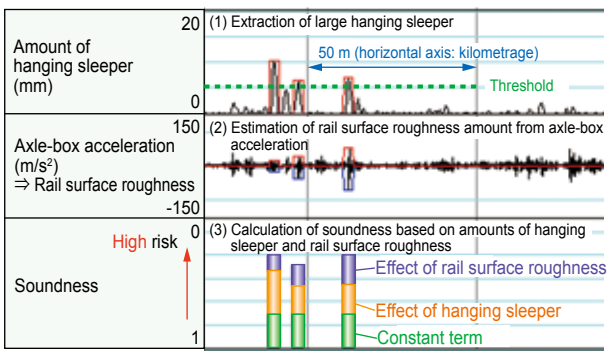


Figure 4 Rail soundness condition displayed in LABOCS

13. Support Method for Extending Inspection Periods Based on Statistical Analysis of Equipment Inspection Records

- We have developed a statistical framework to estimate the relationship between service life and failure occurrence rate, considering heterogeneity among individual equipment, based on equipment inspection records and ledger data.
- We have proposed an approach to optimizing inspection periods based on failure occurrence rates, and applied to support a railway operator's decision-making to extend the period for point machines on a certain actual railway section from three months to four months.

Assessing equipment condition in detail and with continuous values, it is possible to extend inspection periods without lowering the current management standards. Since a lot of equipment has inspection records that regularly document their condition through daily inspections, we developed a method that utilizes the statistical properties of these inspection records to determine the feasibility of extending inspection periods.

One of the challenges in analyzing inspection records statistically was the use of discrete evaluation scales like ○(normal) and □(failure), and the need to account for individual differences that cannot be explained solely by easily accessible factors from ledgers (such as the number of operations in point machines). To address this, we developed a statistical analysis method that models failure occurrence using a probabilistic approach while also accounting for differences in failure occurrence frequency among individual equipment.

This method enables the quantification of the relationship between service life and failure occurrence rate (risk) for each piece of equipment based on past inspection records. If the maximum risk under the current inspection period is set as the allowable value, the feasibility of extending the inspection period can be evaluated by comparing it with the failure occurrence rate of each piece of equipment after the extension. For example, in the case shown in Figure 1, even if the inspection period is extended from the current 90 days to 120 days, the failure occurrence rate for the majority of equipment remains below the current allowable value, indicating that the extension is feasible. Furthermore, for some equipment whose failure occurrence rate exceeds the allowable value after the extension, it is still possible to consider extending the inspection period by setting conditions such as implementing monitoring measures. This method was applied to 280 point machines on an actual railway line, supporting the railway operator's decision to extend the inspection period by approximately 1.3 times.

This method was developed as a functional module of an integrated analysis platform for railways, which enables centralized management and analysis of various types of maintenance data, including location information. It can also be applied to various types of equipment where inspection records are stored in a similar format, and can be used to review and optimize inspection periods for them.

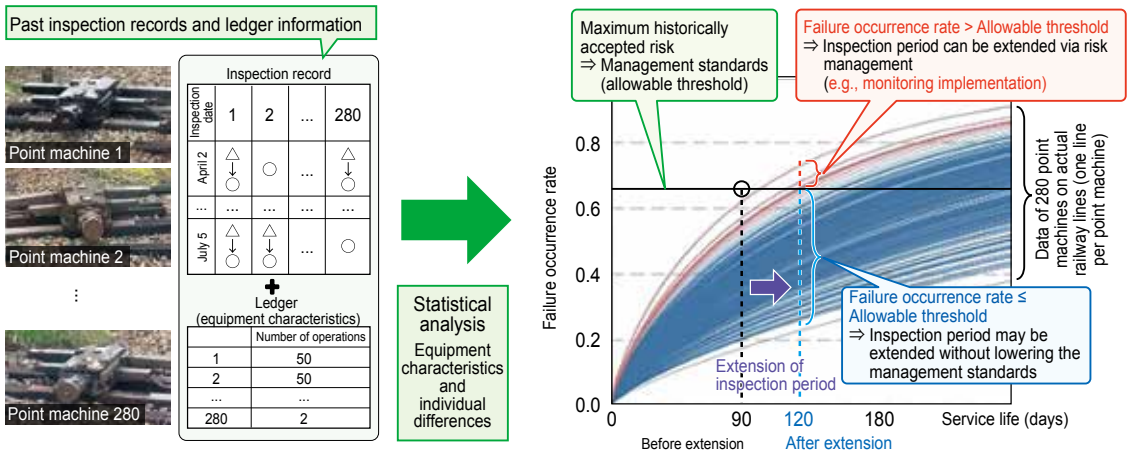


Figure 1 Support method for extending point machine inspection periods based on statistical analysis of inspection records

14. Automated Visual Inspection System for Vehicle Underbody

- We have developed a system that captures high-resolution continuous images of the underbody of passing vehicles and diagnoses any external abnormalities, replacing manual visual inspection.
- Recognizing the vehicle number displayed on the carbody from these images eliminates the need for RFID tags and reduces cost.
- The system enables high-frequency inspections outdoors regardless of the time of day or weather conditions.

Periodic visual inspections of rolling stock do not require disassembly of the vehicles, but they require manpower due to the short inspection intervals and the reliance on manual checks. Under these circumstances, we developed a system that automatically inspects the bogies and underbody of vehicles, which have many inspection points, for any visible abnormalities.

The system captures images of the underbody of passing vehicles using an imaging device installed at the entrance of the depot, or similar locations (Figures 1 and 2). By using a line-scan camera, the system can obtain high-resolution continuous images. By automatically recognizing the vehicle number displayed on the carbody from the captured images, the system can manage the images by vehicle number without the need to install RFID tags or similar devices on the vehicles. Additionally, the diagnostic algorithm, which suppresses the effects of disturbances such as direct sunlight and rain and evaluates differences from the normal appearance as an anomaly score (Figure 3), enables the detection of unspecified abnormalities regardless of the time of day or weather conditions.

As a result of verification through the imaging of shunting vehicles for up to 21 months, we confirmed that the system can diagnose 17 out of 24 simulated abnormalities (Table 1) with 0% false negatives and less than 1% false positives. Automating the manual visual inspection with this system contributes to labor savings in rolling stock inspections.

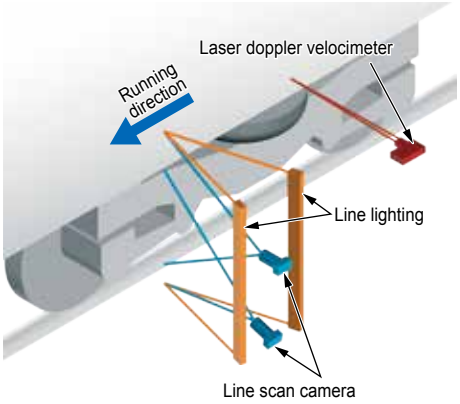


Figure 1 Overview of the imaging device

Figure 2 Imaging device capturing a running vehicle

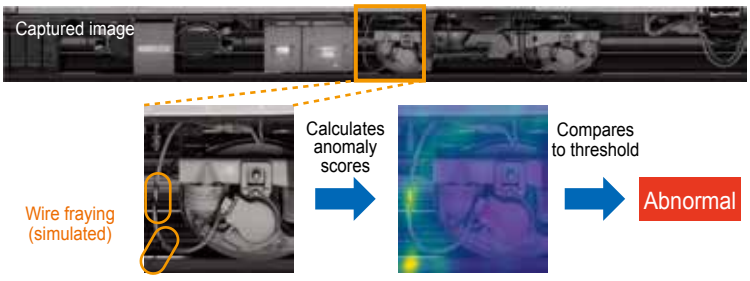


Figure 3 Example of diagnosis for wire fraying

Table 1 Detected abnormalities

Component detachment	Wire fraying or disconnection, bolt/nut loss, wire breakage, adjustment rod detachment, brake shoe loss
Deformation and damage	Lifeguard bending, opened crack on bogie frame
Incorrect handle position	Box lid unlocked, incorrect valve state or half-opened
Foreign object	Branch, plastic bag, hammer
Others	Yaw damper oil leak

15. Autonomous Train Operation System

- We have developed an autonomous train operation system that enables trains to make operation decisions and control point machines & level crossings autonomously, based on the status information on railway tracks and along waysides.
- In the future, this system has the potential to reduce labor and manpower across the entire train operation process, including driving, maintenance, and traffic control.
- Sharing information through the Railway Dynamic Map can be effectively used to enhance traffic control.

We are engaged in the research and development of an autonomous train operation system that goes beyond conventional automatic driving, aiming to reduce labor and manpower across the entire train operation process, including driving, maintenance, and train operation control. This system provides trains with information such as the presence of obstacles on railway tracks or along waysides, and operation controls due to maintenance work or natural disasters, enabling each train to assess the situation autonomously. The goal is to achieve safe and flexible train operations.

This system consists of an on-board control unit, an operation decision module, a speed profile calculator, a train front obstacle detection system, an abnormal sound detection device, a wayside obstacle detection system, a traffic controller, point machine controllers and level crossing controllers (Figure 1). These devices work in coordination, with information detected by the monitoring systems mapped on the Railway Dynamic Map within the operation decision unit. This information is shared between ground and on-board systems, as well as among trains, enabling each train to autonomously determine whether to continue operation, avoid hazardous events automatically, and resume operation when appropriate.

Using a prototype system, we conducted demonstration tests on the test track at the Railway Technical Research Institute. Through these tests, we confirmed several key functions: automatic train operation while controlling wayside equipment in accordance with calculated speed profiles; automatic hazard avoidance by having the on-board operation decision unit command the train to stop based on information from the train front obstacle detection system detecting obstacle on the railway track; and resumption of operation after the obstacle is removed, based on automatic judgment by the on-board operation decision module (Figure 2).

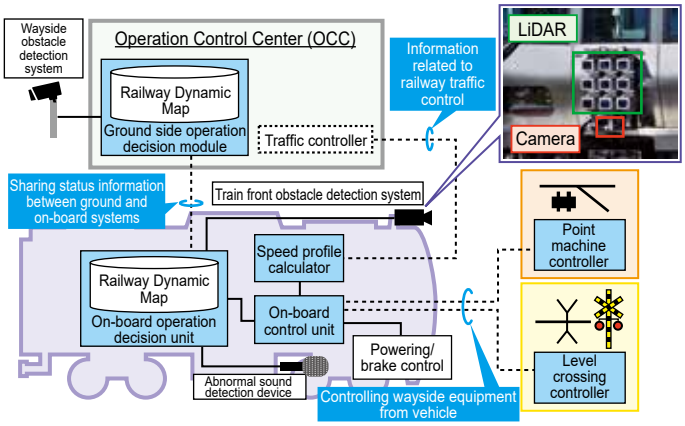


Figure 1 System configuration

This system enables direct control of wayside equipment from on-board units, allowing for a reduction in ground-based interlocking devices and thereby reducing labor of the construction and maintenance of ground equipment. Furthermore, the automatic generation of speed profiles is expected to improve the efficiency of train operation control. This system serves as a core technology for future labor and manpower reduction across the entire train operation process. Additionally, the technologies for obstacle detection, information sharing and operation decision-making using the Railway Dynamic Map can be applied to enable driverless operation on conventional lines with level crossings, as well as to improve current train operation practices.

