Toward Railway Innovation

Ascent

Railway Technical Research Institute

No. 14
March 2024

www.rtri.or.jp/eng
JAPAN

The Initiatives of its Technology Divisions 2

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Message from Managing Editor Dr. Toru MIYAUCHI

Dr. Toru Miyauchi
Managing Editor
Associate Director (International Affairs),
Research & Development Promotion
Division

Under the main theme of "The Initiatives of its Technology Divisions 2", this issue of Ascent focuses on four technology divisions – Disaster Prevention Technology Division, Signalling and Operation Systems Technology Division, Information and Communication Technology Division, and Materials Technology Division. As for the other divisions, they will be introduced in the next and subsequent issues.

RTRI has been able to travel to foreign countries again since May 8th, 2023, and so far, I have visited the Philippines, Thailand, France, and the UK. In those trips I really felt that going abroad provides precious opportunities to communicate face-to-face. Take, for example, my latest business trips to France and the UK where I was able to meet RTRI staff members who are working there. By talking with them in person, I learned a lot more about their situations than by communicating through contactless communication tools such as e-mail. I hope that we will have more opportunities than ever before to meet our readers face-to-face and to make our friendships even stronger.

	Ascent No. 14 March 2024
Editor-in-chief	Kimitoshi Ashiya (Executive Vice President of RTRI)
Managing Editor	Toru Miyauchi (Associate Director (International Affairs), Research & Development Promotion Division of RTRI)
Publisher	Railway Technical Research Institute
Address	2-8-38 Hikari-cho, Kokubunji-shi, Tokyo 185-8540, JAPAN
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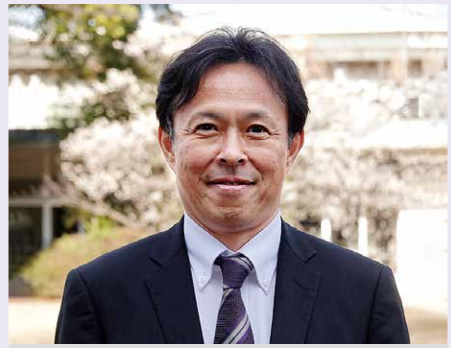
Front cover photo: Cherry blossoms and exhibited former Maglev linear test vehicles at RTRI

The Disaster Prevention Technology Division focuses on the prevention and mitigation of damage and degradation caused by natural disasters such as, heavy rainfall, high wind, ice and snow, and weathering, along railways and surrounding areas. It has been developing techniques to investigate and assess the topographical and geological features and ground water conditions along railways, as well as conducting research on ground vibrations from running trains. We introduce herewith the latest examples of our research and development efforts.



Dr. Osamu Nunokawa
Director,
Head of Disaster Prevention Technology Division

Recent Research and Development of Disaster Prevention Technology Division

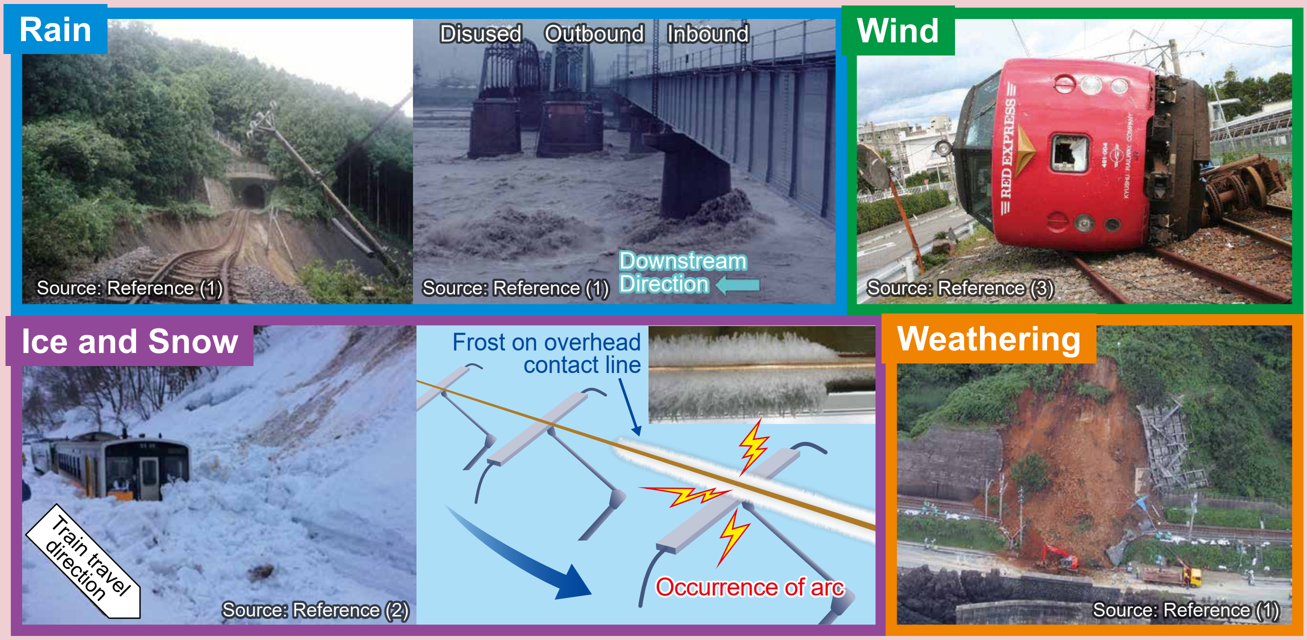
Introduction

The worsening climate change associated with global warming is raising concerns about the increasing risks of climate disasters (e.g., heavy rainfall and high wind). Japan, in particular, has been hit by various natural disasters every year due to its topographical, geological, and climatic conditions being harsher than those of Europe and the United States. The Disaster Prevention Technology Division, which is composed of the Meteorological Disaster Prevention, Geo-hazard and Risk Mitigation, and Geology laboratories, has thus pushed forward with research and development efforts that focus on techniques to prevent and mitigate the damage from natural disasters along railways (*Technical Fields Covered by the Disaster Prevention Technology Division*). Our main research subjects and examples of the specific themes we examine are as follows:

- Heavy rainfall : Landslide disasters triggered by heavy rainfall, damage to bridges due to water level rise
- High wind : Derailment and overturning accidents caused by high wind
- Ice and snow : Avalanches, snow accretion on railway vehicles, frost accretion on overhead contact lines
- Weathering : Landslide disasters triggered by ground weathering

We are also developing investigation and assessment techniques related to topographical and geological features and ground water conditions, and conducting research on ground vibrations from running trains. Below are the latest examples of our research and development on countermeasures against snow, wind, and weathering.

Technologies for the prevention and mitigation of damage from natural disasters on railways and surrounding areas



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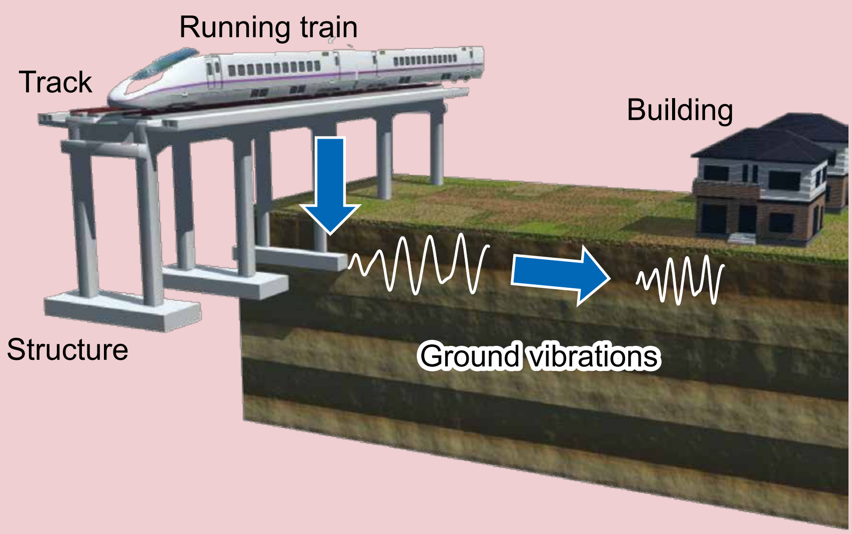
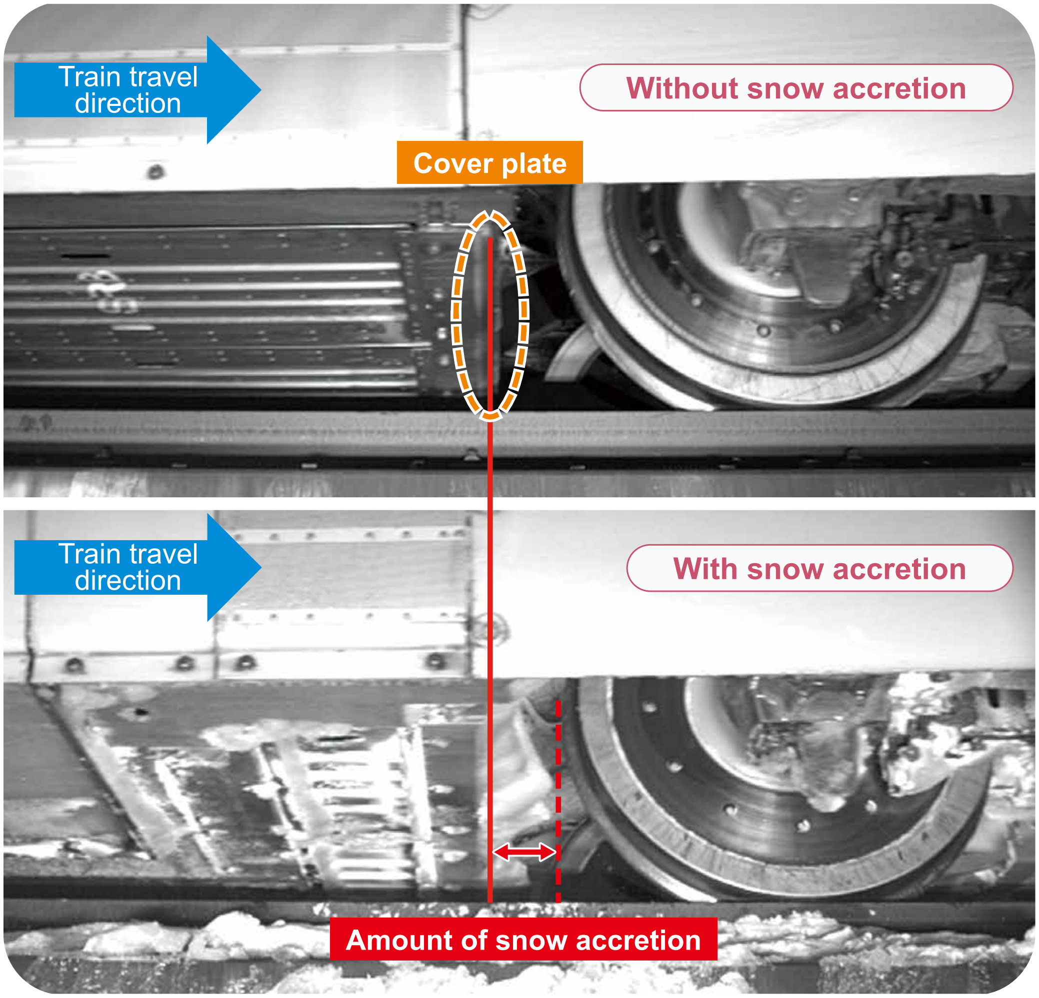
- ◆Investigation and assessment techniques related to topographical and geological features and ground water conditions
- ◆Ground vibrations from running trains



Technical Fields Covered by the Disaster Prevention Technology Division

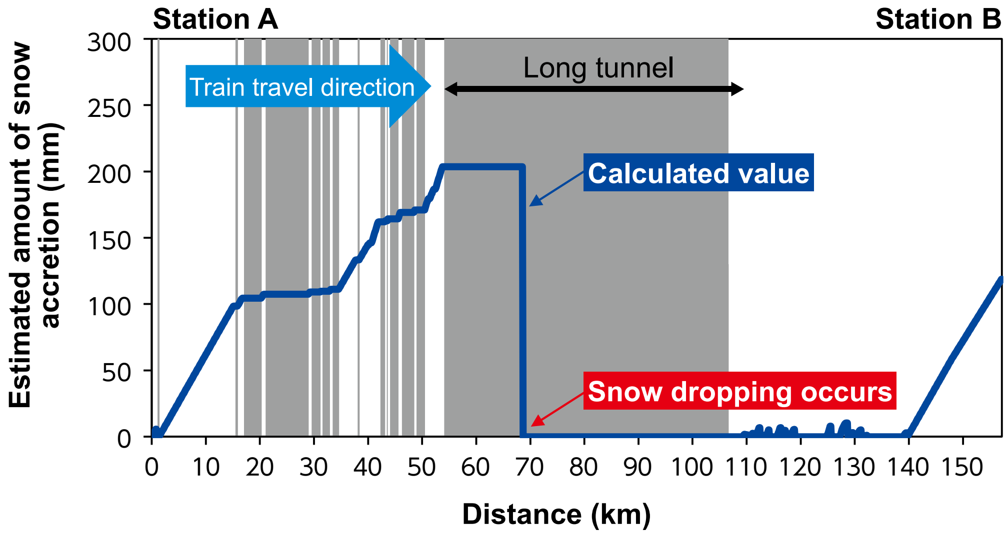


Example of Snow Settling on Bogie End Cover Plate[4)]