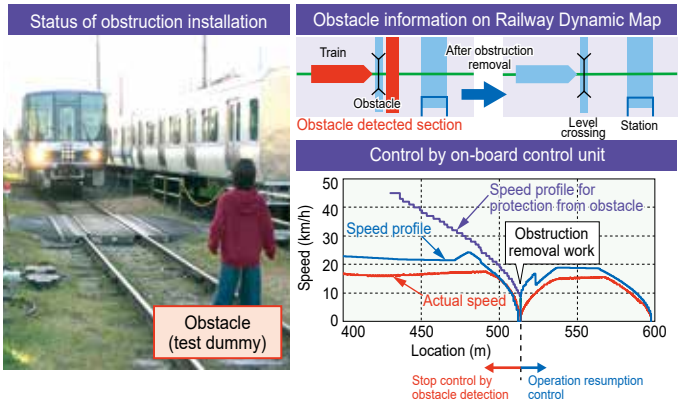


Figure 2 Automatic train stop and resume operation triggered by obstacle detection

16. General Purpose Real-time Algorithm for Generating Driving Curves for Driver Advisory System

- We have developed a real-time algorithm for generating driving curves for driver advisory system that can be applied to various types of trains and railway routes.
- We have confirmed that the driving method to achieve on-time operation is presented within a short time.
- The algorithm was validated across numerous railway routes and trains, receiving generally favorable evaluations from train drivers.

At the Railway Technical Research Institute, we have developed a driver advisory system that generates driving curves with excellent punctuality and energy efficiency in real time and suggests driving methods up to a passage station. However, its applicability has been limited.

Therefore, we developed a real-time driving curve generation algorithm for the driver advisory system that can handle various diverse conditions such as train running times and railway routes. This algorithm is based on a sawtooth driving pattern that targets the scheduled average speed to the next station as the goal speed (Figure 1), and it corrects the target speed for speed limits and gradients. As a result, the algorithm generates driving curves that achieve on-time operation even in sections with speed limits, while prioritizing powering on uphill gradients to create easily operable driving patterns (Figure 2).

The driver advisory system incorporating this algorithm can promptly provide driving methods that achieve on-time operation. Although dependent on the train's traffic conditions, we confirmed that compared to the previous algorithm that searches for end-of-acceleration speed at each passage station, the proposed algorithm achieves a higher rate of on-time operation suggestions while reducing search time (Figure 3). Additionally, over 800 validation tests while in revenue operation were conducted on 30 trains across five railway routes to verify energy-saving effects, and it was confirmed that train drivers generally hold favorable opinions about the system (Figure 4).

Based on these results, we confirmed that this system can be expected to achieve on-time operation, energy savings, and reduced driver workload for pass-through train operations.

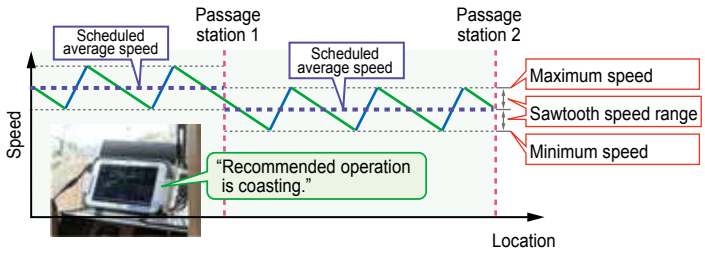


Figure 1 Concept of sawtooth driving based on scheduled average speed

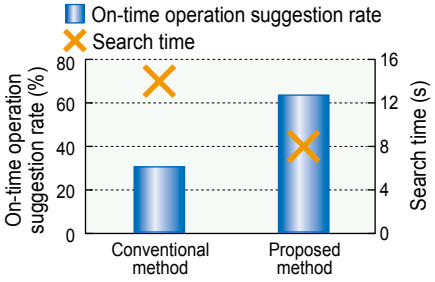


Figure 3 On-time operation suggestion rate and search time

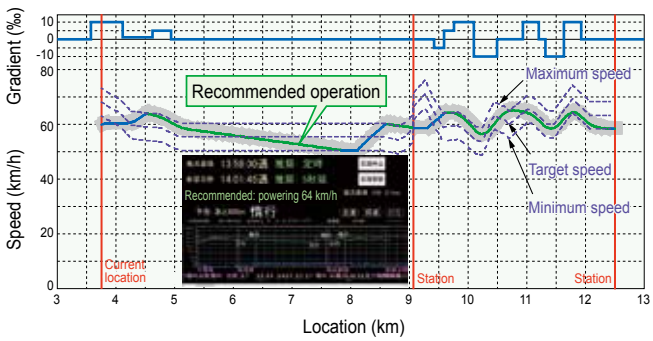


Figure 2 Example of train performance curve generation for operation support

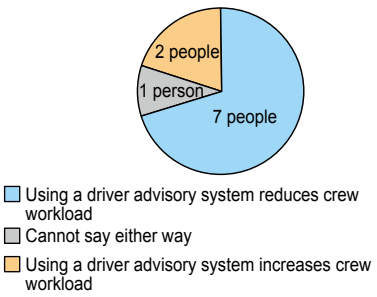


Figure 4 Example of survey results from train drivers

17. Method for Updating On-board Databases Using Public Communication Networks

- The update of on-board databases for train control, which was previously performed manually by staff for each vehicle, can now be automated, enabling significant time reduction and labor-savings in the update process.
- Since updates can be performed even while the train is stopped at a station, it becomes easier to introduce on-board database-based train protection systems on through service lines where diverse vehicles are running.

In on-board train protection systems with databases containing railway track conditions and related information, the database must be updated whenever conditions such as track alignment change. Currently, staff are required to perform update operations for each vehicle within the depot, which limits the update location to the depot and involves significant labor and time—these have been ongoing challenges.

Therefore, we proposed a method that utilizes public communication networks to deliver data to on-board unit and automatically update the databases. To implement such a method, technology is required to verify within a short time of about a few minutes that there are no cyberattacks from external sources and no errors in the delivered data. This method not only provides security features such as detecting external tampering of delivered data but also enables simultaneous verification of errors in the delivered data caused by encryption module faults or communication errors. Specifically, along with the data delivered from the central equipment to the on-board unit, an encrypted identification code of the data is transmitted to the on-board unit via public communication networks. The on-board unit encrypts the received data to generate an identification code, which it then compares and verifies against the transmitted identification code. If there is a mismatch, the data is retransmitted. However, since generating the identification code on the on-board unit requires time, a high-speed encryption module is applied to shorten the processing time (Figure 1). Additionally, a test unit for this method was constructed to verify functions such as the detection of mismatches and the required verification time relative to data volume.

This method allows on-board databases to be updated within a few minutes at any location within the coverage area of public communication networks, making it possible to perform updates even while the train is stopped at a station (Table 1). Furthermore, by not registering the entire on-board database in advance and instead receiving and updating only the necessary data ahead of each section according to the running section, it becomes easier to introduce on-board database-based train protection systems on through service lines where various vehicles operate.

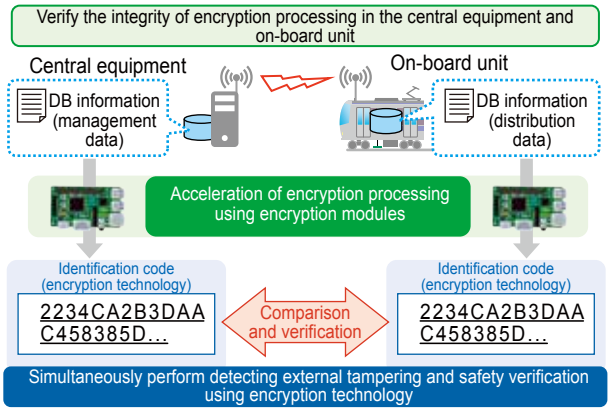


Figure 1 On-board database (DB) verification method

	Conventional method	Developed method
Update location	Within the depot	Within the public communication network coverage area
Target section	All sections	Only the sections required for vehicle operation
Target vehicle	All vehicles that may operate on the target section	Only vehicles operating on the target section
Rolling stock schedule	Deadheading to depot required	Not applicable
Others	Simultaneous update for all vehicles	Individual vehicle update before operating section

Table 1 Features of the development method

18. Labor-saving for Generating Crew Schedule to Enable Workforce Efficiency and Reduce Labor Burden

- We have developed a method for automatically generating crew schedules that balance workforce efficiency and labor burden reduction, specifically for train timetable revisions.
- The method can generate crew schedules in approximately five hours even for high-density lines with over 500 trains per day, resulting in labor-saving in the planning process.

During train timetable revisions, it is necessary to generate crew schedules that outline work plan, alongside train schedules and rolling stock schedules. Crew schedules must satisfy numerous regulatory constraints while ensuring workforce efficiency. In addition, reducing the labor burden on crew members is also required. As a result, even experienced personnel currently require several days or more to generate crew schedules for each rail line.

To date, we have developed an automated method for generating crew schedules focused specifically on workforce efficiency. However, since workforce efficiency and labor burden are in a trade-off relationship, the previously developed method struggled to balance both effectively, and faced significant increases in computation time on high-density lines. Therefore, we defined a new labor burden index representing factors such as on-duty time, working hours, sleep time, and meal time. Using mathematical optimization techniques, we developed a two-step solution method that first minimizes the number of working days, an indicator of workforce efficiency, and then reduces the labor burden index within the obtained upper limit of working days (Figure 1). This enables the generation of crew schedules that prioritize workforce efficiency while considering crew labor burden, all within a short time.

The developed method can generate the crew schedules in approximately five hours on a commercially available personal computer even for high-density lines with over 500 trains per day. Compared to actual crew schedules generated by personnel over several days, the method achieves equal or fewer working days while improving the labor burden index over the previously developed approach (Figure 2). This method enables labor-saving and de-skilling in the generation of crew schedules.