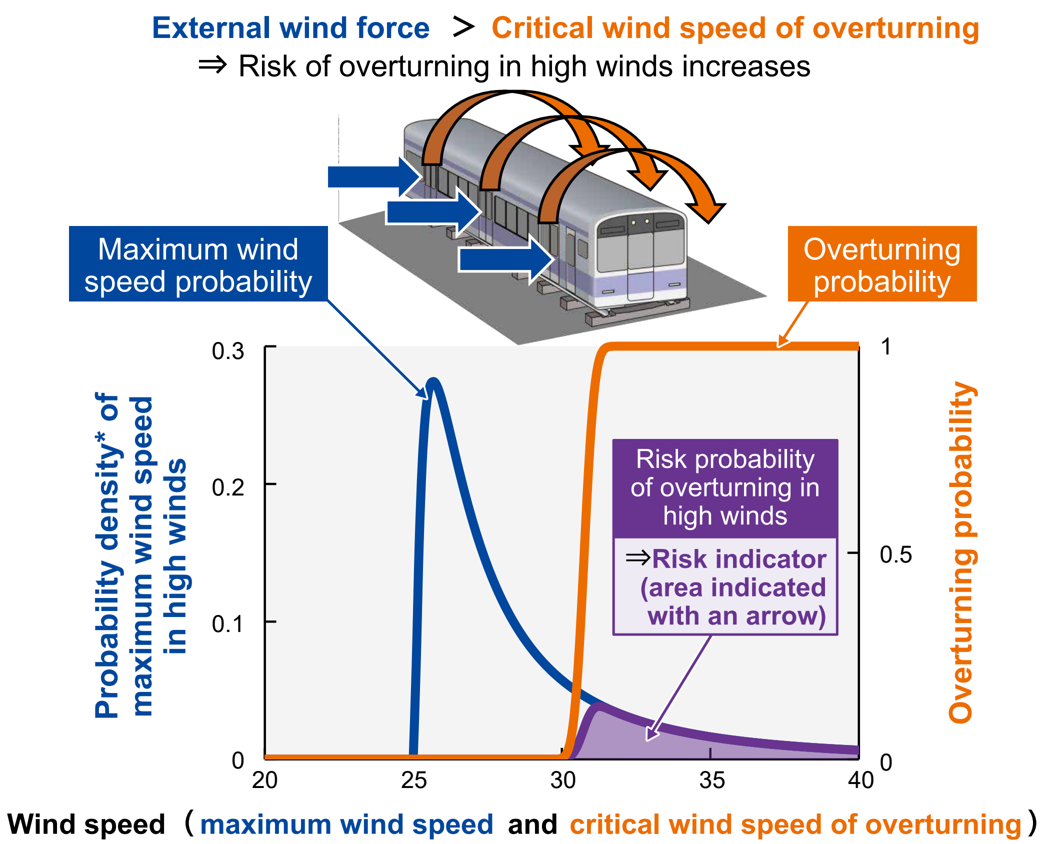
Estimating Snow Accretion and Dropping from Train Vehicles to Verify Countermeasures Against Snow Dropping

In snowy areas, snow blown up by running trains often settles on bogie end cover plates (*Example of Snow Settling on Bogie End Cover Plate*[4)]) and the like. The accumulated snow often forms chunks of ice, which can drop off while trains are running and damage ground equipment. As a countermeasure against such potential damage, railway workers have to clear accumulated snow at train stops. However, since whether or not snow removal is necessary relies only on weather forecasts, railway workers have to be mobilized at all times even when removal work is not needed.

To improve staffing efficiency, we developed a method for estimating the snow accretion on and snow-dropping from train vehicles. Our proposed method estimates the location where the snow drops off and the amount of snow accretion in real time. We calculate the amount of snow accretion on the bogie cover plates in cold open sections based on weather information along the line (*Example of Snow Settling on Bogie End Cover Plate*[4)]). The loss of snow when it drops off in warmer environments, such as tunnels, is also considered (*Example of Calculation of Snow Accretion Amount (gray shaded areas represent tunnel sections)*). We compared the actual measured and estimated amounts of snow accretion upon the train's arrival at the station and found an error margin of approximately 3 cm. We are now proceeding with our research and development to obtain a more accurate estimation.



Example of Calculation of Snow Accretion Amount (gray shaded areas represent tunnel sections)



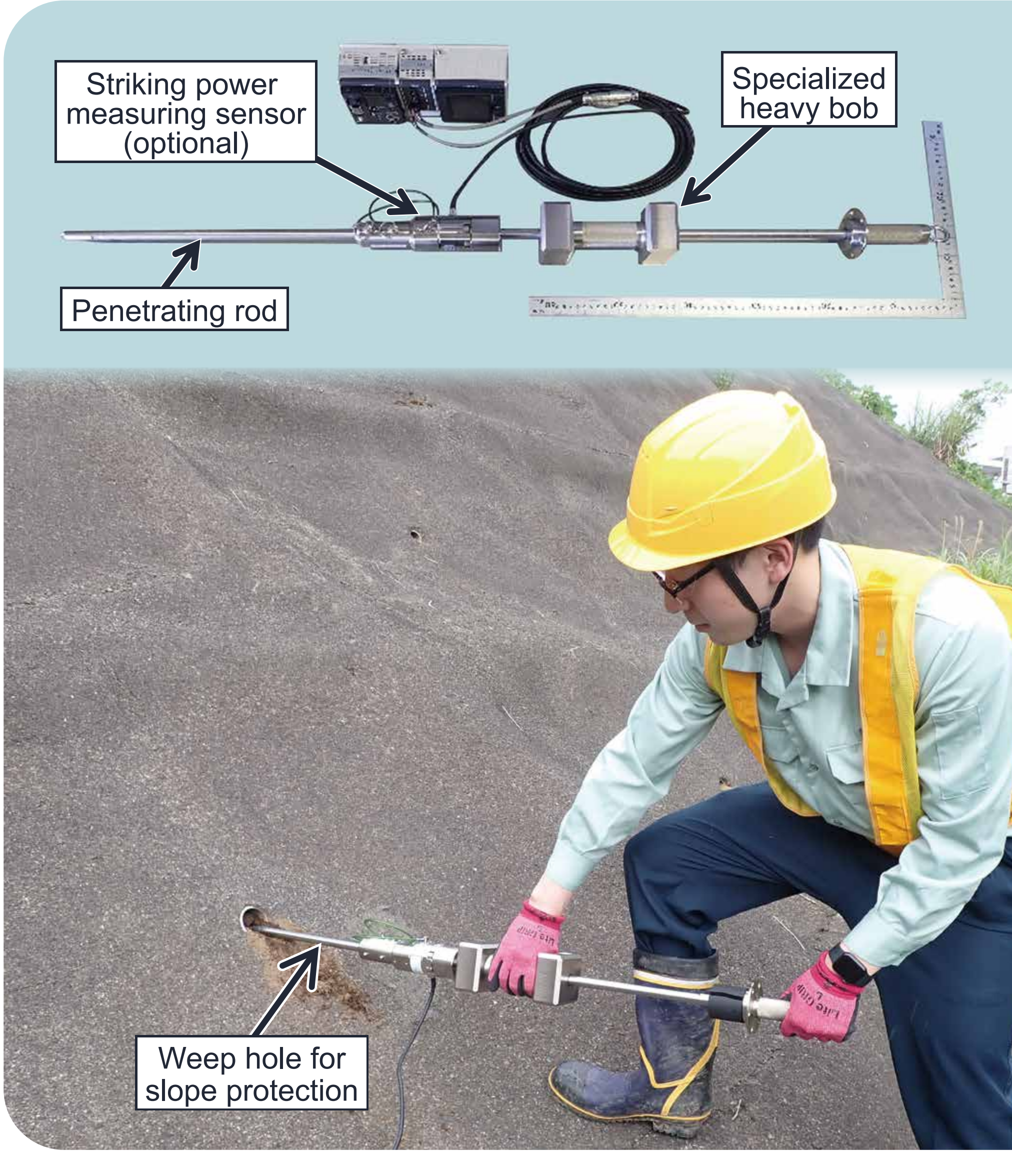
*Probability density refers to a value whose integral over a specific domain can be used to obtain the probability (area under the distribution curve equals to one).

Overview of Method for Evaluating Vehicle Safety During High Winds Using Probabilistic Risk Assessment

Evaluating Vehicle Safety in High Winds Using Probabilistic Risk Assessment

To prevent overturning accidents in high winds, train operation is regulated (either slowed down or cancelled) when the wind speed exceeds a certain limit (regulated wind speed). With meteorological disasters aggravating year after year, train operations need to be regulated when the wind is strong enough to overturn trains. However, regulated values that are extremely biased toward safety may hinder stable transport operations. Therefore, before discussing regulations on wind speed, quantitative safety indicators for various types of vehicles are required against overturning accidents in high winds. We thus propose a method for evaluating vehicle safety in high winds using probabilistic risk assessment.

When the wind speed exceeds a certain critical value (critical wind speed of overturning), the risk of vehicle overturning increases. The critical wind speed of overturning varies with lateral vibration acceleration that occurs depending on the running conditions (track conditions and running speeds). Moreover, because winds are natural phenomena, the maximum value of wind speed that overturns vehicles (i.e., maximum wind speed) also varies with the situation. The proposed method calculates the risk probability of overturning by expressing these variations in terms of probability distributions to use the risk probability thus obtained as a risk indicator of overturning (*Overview of Method for Evaluating Vehicle Safety During High Winds Using Probabilistic Risk Assessment*). The safety of various types of vehicles in high winds can be quantitatively compared by using the aforementioned risk indicator for discussing the regulation of train operations when high winds blow.

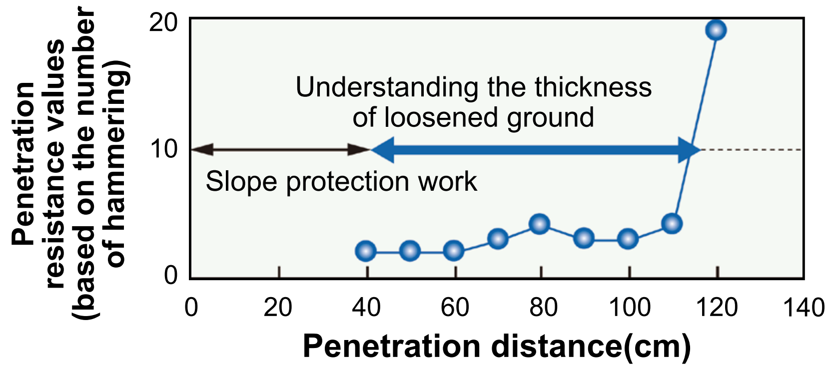


Simplified Free-Fall Striking Penetration Testing Machine (Above) and its Usage (Below)

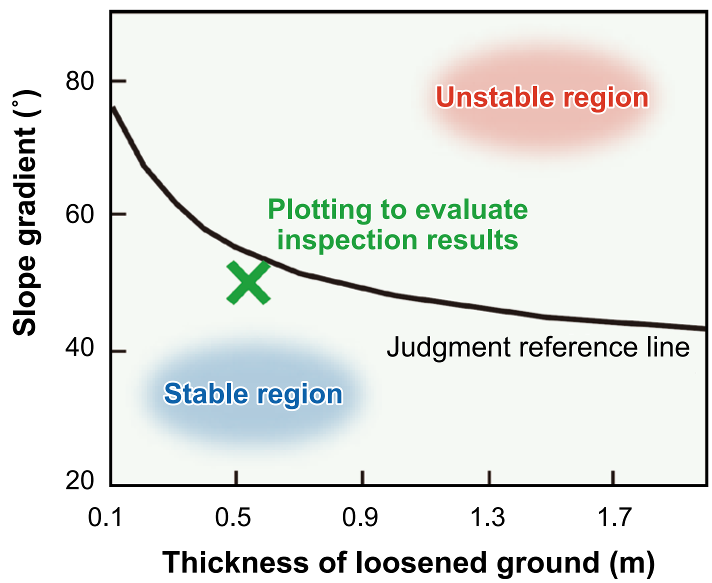
Low-Cost Deterioration Evaluation of the Backside Ground of Slope Protection Works

The excavation of grounds during railway construction in mountainous areas results in the formation of several slopes (cutting slopes). To protect the cutting slopes from weather, some slopes are treated with surface protection, such as concrete. If the backside ground deteriorates too severely with aging that it can no longer stand on its own, landslides from the ground may push the surface protection of the slope forward, eventually leading to the collapse of the slope. Conventionally, the deterioration of backside ground treated with slope protection could not be confirmed only by ordinary visual inspection but also required horizontal boring investigation, which involved large-scale devices. To address this issue, we developed a low-cost horizontal test machine (hereinafter referred to as “simplified free-fall striking penetration testing machine”) to confirm the deterioration of backside ground.

The simplified free-fall striking penetration testing machine penetrates a rod by hammering it horizontally from a point on the weep hole already installed on the slope protection surface to a point on the backside ground by a constant striking force (*Simplified Free-Fall Striking Penetration Testing Machine (Above) and its Usage (Below)*). The machine calculates the penetration resistance values based on the number of hammerings to determine the range of ground deterioration (*Example of Test Result*). Based on the test results, it evaluates slope stability by plotting the range of deterioration on a nomogram (*Example of a Nomogram for Evaluating Slope Stability*). This type of research can be done within approximately 10 minutes per location and does not require construction work, such as the removal of slope protection materials.



Example of Test Result



Example of a Nomogram for Evaluating Slope Stability

Conclusions

This report covered examples of the latest research and development approaches of the Disaster Prevention Technology Division. For more information about our other research achievements, please visit the Railway Technical Research Institute (RTRI) website (https://www.rtri.or.jp/eng/rd/division/rd46/).

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Recent Research and Development of Signalling and Operation Systems Technology Division