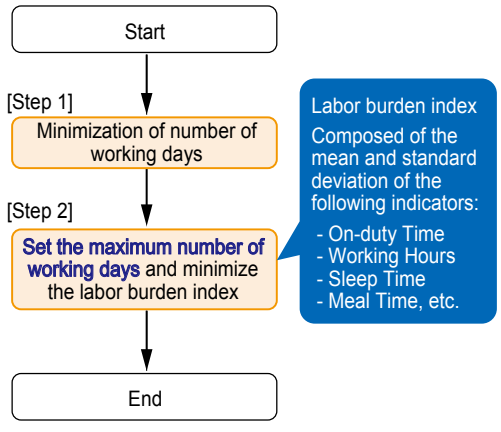
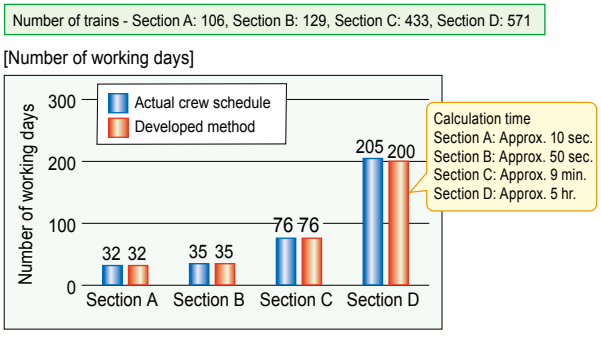


Figure 1 Procedure for automatic generation considering labor burden



[Reduction rate of the labor burden index compared to the previously developed method]

Section A	Section B	Section C	Section D
2.0%	3.8%	0.4%	0.5%

Figure 2 Comparison of working days and labor burden index

19. Two-Step Cross-Sectional Tunnel Entrance Hood

- As an effective tunnel entrance hood extension for reducing micro-pressure waves, we proposed a two-step cross-sectional tunnel entrance hood with an extended section that has a larger cross-sectional area than the existing section.
- Field measurements were conducted in a tunnel equipped with the two-step cross-sectional tunnel entrance hood, confirming that the micro-pressure waves did not worsen compared to the current condition before and after the speed increase.

One method to reduce micro-pressure waves emitted from exit of tunnels is the installation of a tunnel entrance hood at the entrance of tunnels. With increasing speeds, extending the tunnel entrance hood is necessary; however, longer extensions lead to higher costs and may be difficult to implement depending on the conditions around the entrance of tunnel. Therefore, we estimated specifications for a more effective tunnel entrance hood extension using acoustic model calculations and verified them through scale model experiments (Figure 1).

As a result, while conventional tunnel entrance hoods typically have a cross-sectional area about 1.5 times that of the main tunnel, increasing the extension section's cross-sectional area to 2.5 to 3.0 times that of the main tunnel allowed a reduction of the maximum pressure gradient of the compression wavefront to a similar level, even with approximately 15% shorter length than conventional tunnel entrance hoods. This indicates its effectiveness in reducing micro-pressure waves (Figure 2).

Based on these studies, a two-step cross-sectional tunnel entrance hood with an extension section having 2.5 times the cross-sectional area of the main tunnel was installed in a Shinkansen tunnel (Figure 3), and its effectiveness was verified through field measurements. As a result, the maximum micro-pressure wave at the same speed was significantly reduced. At a train speed of 320 km/h, the maximum micro-pressure wave was lower than that at 260 km/h before the tunnel entrance hood extension, confirming that the increase in train speed does not worsen the current conditions (Figure 4).

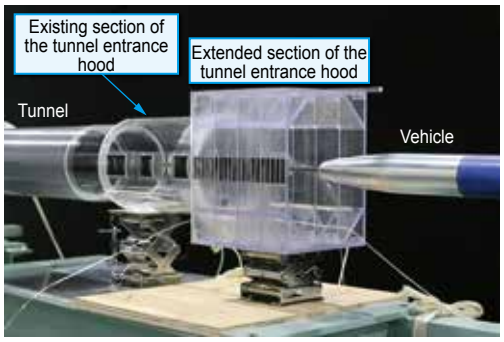


Figure 1 Status of model experiment implementation

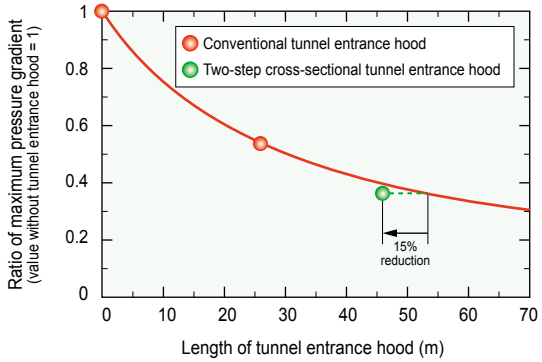


Figure 2 Results of the model experiments

Figure 3 Two-step cross-sectional tunnel entrance hood installed in a Shinkansen tunnel

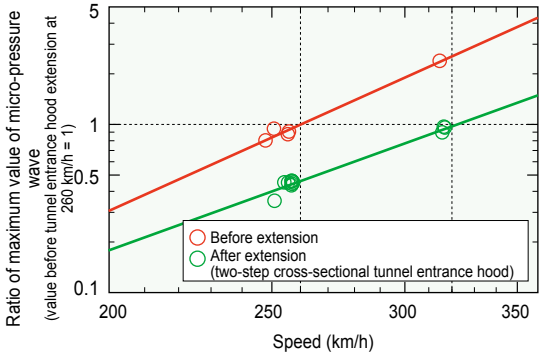


Figure 4 On-site measurement results

20. Method for Detailed Prediction of Contribution of Each Noise Source on Wayside Noise Generated by Shinkansen Vehicles

- We developed a method for predicting wayside noise at an evaluation point 25 m away from the center of the nearest track by using high-resolution measured noise source distributions around vehicles and applying sound propagation characteristics of point source.
- Since the method enables the calculation of the detailed contribution ratio of each noise source at the evaluation point, it allows for the prediction of the noise when modifying the shape of specific vehicle components or changing the height of noise barriers.

Prediction methods for the wayside noise level (at an evaluation point 25 m away from the center of the nearest track) and the contribution of each noise source during Shinkansen vehicle running is utilized in determining appropriate noise barrier heights when increasing running speeds, introducing new vehicle models, or opening new lines. In this study, in evaluating the effectiveness of noise reduction measures such as modifying the shape of specific vehicle components, there has been a need for more detailed breakdowns of the contribution of each noise source.

In this study, we developed a method for predicting wayside noise by using high-resolution noise source distributions around vehicles measured with a two-dimensional microphone array and applying sound propagation characteristics of point source (Figures 1 and 2). Here, propagation characteristics refer to the level difference between the sound power of a point source placed around the vehicle and the sound pressure at the evaluation point, as determined through acoustic scale model experiments (1/20 scale). These characteristics are experimentally derived and account for sound attenuation effects such as diffraction and sound insulation. In particular, a new method employing a point source device capable of generating spherical waves has made such acoustic scale model experiments feasible.

This prediction method can be used for preliminary studies during the vehicle design phase, evaluation of running tests, modifications of the shape of specific components, and evaluation of the effectiveness of ground-based noise barriers and their sound insulation performance. Moreover, since this method can predict wayside noise under various conditions such as when modifications of the shape of specific components are applied to the entire train set, it can also contribute to reducing the number of running tests.

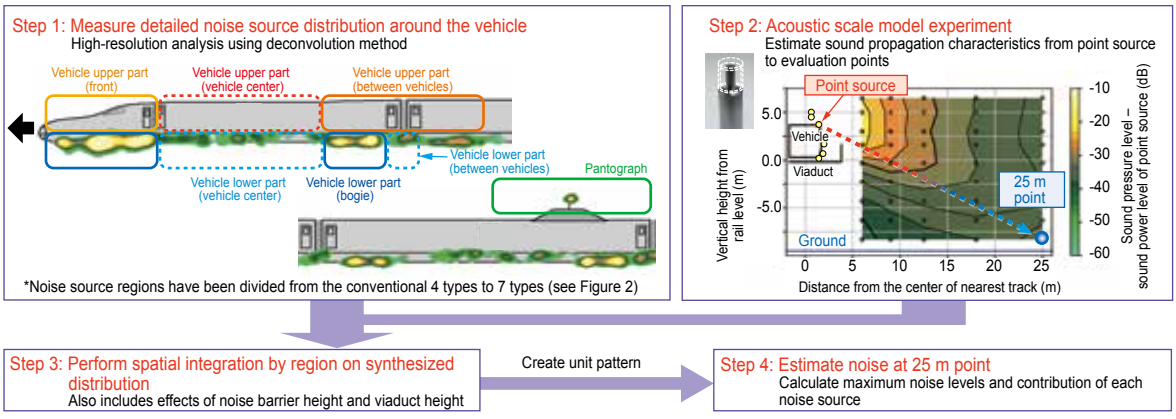


Figure 1 Flow of the proposed method and details of each step

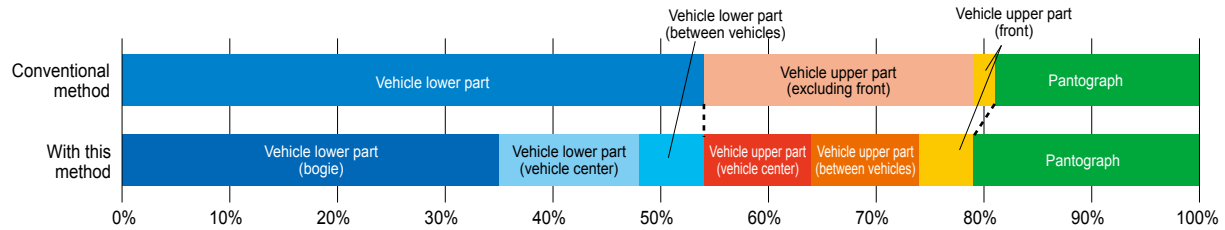


Figure 2 Example of calculated contribution of each noise source on wayside noise at 25 m away from the center of the nearest track

21. Integrated Control Method for Railway Energy Storage Systems Enabling the Use of Renewable Energy

- We have developed an algorithm that integrally controls the charge/discharge of both stationary and on-board energy storage systems in order to enable the stable use of fluctuating renewable energy.
- We have implemented the control function of the on-board energy storage system based on charge/discharge demands at an in-house test track, and demonstrated that it is possible to utilize both regenerative energy and renewable energy.

Energy storage systems for DC traction power supply systems are mainly introduced for energy saving by absorbing regenerative energy, and for use as emergency power sources. We explored the stable utilization of renewable energy, which fluctuates significantly depending on the time of day, by coordinating the charge/discharge control between fixed installation systems and on-board systems.

We developed an algorithm that integrally controls the charge/discharge of railway energy storage systems according to the amount of surplus renewable energy (Figure 1). In this algorithm, the integration controller distributes charge/discharge demands to the controllers of each energy storage system in a way that equalizes their state of charge as much as possible. To evaluate the effectiveness of the developed algorithm, we implemented a control function to charge/discharge an on-board energy storage system on a single train set, triggered by charge/discharge demands (Figure 2) and made several tests on the test track at the Institute. As a result of tests assuming a surplus of renewable energy, we demonstrated it is possible to charge the on-board storage battery with a surplus of the renewable energy based on the current demand from the integration controller, as well as charging regenerative electric power of another running vehicle as needed (Figure 3).

This method is expected to contribute to the realization of a decarbonized society by increasing the amount of renewable energy that can be utilized through railway energy storage systems.