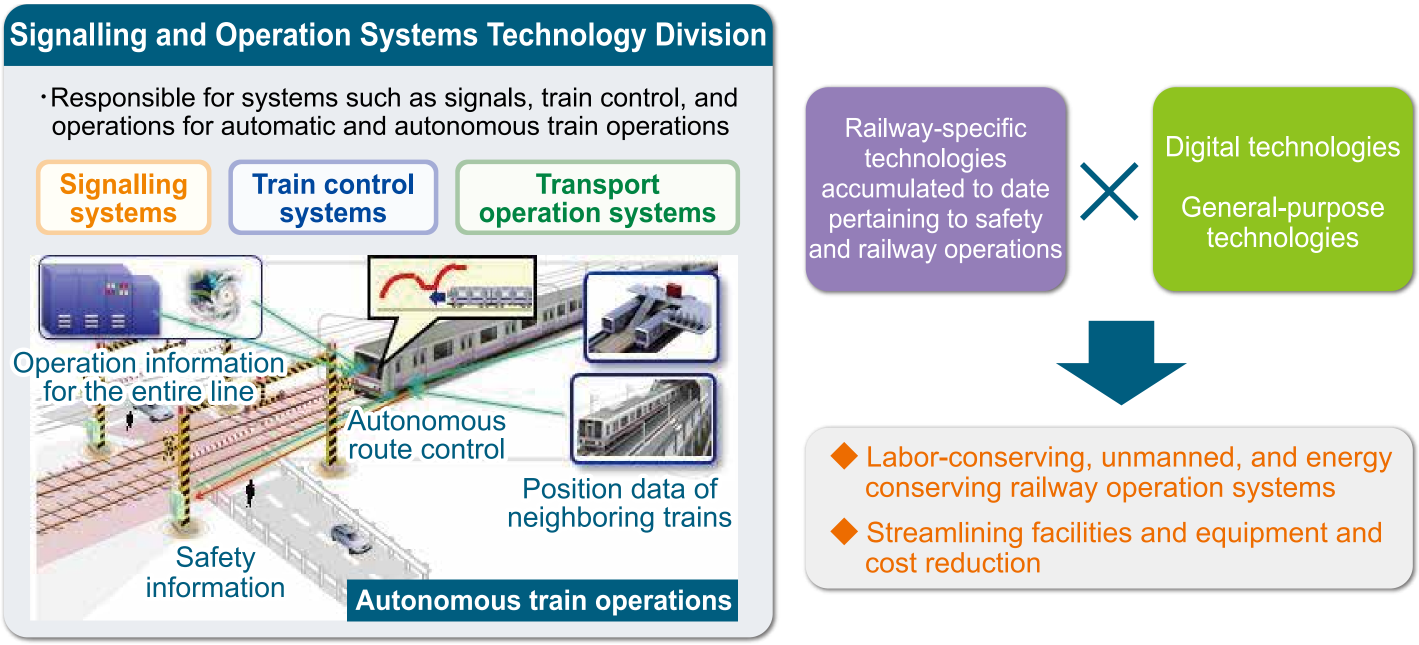
The Signalling and Operation Systems Technology Division (S&O div.) conducts research and development on signalling safety and train control systems, both essential for ensuring safe and stable railway transport. Additionally, the division explores operations planning and management, typically including timetables, vehicles, and crew scheduling. Moreover, to establish innovative railway systems in the future, we are actively involved in research and development activities that integrate Information and Communication Technologies (ICT) and other cutting-edge digital technologies with existing railway-specific technologies pertaining to safety and railway operations. In this section, we present the approaches most recently used in our research and development endeavors.

Dr. Hideki Arai
Director,
Head of Signalling and Operation Systems Technology Division

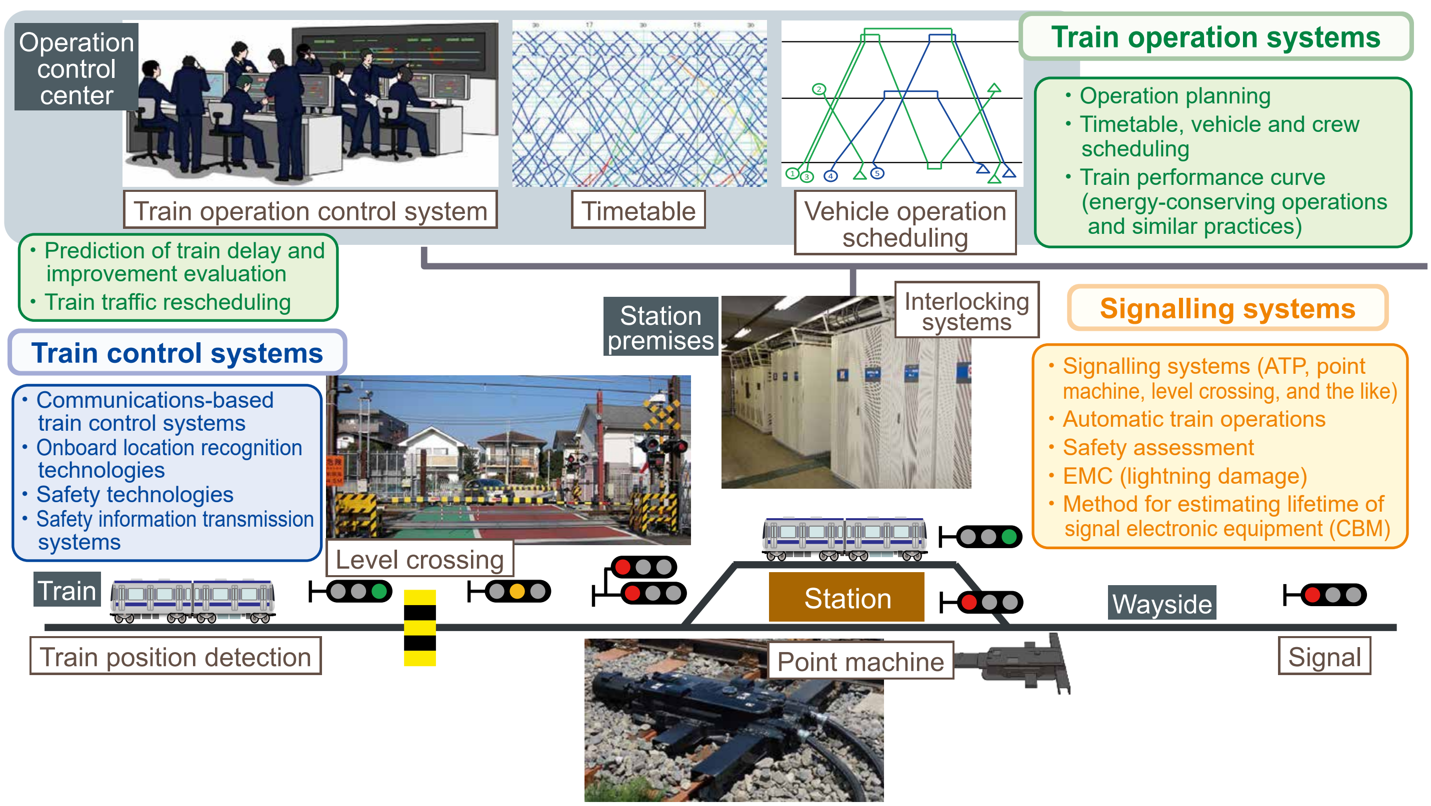
Introduction

Recent progress in digital technologies and their rapid integration heighten our expectations for safer and more advanced railway operation control. Amid such expectations, the S&O div. was established in the organizational reform of the Railway Technical Research Institute (RTRI) on April 1, 2022. The institute serves as a core research hub for developing innovative railway systems based on digital technologies, focusing on automatic and autonomous railway systems (*Responsibilities of Signalling and Operation Systems Technology Division*)[1]. The S&O div. consists of three laboratories: Signalling Systems, Train Control Systems, and Transport Operation Systems. These laboratories are engaged in research and development pertaining to signalling safety systems, communications-based train control systems, automatic train operations, operation planning, train performance curves (including energy-saving operations), and train rescheduling after a schedule disruption (*Overview of areas within the responsibility of S&O div*).

Herein, we present the latest approaches used in our research and development efforts to achieve the autonomy of train operation systems. Additionally, we demonstrate methods for applying cameras and image processing units of Commercial Off-The-Shelf (COTS) to signalling systems. Furthermore, we introduce methods for quantitatively estimating the lifetime of electronic equipment in preparation for the future implementation of Condition-Based Maintenance (CBM) of signalling systems using electronic equipment.



Responsibilities of Signalling and Operation Systems Technology Division



Overview of areas within the responsibility of S&O div

Research and Development for Future Autonomous Train Operations

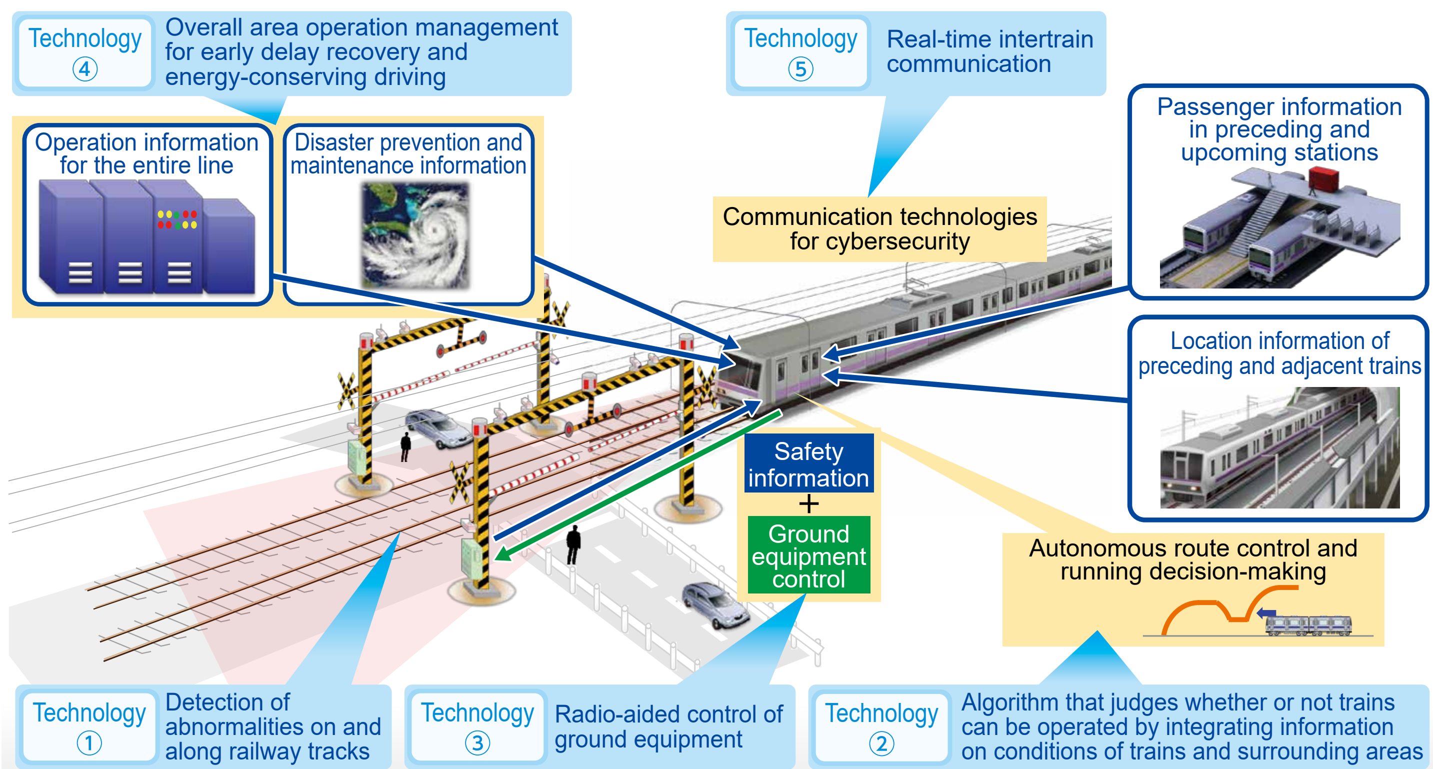
Under the RESEARCH 2025 strategic plan — the basic five-year plan of the RTRI from FY 2020 to FY 2024— the institute has been actively engaged in the research and development of autonomous train operations as a primary concern for the future. As part of these efforts, the S&O div. has promoted the research and development of autonomous train operations.

Autonomous train operation systems enable driverless trains to run safely and flexibly while controlling wayside signalling systems based on information related to conditions on and along railway tracks, passenger flow, disaster prevention, maintenance, and power consumption. The S&O div. is actively engaged in research and development to foster essential technologies for constructing autonomous train operation systems (*Autonomous train operations*)[2], including:

(1) Detection of abnormalities on and along railway tracks using images and Light Detection And Ranging (LiDAR).
(2) Technologies that integrate onboard information about the conditions on and along railway tracks, as well as those of trains, automatically make onboard judgments about the feasibility of train operations.
(3) Onboard radio-aided direct control of ground signalling systems.
(4) Train traffic rescheduling technologies are required to remediate schedule disruptions— including preventing the spread of delays and early delay recovery— and automatic train operation management technologies are required for energy-conserving operations in wide areas.
(5) Real-time intertrain communication technologies with due consideration to cybersecurity.

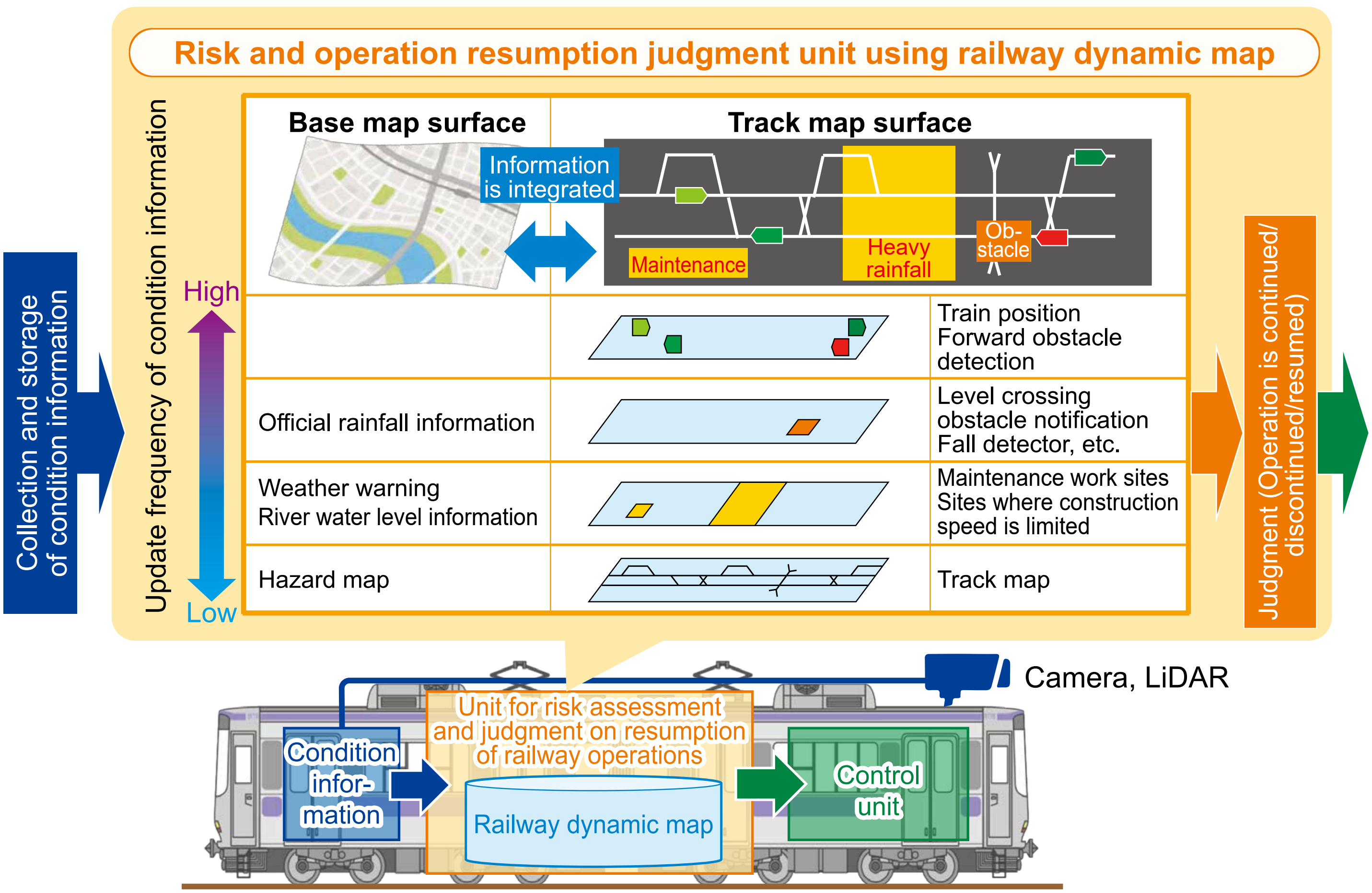
Implementing the aforementioned technologies will facilitate autonomous operations on general railway lines with level crossings as well as highly automated driving using less wayside equipment.