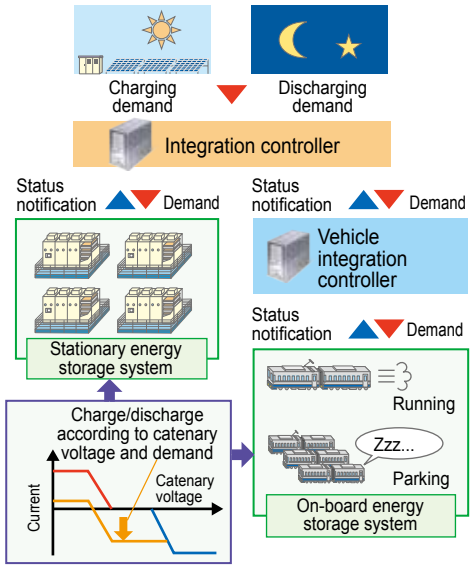


Figure 1 Integrated control algorithm for charging and discharging energy storage systems

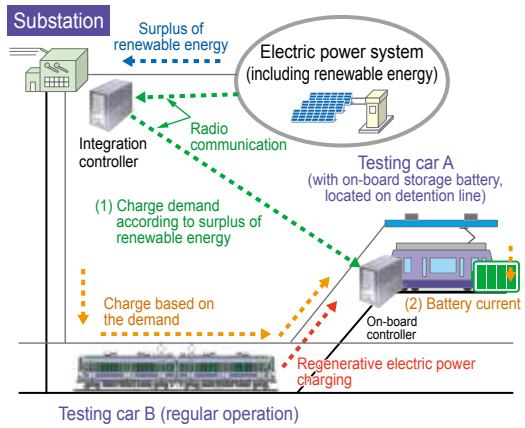


Figure 2 Integrated control function implemented at the in-house test track

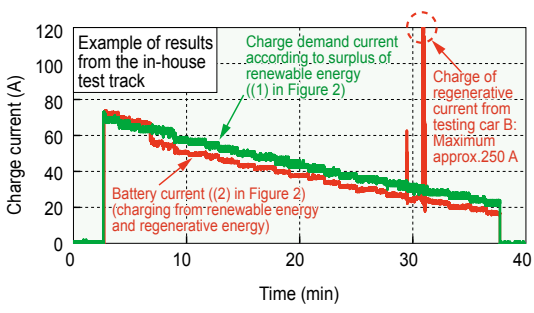


Figure 3 Example of current characteristics during renewable energy charging dispatcher

22. Development and Commercial Operation Demonstration of High-capacity Superconducting Feeding for Urban Commuter Lines

- We have developed a high-capacity superconducting feeding system for urban commuter lines.
- Demonstration tests on actual railway lines confirmed that the system can suppress voltage drops even under a high-density timetable, enabling electric power transmission to commercial trains with stability.
- The superconducting feeding system enables a reduction in substation load and a decrease in the number of substations.

In urban commuter lines, a large number of trains run throughout the day requiring currents of several thousand amperes to be supplied. To prevent voltage drops and ensure stable power supply, many substations are required. Therefore, we developed a superconducting feeding system for urban commuter lines that eliminates electrical resistance, thereby suppressing voltage drops. The superconducting cable measures 408 meters in length and has a current capacity exceeding 8,000 amperes. To maintain its superconducting state, we adopted a Brayton cycle refrigerator with a cooling capacity of over 2 kW, suitable for large-scale applications.

We installed the developed superconducting feeding system at the Hino Civil Engineering Testing Station of the Railway Technical Research Institute (Figure 1) and conducted demonstration tests supplying electricity via the superconducting cable to commercial trains running on an adjacent line. The system was able to handle the complex current variations during powering and regenerative braking of commercial trains operating under the line's complex timetable. We confirmed that voltage drops were suppressed even at high current levels, up to 3,692 A during powering and 2,768 A during regeneration, demonstrating the effectiveness of the superconducting feeding system (Figure 2). Additionally, the cable temperature remained stable without being affected by the powering or regenerative braking of commercial trains, confirming that the superconducting state was maintained (Figure 3). This marked the world's first successful demonstration of superconducting electric power transmission on a high-load urban commuter line. The superconducting feeding system allows for longer intervals between substations, enabling a reduction in substation load and the number of substations.

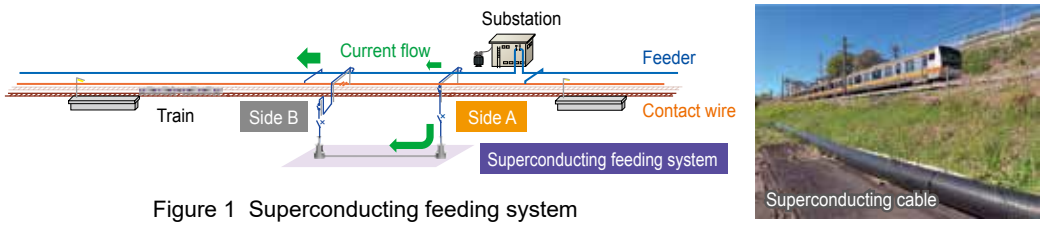


Figure 1 Superconducting feeding system

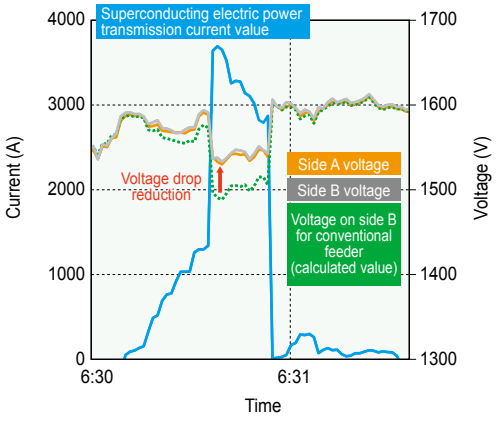


Figure 2 Demonstration of superconducting feeding functionality on an urban commuter line

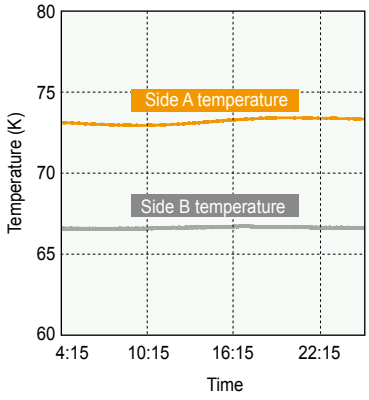


Figure3 Temperature of the superconducting feeding system

23. Safety Assessment of Hydrogen Fuel Cell Multiple Units

- For the social implementation of hydrogen fuel cell multiple units we have conducted a risk assessment and proposed safety measures including leak and pressure sensor, safety valves and shut-off valves, as well as structural protections.
- In particular, we conducted simulations to verify safety regarding small leaks from rooftop equipment piping and large releases from thermal safety valves during fires inside tunnels.

For the social implementation of hydrogen fuel cell multiple units, it is necessary to establish technical regulatory standards in regulations and ordinances that allow the installation of hydrogen fuel as high-pressure gas on board without requiring special approvals or permits. To that end, it is necessary to conduct a risk assessment of hydrogen fuel cell multiple units in advance.

Based on past railway accident investigation results, we developed scenarios and conducted a risk assessment including numerical analyses. We also proposed safety measures such as leak and pressure detection devices, safety valves, shut-off valves, and structural protections (Figure 1). In particular, regarding hydrogen flow in enclosed spaces such as tunnels, we conducted simulation-based verification of small leaks from rooftop equipment piping on hydrogen fuel cell vehicles and large releases from thermal safety valves during fires. As a result, for small leaks, it was found that even in areas considered high-risk due to queues, the concentration remains below 4%, which is the lower flammability limit (Figure 2). Regarding large releases, and assuming ignition scenarios, we estimated the pressure exerted on the human body at evacuation points in the event of a hydrogen explosion and confirmed that it remains within the acceptable limit of 20 kPa or less (Figure 3).

We presented these findings to the Committee on Safety Verification of Hydrogen Fuel Cell Multiple Units (hosted by the Ministry of Land, Infrastructure, Transport and Tourism, secretariat: Railway Technical Research Institute), contributing to the development of technical regulatory standards.

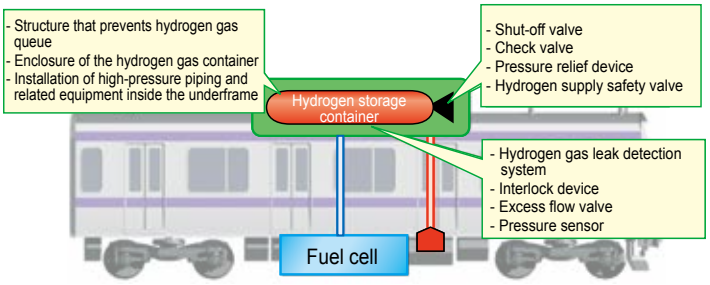
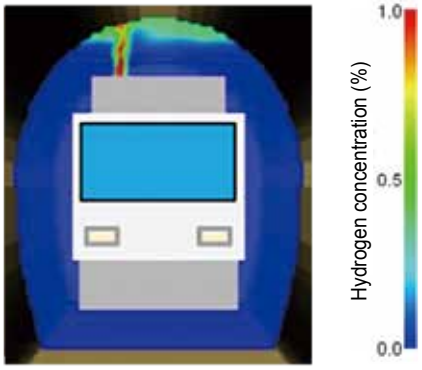


Figure 1 Safety measures for hydrogen fuel cell railway vehicles



*3600 seconds after hydrogen leak started

Figure 2 Example of hydrogen concentration distribution during small leak

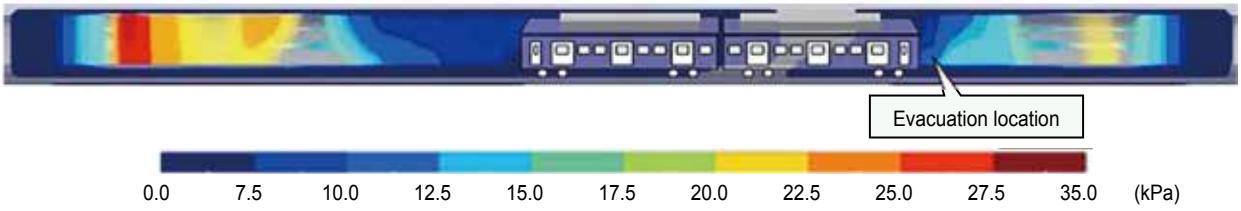


Figure 3 Example of blast wind pressure distribution from ignited hydrogen released inside a tunnel

24. Automatic Pantograph Drop System Using Real-time Abnormality Detection in the Current Collection System

- We have developed a system that detects pantograph part detachments and foreign objects attached to the overhead contact line in real time using camera images and automatically lowers the pantograph when abnormalities are detected.
- This system helps prevent a chain of equipment damage caused by the current collection system, thereby reducing downtime.

When abnormalities occur in the pantograph or overhead contact line, they can cause a chain of damage to the overhead lines in a wide area or complete failure of pantographs within a train set, potentially leading to large-scale transportation disorders. Therefore, we developed a system that installs a camera on-board to monitor the current collection system in real time and automatically lowers the pantograph when abnormalities are detected from the images (Figure 1). Based on records of past large-scale transport disorders, the detection targets were set to pantograph part detachments and foreign objects attached to the overhead contact line.