As an illustration of the aforementioned technology (2), we introduce an onboard automatic judgment method for the re-



Autonomous train operations

sumption of railway operations utilizing a railway dynamic map. Current decision-making processes require operation commanders at operation control centers to determine whether train operations can be resumed for wide-area operations involving numerous trains. When immediate decisions are necessary, train crews can decide on the resumption of operations. In current autonomous train operation systems, each train must collect various types of condition information required for operation decisions and automatically perform onboard risk judgment and decision-making for resuming railway operations. We developed a railway dynamic map as a basis for conducting onboard risk judgments and making decisions to resume operations (*Automation of risk and operation resumption judgment using railway dynamic map*)[3]. The railway dynamic map, which consists of a base map and track map, is classified hierarchically according to the update frequency of various types of condition information. The railway dynamic map, capable of transitioning between a base map and a track map, can integrate railway-specific kilometrage-based and public condition information based on the position on the map (e.g., weather information) and chronologically manage the integrated information. When abnormalities occur in the condition information on and along railway tracks as well as on weather-related condition information such as rainfall amount and wind speed, the detected information is stored in the railway dynamic map. Then, each train can search for and identify abnormalities in its running route on the map based on its current position. We will continue to work toward innovative automatic risk avoidance during operation and automatic decision-making for resuming train operations based on the railway dynamic map.



Automation of risk and operation resumption judgment using railway dynamic map

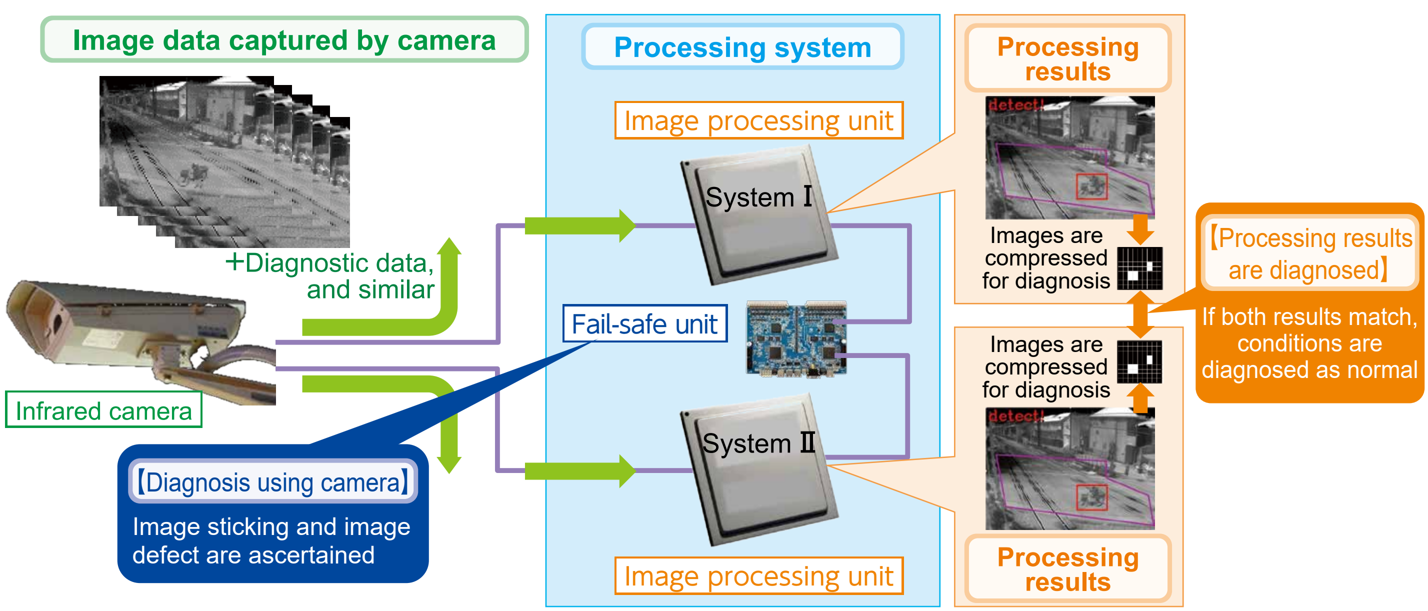
Method for Ensuring Safety in the Integration of COTS Equipment to Signalling Systems

Although cameras and image-processing units of COTS are often used as obstacle detection devices owing to their increasing sophistication and cost-effectiveness, improving safety measures against failures has become an issue because COTS equipment cannot self-diagnose failures. To solve this issue, we developed a method for diagnosing failures in image-processing units and cameras by combining COTS equipment with the fail-safe units of signalling systems (*Examples of the means of ensuring safety when applying COTS equipment to signalling systems*)[4]. Using this method, we can compress the results processed by image-processing units into images for diagnosis and determine similarities using fail-safe units. Moreover, we can diagnose abnormalities, such as images sticking in the fail-safe unit, by adding new camera functions. Specifically, a function to embed diagnostic data in image data and another one to output test patterns.

We validated the efficacy of the fault diagnosis functions through testing by prototyping a verification device equipped with this method and artificially inducing failures. This method is also applicable to the fault diagnosis of other COTS equipment. With a focus on reducing signalling equipment costs, we are committed to integrating railway-specific technologies with digital technologies. This includes ongoing research and development related to the safe use of cutting-edge digital technologies, such as ICT.