For detecting pantograph part detachments, we developed a detection algorithm combining object detection AI with coordinate processing. This algorithm also supports detection of step-shaped wear on pantograph contact strips and abnormal arcs. For foreign objects such as plastic sheets or futons attached to the overhead contact line, which are difficult to pre-train on, we developed a detection algorithm that combines AI requiring no training data and a system for abstract specification of detection targets within the overhead contact line area setting. Results from in-house testing confirmed that pantograph part detachments can be detected within one second, and foreign objects can be detected up to 40 meters away from the camera, both with no false positives or missed detections.

This system can prevent a chain of equipment damage caused by the current collection system, which is expected to reduce downtime by ensuring train operability and shortening equipment restoration time.

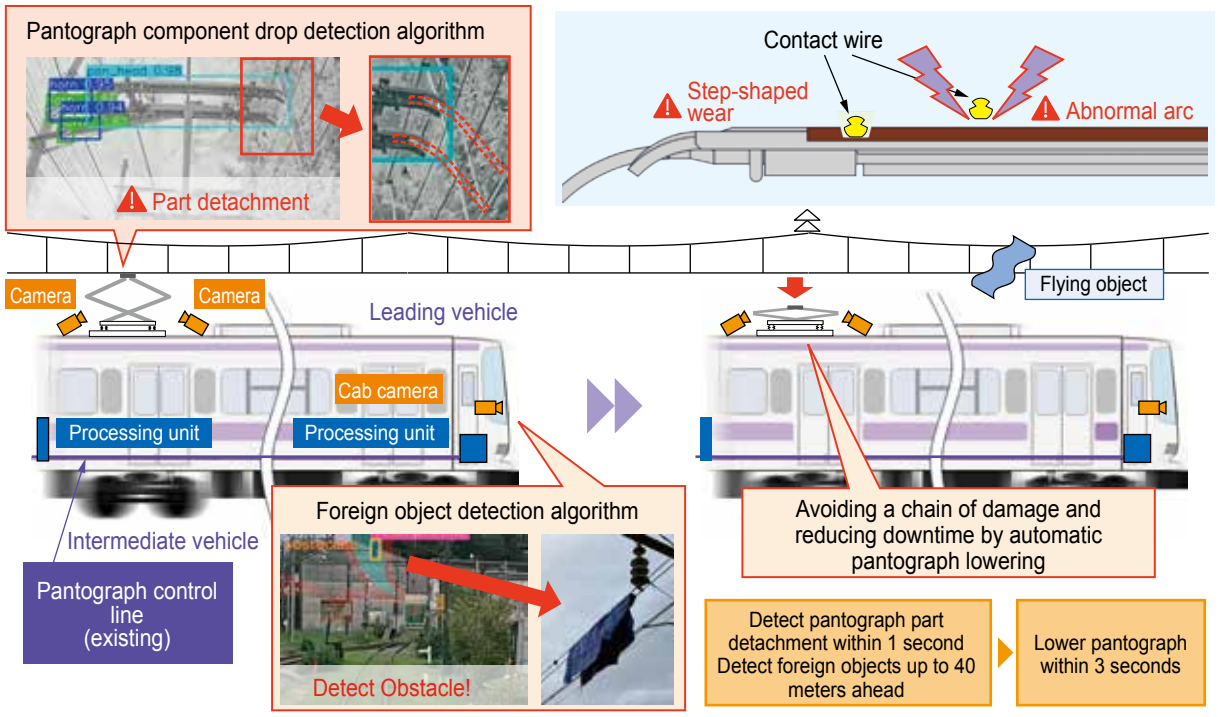


Figure 1 Automatic pantograph drop system

25. Development of a Low-cost Primary and Secondary Vertical Semi-active Suspension System

- We have developed a system that achieves high vibration reduction performance at low cost by designing variable dampers suitable for mass production and optimizing the combination and placement of sensors used.
- This system is suitable for reducing vertical and roll vibrations of high-speed Shinkansen trains, thereby improving ride comfort.
- In vibration excitation tests simulating actual running, we confirmed the system's effectiveness in improving ride comfort.

In recent years, as ride comfort in the lateral direction of Shinkansen trains has improved, vertical vibrations have sometimes become more noticeable, creating a demand for effective countermeasures. In particular, vertical ride comfort on high-speed Shinkansen trains is affected not only by rigid-body vibrations, where the entire carbody moves as one unit, but also by elastic vibrations involving bending deformation of the car body, which differs from lateral vibrations. At the Railway Technical Research Institute, we have proposed a vibration reduction control method that combines variable primary and secondary vertical dampers, both equipped with damping force control functions, to improve vertical ride comfort.

This system is designed to commercialize the above method by balancing vibration reduction performance with cost reduction. Specifically, for the two types of variable dampers, manufacturing costs were reduced by utilizing automotive parts and by decreasing the number of components and machining processes. Additionally, for the sensors that detect vehicle vibrations and are mounted on the bogie, we combined accelerometers and gyroscopes to reduce the number of sensor installation points from two to one per bogie, thereby lowering costs (Figure 1).

The system was installed on a vehicle, and vibration excitation tests simulating actual Shinkansen operation were conducted on a rolling stock test stand. As a result, the peak value of the vertical vibration acceleration PSD at the center of the carbody was reduced to 1/25 through control, achieving a maximum ride quality level (LT value) improvement of 5.2 dB (Figure 2).

This system is expected to be utilized as a low-cost solution for improving vertical ride comfort in Shinkansen trains operating at high speeds.

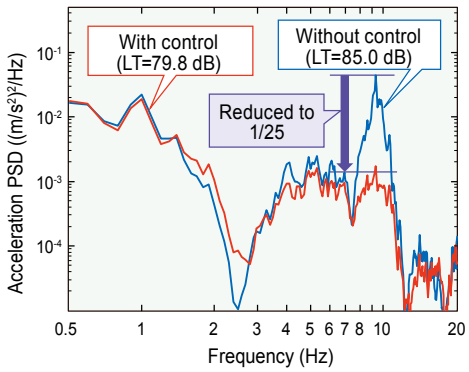


Figure 2 Example of vertical vibration reduction effect (vibration results simulating actual running on a rolling stock test stand)

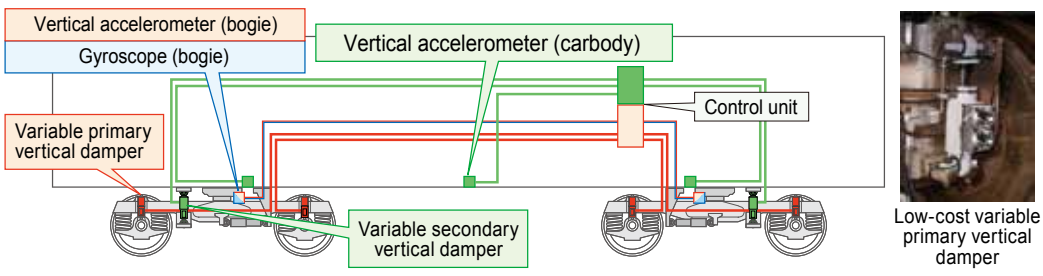


Figure 1 Configuration of the low-cost primary and secondary vertical semi-active suspension

26. Thermal Comfort Evaluation Method Using Air Conditioning Log Data from Commuter Trains

- We have proposed a method to evaluate thermal comfort by utilizing existing air conditioning log data.
- We have conducted thermal sensation surveys inside operating trains during summer and winter, and confirmed that the comfort evaluations using the proposed method closely matched the actual evaluations.
- The method is able to detect hot or cold conditions inside the train and be used to examine measures for improving air conditioning control.

Every year, many complaints from passengers about hot or cold conditions inside commuter trains are received. In response, railway operators strive to improve comfort by adjusting set temperatures and conducting actual measurement surveys to understand the conditions. On the other hand, it is difficult to objectively and quantitatively assess how much the overall passenger comfort improves through temperature adjustments, and conducting actual measurement surveys of the thermal environment inside trains requires significant human resources.

Therefore, we proposed a method that utilizes the “air-conditioning log data” from commuter trains accumulated on a daily basis (Figure 1, top) together with the thermal comfort evaluation model we previously developed (Figure 2) that takes into account the characteristics of thermal sensation and individual differences. This approach enables us to objectively and quantitatively assess the overall passenger comfort while capturing the actual thermal environment inside the train, without allocating extensive resources to actual measurement surveys. In the proposed method, inputs such as in-car temperature and humidity, passenger load factor, and outside air temperature recorded in the air-conditioning log data are used to calculate the apparent temperature inside the train, taking into account passengers’ clothing and posture (standing or seated). Based on past experimental data collected inside commuter trains, the method then outputs the proportion of passengers who feel uncomfortably hot or cold (Figure 1, bottom).

A thermal sensation survey was conducted among railway passengers on operating trains (total participants: 74 in summer and 60 in winter), confirming that the proposed method can accurately evaluate passengers’ complaints of feeling too hot or too cold (Figure 3). The proposed method enables year-round evaluation of thermal comfort in commuter trains and can be used to examine measures for improving air conditioning control.

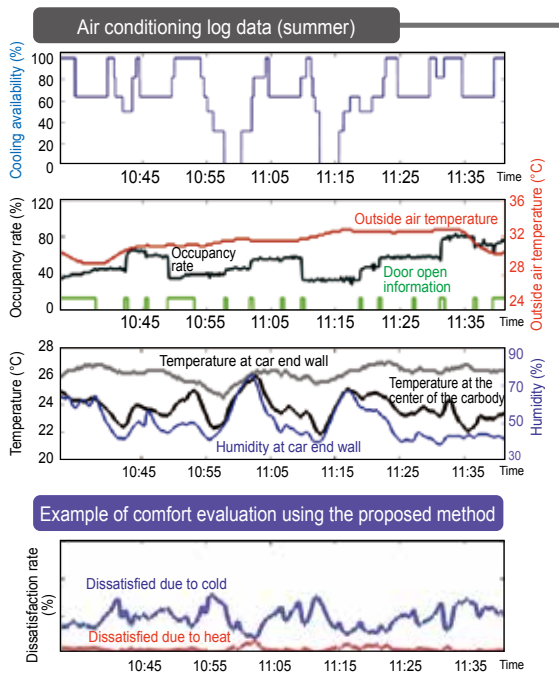


Figure 1 Example of air conditioning log data and comfort evaluation

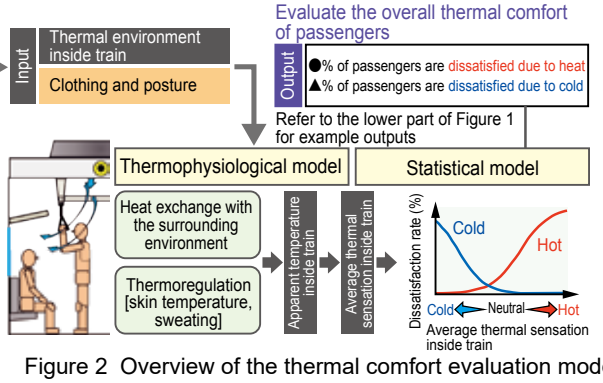


Figure 2 Overview of the thermal comfort evaluation model

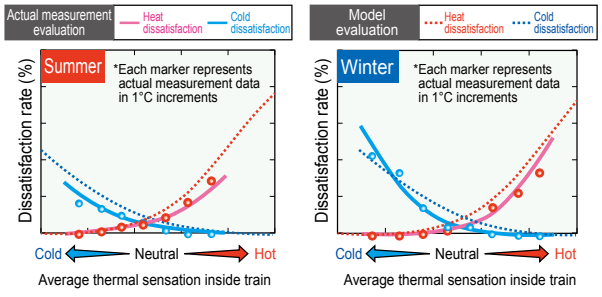


Figure 3 Comparison between the proposed method and actual evaluation

27. Method for Estimating the Density of Newly Fallen Snow Using Dual-polarization Radar

- We have developed a method that uses dual-polarization radar to estimate the density of newly fallen snow according to the snowfall types, such as aggregate or graupel, which could not be distinguished by conventional methods using air temperature.
- Our method can improve the accuracy of avalanche risk assessment, snowfall depth on railway tracks, and the amount of snow accretion under vehicle floors.

An accurate understanding of snowfall depth is crucial for effective operations and snow removal planning. In recent years, the widespread use of polarization radar has enabled highly precise estimation of precipitation distribution. These radars can retrieve information about particle shapes by simultaneously transmitting and receiving horizontally and vertically polarized waves. However, determining the density of newly fallen snow—defined as the density of snow immediately after it has accumulated—is essential for estimating snowfall depth. This is because radars cannot directly estimate snowfall depth; they can only estimate the liquid-equivalent snowfall rate. Traditionally, ground-level air temperature has been used to estimate the density of newly fallen snow. However, this approach only accounts for snowmelt and does not correlate with the density of dry snow, which is primarily influenced by solid hydrometeor types (snowfall type, i.e. aggregate, graupel). To address this limitation, we developed a new method for estimating the density of newly fallen snow by incorporating snowfall types.

We proposed an index to quantify the similarity between observed snowfall types and graupel, based on analyses of radar data and in-situ snow particle observations. Figure 1 shows the relationship between the proposed index and the density of newly fallen snow. Using the empirical formula derived from this relationship, we can estimate the spatial distribution of new snow density in real time, while accounting for snowfall type (Figure 2).

By applying our method to estimate the density of newly fallen snow, improvements are expected in the accuracy of avalanche risk assessments, snowfall depth estimation on railway tracks, and evaluation of snow accretion under vehicle floors.

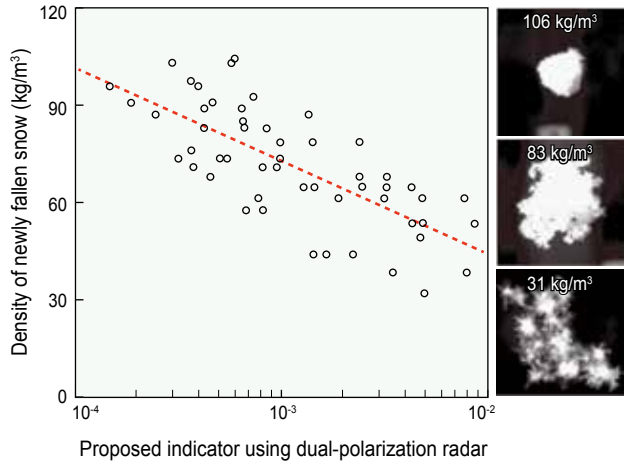


Figure 1 Relationship between the proposed index and the density of newly fallen snow, and examples of snow particles images corresponding to the snow densities

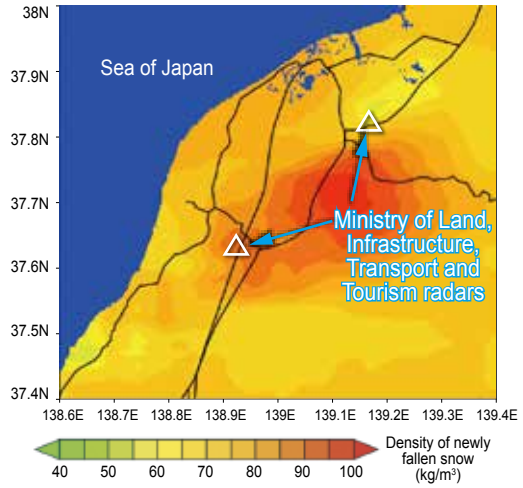


Figure 2 Example estimation of the density of newly fallen snow using the Ministry of Land, Infrastructure, Transport and Tourism radars (Niigata area)

28. Prediction Method for Long-term Deformation Behavior of Concrete Bridges Considering Water Content Conditions

- We have developed a program that analyzes shrinkage strain based on water content conditions and mix proportions using information available in practical applications, and proposed a method to predict the long-term deformation behavior of concrete bridges.
- This advancement in design methods for long-term deformation of concrete bridges is expected to be utilized for designs that control the effects of shrinkage, addressing issues such as track irregularities caused by deflection.

Long-term deformation of railway concrete bridges affects vehicle running performance and track maintenance. This impact is especially pronounced in high-speed railway bridges. With advancements such as diversification of structural types and lengthening of spans, the importance of methods to estimate deformation throughout the entire service life is increasing. In addition, there is a growing need to address how changes in the construction and maintenance environment, such as climate change and shortages of high-quality construction materials, are reflected in design practices.

We developed a shrinkage strain analysis program that calculates the time-dependent changes in water content distributed within concrete based on moisture transfer analysis using diffusion theory. The program predicts the shrinkage-driving force and deformation amount of the concrete up to 100 years ahead according to the water content (Figure 1). By macroscopically capturing physical and chemical phenomena such as hydration in concrete, the amount of information required for calculations is greatly reduced. Using only information measurable in practical work, the program calculates shrinkage strain according to water content conditions and mix proportions. By inputting this shrinkage strain into a structural analysis tool (frame analysis) using steels or beam elements that consider member shapes, the long-term deformation amount of concrete bridges is calculated (Figure 2). The validity of this method has been confirmed by comparing the calculated shrinkage strain using precise methods and the measured deflections of bridges.

Because this method can flexibly respond to construction and maintenance conditions, it contributes to the advancement of design methods for long-term deformation of bridges caused by concrete shrinkage. It is expected to be used for proposing rational new structural types that control the effects of shrinkage and creep, as well as for reducing maintenance.

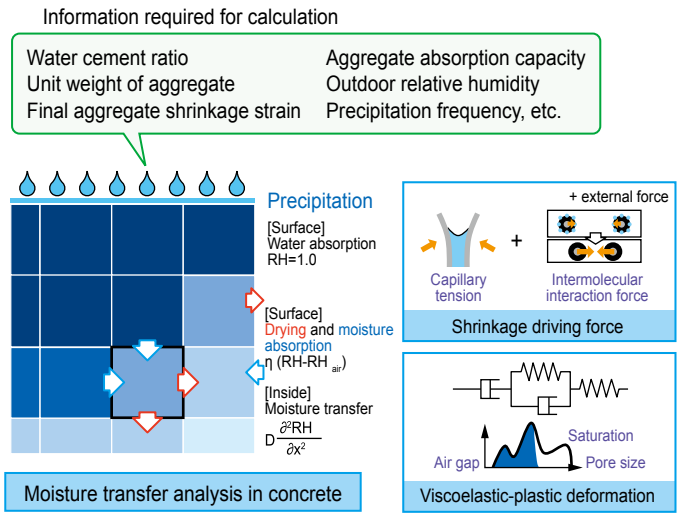


Figure 1 Shrinkage strain analysis program

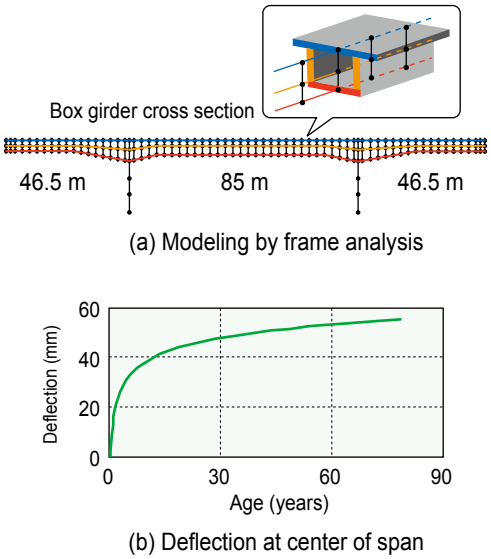


Figure 2 Estimated results for rigid frame box girder bridge

29. Non-contact Disc Brake Enabling Power Regeneration in Trailers

- To pursue energy saving, reduced maintenance, and reduced consumable parts in railway vehicles, we have proposed a non-contact disc brake capable of power regeneration in trailers.
- We have demonstrated that power regeneration can be achieved with a simple circuit using resonance phenomenon between an electromagnet and a capacitor, without the need for an inverter.

In recent years, there has been growing demand for decarbonization of train operations and development of energy-efficient vehicles, along with the need to reduce consumables and automate maintenance. Replacing the axle mounted discs on trailers with electric brakes can reduce energy consumption and consumables. However, this requires installing motors, inverters, gear units, and other equipment on the trailers, which presents challenges such as high installation costs.

We proposed a non-contact disc brake (Figure 1) with a simple circuit configuration that does not use inverters or similar equipment, enabling a simplified electric brake system for trailers. In this electric brake, braking force and regenerative electric power are generated by flowing electric current through resonance phenomenon between an electromagnet and a capacitor.

To confirm feasibility, a proof-of-concept test was conducted, verifying that braking and power regeneration are possible through resonant current flow (Figure 2). Additionally, to obtain fundamental data needed for future full-scale design, element tests using a full-size DC electromagnet were conducted (Figure 3), clarifying the relationship between disc temperature, which reaches several hundred °C, and braking torque. Furthermore, we devised a method to determine the capacitor capacitance needed to achieve the desired resonance state, addressing the complex changes in electrical characteristics that occur according to the brake operating conditions. Based on these tests and study results, we proposed a fundamental design method.

Building on these results, we will advance performance evaluations at the full-scale level and develop detailed design methods tailored to operating conditions, aiming to realize a non-contact disc brake that contributes to energy-saving and low-maintenance railway vehicles.

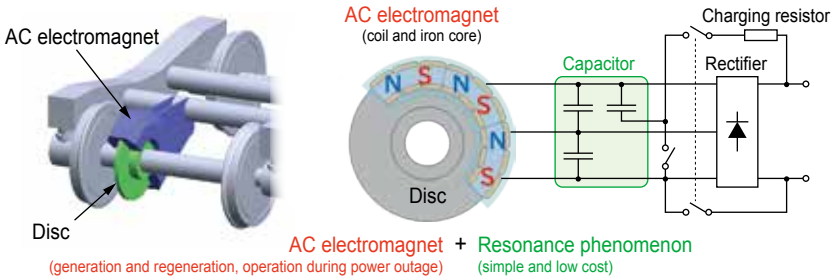


Figure 1 Configuration of the non-contact disc brake with power regeneration for trailers

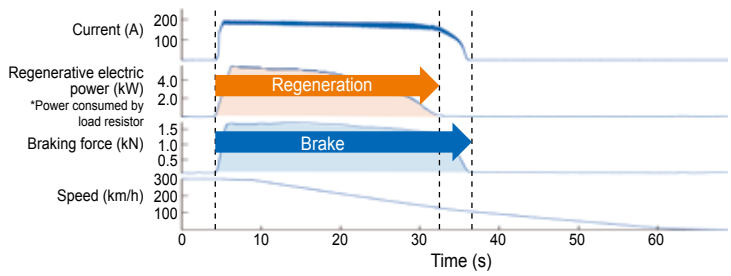


Figure 2 Proof of concept for braking and power regeneration by resonant current flow

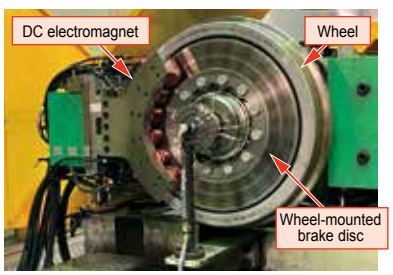


Figure 3 Overview of the element test

30. Method for Reducing Unstable Vibrations of Pantographs Caused by Sliding Friction

- We have clarified that the mechanism causing unstable pantograph vibrations is a phenomenon that occurs when vertical and longitudinal natural modes of vibrations come close and amplify each other under conditions of a high coefficient of friction.
- We have proposed a method to evaluate the proximity and amplification of natural modes to reduce unstable vibrations.
- This method enables the design of pantographs that can slide with stability.

When a train is running at low speed just after departure or just before stopping, a high coefficient of friction between the pantograph contact strip and the contact wire can cause significant unstable vibrations with continuous contact loss in the pantograph. This can lead to train operation becoming impossible or cause arcing that accelerates wear on the contact wire. However, until now, the mechanism causing these unstable vibrations had not been clarified, and no countermeasures based on the mechanism had been proposed.

Through analysis using a detailed pantograph model, we clarified that unstable vibrations occur when the vertical and longitudinal natural modes come close and amplify each other under a high coefficient of friction (Figure 1). Based on this mechanism, we proposed a flowchart for reducing unstable vibrations (Figure 2). In this flowchart, we evaluate whether significant unstable vibrations occur, either through FEM analysis using a detailed model or through low-speed sliding tests with an actual pantograph. Furthermore, by conducting experimental modal analysis and evaluating the proximity and amplification of modes, the natural modes requiring countermeasures are identified. Structural modifications, such as using softer plate spring, can then reduce unstable vibrations even under a high coefficient of friction (Figure 3).

This method allows for the design of pantograph structures and parameters that can maintain stable sliding even when the contact surfaces between the contact strip and the contact wire are rough and the coefficient of friction is high, enabling pantographs that contribute to more stable and reliable transportation.

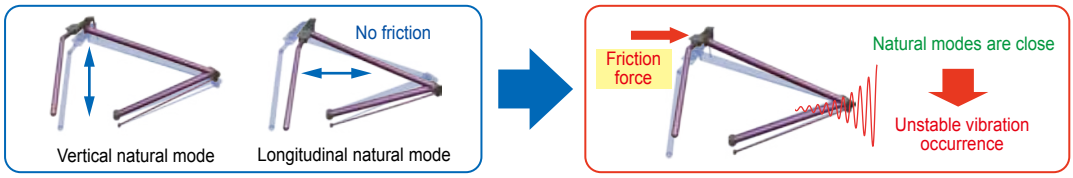


Figure 1 Mechanism of unstable vibration generation

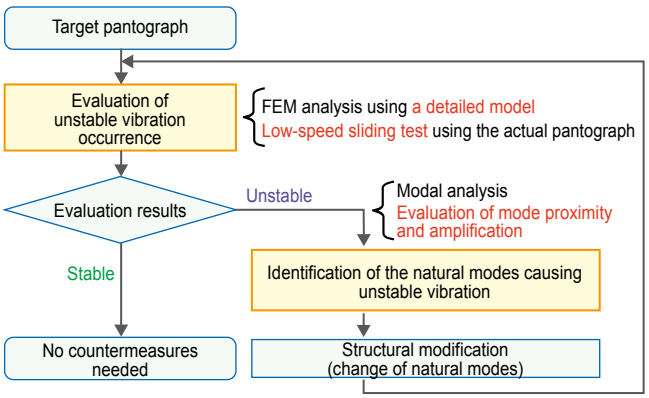


Figure 2 Method for reducing unstable vibrations

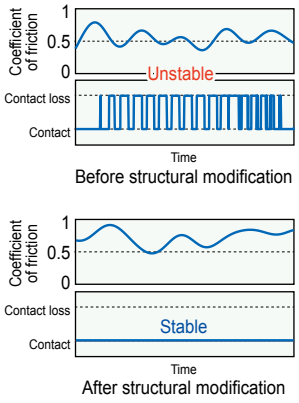


Figure 3 Effect of changing to softer plate spring

Notes

IMPROVEMENT OF SAFETY

- 4 includes collaborative research results with Chalmers University of Technology.
- 8 includes collaborative research results with Hokkaido Development Engineering Center.

COST REDUCTION

- 10 was conducted by collaborative research with Shibaura Institute of Technology and Kawada Industries, Inc.
- 12 was conducted by collaborative research with University of Toyama.
- 13 was conducted by collaborative research with Shikoku Railway Company and Osaka University.
- 18 was conducted by collaborative research with Waseda University.

HARMONY WITH THE ENVIRONMENT

- 22 includes Railway Technology Development Subsidy of Ministry of Land, Infrastructure, Transport and Tourism.
- 23 includes contract research results with AIST Solutions Co., Ltd.

IMPROVEMENT OF CONVENIENCE

- 25 was conducted by collaborative research with Astemo, Ltd.

BASIC RESEARCH

- 27 was conducted by collaborative research with Yamaguchi University and Japan Weather Association.
- 30 was conducted by collaborative research with Kyushu University.

Public Relations

News Release

R&D

M / D / Y	Title	
March 06, 2025	RTRI Develops Inspection Support System Using Images of Tunnel Walls	link
August 29,2024	RTRI Puts “the Signal Arrangement Examination Function” into Practical Use as an Additional Function to the Running Time and Headway Calculation System “SPEEDY”	link
August 29,2024	RTRI Develops High-Performance Wireless Measurement System “IMPACTUS” Used in Impact and Vibration Tests	link

Award

M / D / Y	Title	
June 28, 2024	RTRI Receives 35th Radio Achievement Award	link
June 19, 2024	Mr. Hiroyuki Nozawa Awarded ISO Excellence Award	link
April 22, 2024	RTRI’s Researcher Receives Young Scientist Award	link

Event

M / D / Y	Title	
November 26,2024	RTRI Hosts the 11th SNCF-RTRI Collaborative Research Seminar	link
October 28, 2024	RTRI Hosts 37th Annual Conference	link
September 04,2024	RTRI Hosts Technology Forum FY 2024	link
June 28, 2024	RTRI Hosts 58th Annual Meeting of the Subsonic Aerodynamic Testing Association	link

Administration

M / D / Y	Title	
December 24,2024	RTRI Develops New Master Plan RESEARCH 2030	link

Public Relations

Publications

Quarterly Report (QR)

QR is an electronic quarterly journal published in English to present RTRI's research and development achievements to overseas readers.

Vol. / No.	M / Y	
Vol.66 / No.1	Feb / 2025	link
Vol.65 / No.4	Nov / 2024	link
Vol.65 / No.3	Aug / 2024	link
Vol.65 / No.2	May / 2024	link

Ascent

Ascent, an English-language electronic public relations journal published twice a year, introduces RTRI's research and development efforts to overseas readers.

No.	M / Y	special feature	
No.16	Mar / 2025	The 60th Anniversary of the Shinkansen	link
No.15	Sep / 2024	The Initiatives of its Technology Divisions 3	link

RRR

RRR is an bimonthly newsletter introducing railway related technology and RTRI's research topics. (In Japanese only)

Vol. / No.	M / Y	
Vol.82 / No.2	Mar-Apr / 2025	link
Vol.82 / No.1	Jan-Feb / 2025	link
Vol.81 / No.6	Nov-Dec / 2024	link
Vol.81 / No.5	Sep-Oct / 2024	link
Vol.81 / No.4	Jul-Aug / 2024	link
Vol.81 / No.3	May-Jun / 2024	link

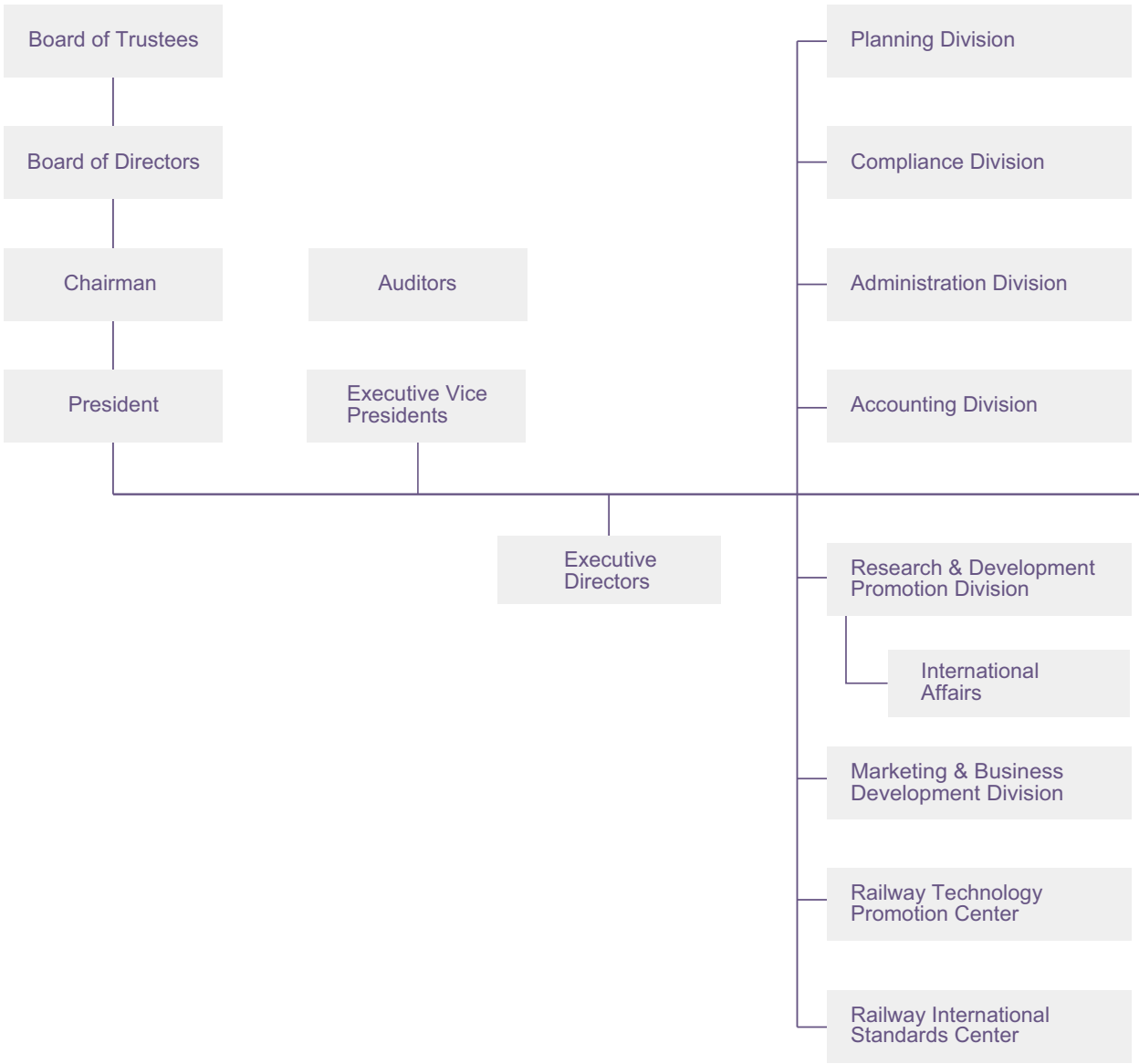
Collaboration with Other Organizations

Collaboration is in progress with the following railway operators, research institutes, universities, and other organizations for joint research, commission research, technical collaboration, and the like.

Organization Name
University of Birmingham
Rail Safety and Standards Board (RSSB)
International Union of Railways (UIC)
Gustave Eiffel University (UGE)
French National Railways (SNCF)
Polytechnic University of Milan
German Aerospace Center (DLR)
DB Systemtechnik (DBST)
High Speed Railways Innovation Centre (HSRIC)
China Academy of Railway Sciences Corporation Ltd. (CARS)
Korea Railroad Research Institute (KRRI)
Taiwan Railway Corporation (TRC)
National Science and Technology Development Agency (NSTDA)

Data

Organization



Research Divison	Research Lab
Vehicle	Vehicle Dynamics / Vehicle Noise and Vibration / Vehicle and Bogie Parts Strength / Hydrogen and Sustainable Energy / Traction Systems / Braking System
Structures	Concrete Structures / Steel and Hybrid Structures / Foundation and Geotechnical Engineering / Tunnel Engineering / Architecture
Power Supply	Power Supply Systems / Current Collection Maintenance / Contact Line Structures
Track	Track Structures and Components / Track Structures and Geotechnology / Track Geometry and Maintenance / Rail Maintenance and Welding
Disaster Prevention	Meteorological Disaster Prevention / Geo-hazard and Risk Mitigation / Geology
Signalling and Operation Systems	Signalling Systems / Train Control Systems / Transport Operation Systems
Information and Communication	Data Analytics / Image Analysis / Telecommunications and Networking
Materials	Concrete Materials / Vibration-Isolating Materials / Lubricating Materials / Frictional Materials
Railway Dynamics	Vehicle Mechanics / Current Collection / Track Dynamics / Structural Mechanics / Computational Mechanics
Environmental Engineering	Vehicle Aerodynamics / Heat and Air Flow Analysis / Noise Analysis
Human Science	Safety Psychology / Ergonomics / Comfort Science and Engineering
Maglev Systems	Magnetic Levitation / Electrical Machines / Superconductivity and Cryogenics
Center for Railway Earthquake Engineering Research	Seismic Data Analysis / Soil Dynamics and Earthquake Engineering / Structural Dynamics and Response Control

Overview of RTRI (as of 1 April, 2025)

Legal Name of the Organization
Railway Technical Research Institute(RTRI)

Registered Office Address
2-8-38 Hikari-cho, Kokubunji-shi, Tokyo
(Postal code) 185-8540

Date of Establishment
December 10th, 1986

Start of Operation
April 1st, 1987

Original Purpose of Establishment
The original purpose of the organization was to succeed the research and testing activities of the Japanese National Railways Reform Act (Act No. 87 of 1986). This aimed to conduct comprehensive research and development, ranging from fundamental research to applied studies, as well as investigations in railway technology and railway labor science. Through these efforts, the institute strived to contribute to the advancement of railways and the enhancement of academic and cultural standards.

External Research Facilities and Locations
Wind Tunnel Technical Center (Maibara-shi, Shiga)
Civil Engineering Testing Station (Hino-shi, Tokyo)
Snow Testing Station (Shiozawa, Minami-Uonuma-shi, Niigata)
Anti-Salt Testing Station (Yamakita-cho, Murakami-shi, Niitgata)

Workforce Composition
Total personnel: 534
Researchers with Doctoral Degrees: 207
Professional Engineers: 97

Master Plan

- Research and Development for Creating the Future of Railways -
RESEARCH2025
(2020–2024)

https://www.rtri.or.jp/assets/edga9q00000003x7-att/RESEARCH2025RTRI_E.pdf

Compliance and a Better Work Environment

Human rights policies and action agenda for compliance

We respect human rights, comply with laws and regulations, and commit ourselves always to act as a member of society conscious of high ethical standards.

Human rights policies

Based on the vision “We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society,” we will further promote our activities. We believe that respect for human rights is the foundation of all our business activities. To fulfill our social responsibility, we have established the “RTRI Human Rights Policy” with the aim of realizing respect for human rights.

Action agenda for compliance

We, the executives and the staff members of RTRI, act on the basis of the guiding principles listed below in order to promote compliance and to contribute to the development of the railway system, science and technologies.

1. We commit ourselves always to act as a member of society conscious of high ethical standards.
2. We undertake to observe laws, ordinances and social norms and behave in a fair and sincere manner.
3. We, the executives and the staff members of RTRI, undertake to bear in mind our missions as the members of a public interest corporation. In disseminating the research results, we shall endeavour to maintain and further reinforce our social confidence.
4. We commit ourselves to faithfully fulfill our missions, abiding by RTRI rules and regulations.
5. We undertake to respect our responsibilities and standpoints among ourselves and to maintain/foster a healthy work environment where different opinions can actively be exchanged without restraint.

Data

Commitment to SDGs

Our work at RTRI is directed at contributing to the realization of nine of the 17 SDG goals through our business activities. Our key focus is on helping to realize SDG “GOAL 9: Industry, Innovation and Infrastructure.”

The nine SDGs addressed by RTRI

Goal 4: Quality education
Goal 5: Gender equality
Goal 7: Affordable and clean energy
Goal 8: Decent work and economic growth
Goal 9: Industry, innovation and infrastructure
Goal 11: Sustainable cities and communities
Goal 13: Climate action
Goal 16: Peace, justice and strong institutions
Goal 17: Partnerships for the goals

***RTRI supports the Sustainable Development Goals (SDGs).**

Creation of a vibrant workplace

We aim to create a workplace that promotes well-being and allows each individual to experience their own self-realization.

Support for flexible work styles

We have introduced flextime and telecommuting systems, support for childcare and nursing care.

Measures to nurture and develop future generations

RTRI achieved recognition as an excellent “company supporting family life” for its even higher level of commitment to supporting families with children, and was awarded the highest level of accreditation: the “Platinum Kurumin.”

Support for self-development

RTRI provides support for self-development, such as assistance for doctoral studies and incentive payments for obtaining professional qualifications.

Employee benefits

Our employee benefits include family housing, dormitories for single employees, housing allowances, a cafeteria plan, and a student loan repayment assistance program.

Historical Background

1986
Dec. 10: Establishment of RTRI authorized by the Minister of Transport.

1987
Apr. 01: RTRI inherited the R&D arm of Japanese National Railways upon its division and privatization.

1990
Nov. 15: New Rolling Stock Test Facility completed.

1991
Mar. 31: Test Building E (human science) completed.

1992
Oct. 13: International railway research seminar on “R&D in World Railway -Today and Tomorrow-” (later developed into the World Congress on Railway Research (WCRR)).

1993
Jan. 31: Brake Test Facility completed.

1996
Jun. 05: Large-Scale Low-Noise Wind Tunnel completed.
Jul. 01: Yamanashi Maglev Test Center opened.
Jul. 01: Railway Technology Promotion Center opened.

1997
Mar. 21: First railway design engineer examination administered.

1999
Oct. 19-23: World Congress on Railway Research 1999 (WCRR ‘99) held at RTRI.

2003
Dec. 02: World speed record of 581 km/h for a manned train (MLX01) attained on the Yamanashi Maglev Test Line.

2004
Nov. 16: Two-train crossing test at a relative speed of 1026 km/h on the Yamanashi Maglev Test Line.

2006
Apr. 26: Running test of fuel-cell railway vehicle succeeded.

2007
Oct. 25: A battery-driven, energy-recycling light-rail vehicle opened to the public.

2008
Oct. 31: Large-scale vibration test machine completed.

2010
Apr. 01: Inauguration of the Railway International Standards Center
May 18: Took on the responsibility as the secretariat for national mirror committee of ISO (International Organization for Standardization) / TC17 (Steel) / SC15 (Railway rails, rails fasteners, wheels and wheelsets).

2011
Mar. 11:Great East Japan Earthquake (participation in recovery support activities).
Apr. 01: Accredited as a public interest incorporated foundation.

2012
July 18: Took on the responsibility as the secretariat for national mirror committee of ISO (International Organization for Standardization) / TC269 (Railway applications).

2014
Apr. 01: Center for Railway Earthquake Engineering Research inaugurated.
Dec. 11: The vision “We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society” decided.

2015
Apr. 01: Master Plan “RESEARCH 2020” that embodied a strategy based on the vision started. (until the end of fiscal 2019).
June 01: Started operation of an Earthquake Information Disclosure System for Railways.

2016
Apr. 14: Kumamoto earthquake (participation in recovery support activities).
Nov. 30: “Ascent” a public relations magazine for overseas launched.

2019
Oct. 12: Reiwa 1 East Japan Typhoon (Typhoon Hagibis) (participation in recovery support activities).
Oct. 28 – Nov. 01: 12th World Congress on Railway Research (WCRR 2019) held at Tokyo International Forum.

2020
Apr. 01: Master Plan “RESEARCH 2025” started (until the end of fiscal 2024).
July 03 – July 31: The 2020 Kyushu floods (participation in recovery support activities)
July 10: Low-Noise Moving Model Test Facility completed.
Sep. 30: High-Speed Test Facility for Pantograph/OCL Systems completed.

2021
Feb. 26: High-Speed Wheelset Dynamic Load Test Facility completed.

YEAR 2024-2025: April 1, 2024 - March 31, 2025

International Affairs, Research and Development Promotion Division,
Railway Technical Research Institute
Hikari-cho 2-8-38, Kokubunji-shi, Tokyo 185-8540 JAPAN

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