A Method for Quantitatively Estimating the Lifetime of Signalling Equipment for Shifting to CBM

Signalling equipment comprises numerous electronic devices whose deterioration — and indications of deterioration— are difficult to detect. Consequently, equipment replacement is programmed based on Time-Based Maintenance (TBM) policies that define different update cycles for each type of equipment. By contrast, instead of detecting short-term signs of electronic equipment failure, we aim to achieve CBM. This approach involves conducting long-term lifetime estimation by considering the remaining life and degradation levels of electronic equipment, as well as sensing the operating environmental conditions. In this regard, we identified temperature and humidity as the major causes of equipment deterioration and developed a method for quantitative lifetime estimation based on sensing these variables (*Methods for estimating the lifetime of electronic equipment*). Furthermore, we found that lifetime estimation is possible using weather data released by the Japan Meteorological Agency, corresponding to the equipment location. Additionally, a software tool is being developed, which sequentially calculates and displays the estimated lifetime

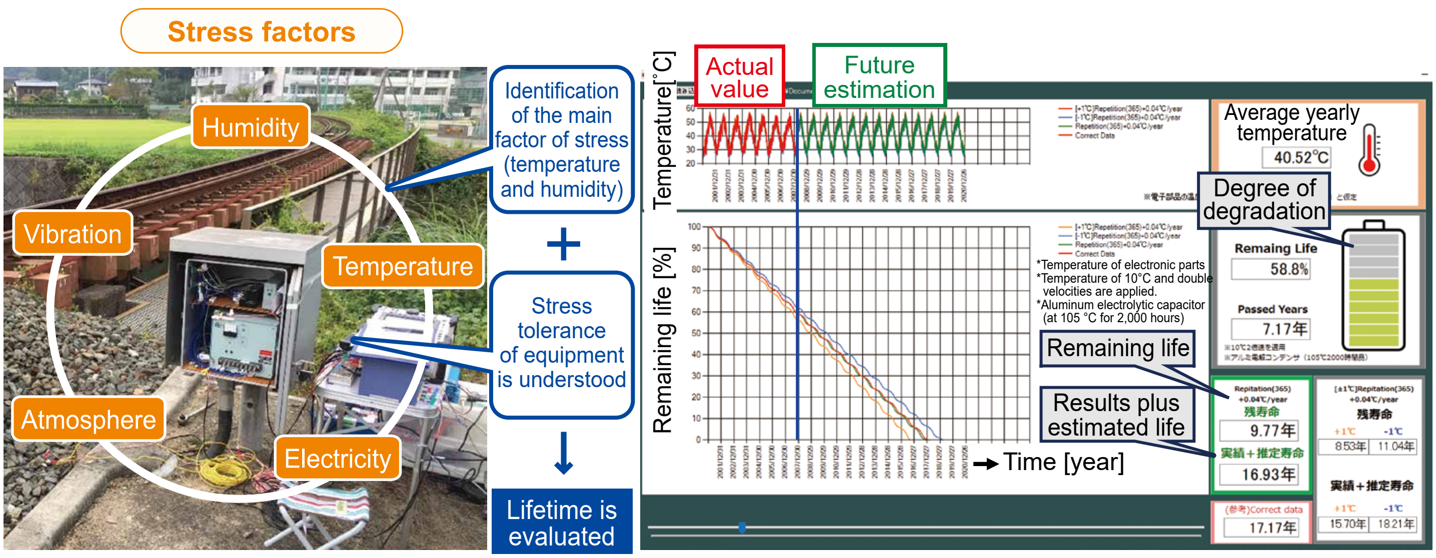


Examples of the means of ensuring safety when applying COTS equipment to signalling systems

based on sensed operation environmental conditions (*Methods for estimating the lifetime of electronic equipment*)[5] to enable a more judicious replacement of signalling systems using electronic equipment.

Conclusions

We provided examples of the latest research and development approaches of the signaling and operation systems. Furthermore, we are currently conducting research to develop methods for predicting train delays using machine learning, automatically creating operation and management plans for scheduling vehicles and crew, and efficiently using regenerative braking energy. For more information on other research and development achievements, please refer to the RTRI website (https://www.rtri.or.jp/rd/division/rd47/). The S&O div. is committed to the advancement of research and development for improving railway safety, reliability, convenience, and energy conservation.



Methods for estimating the lifetime of electronic equipment

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Recent Research and Development of Information and Communication Technology Division

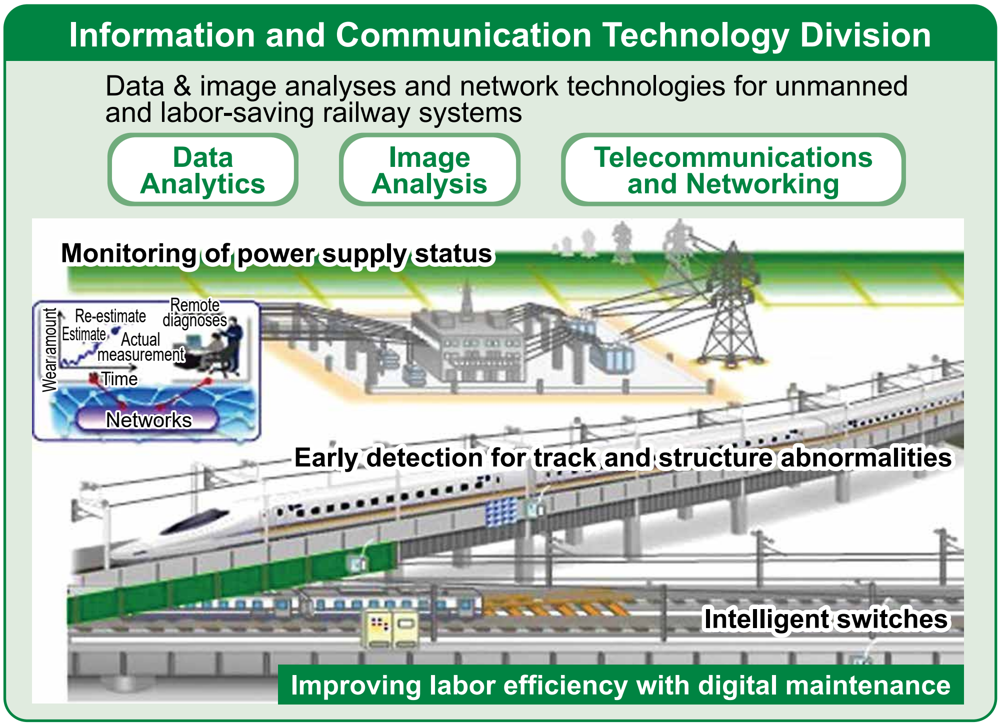
Mr. Mitsuyoshi Fukuda
Director,
Head of Information and
Communication Technology Division

The aim of the Information and Communication Technology Division is "developing innovative railway systems based on digital technologies." Under this policy, we are advancing our research and development (R&D) efforts by developing digital techniques for fields such as data analysis, machine learning, image processing, sensing, and communications networks to improve the labor efficiency in systems like unmanned and labor-saving railway systems. If these techniques are used without any cooperation across disciplinary boundaries, they cannot provide satisfactory results. Therefore, we are working on R&D activities in cooperation with other divisions and research centers. This paper introduces our most recent cross-sectoral efforts.

Introduction

Recent remarkable progress in digital technologies has led to maintenance and service innovations based on digital technologies gaining considerable attention among various industries. The Japanese railway industry is struggling to deal with the impact of the declining working-age population, falling birth rates, and the aging population. Therefore, creating unmanned and labor-saving railway systems in each technical field is essential to maintain and improve the safety and stability in railway transportation.

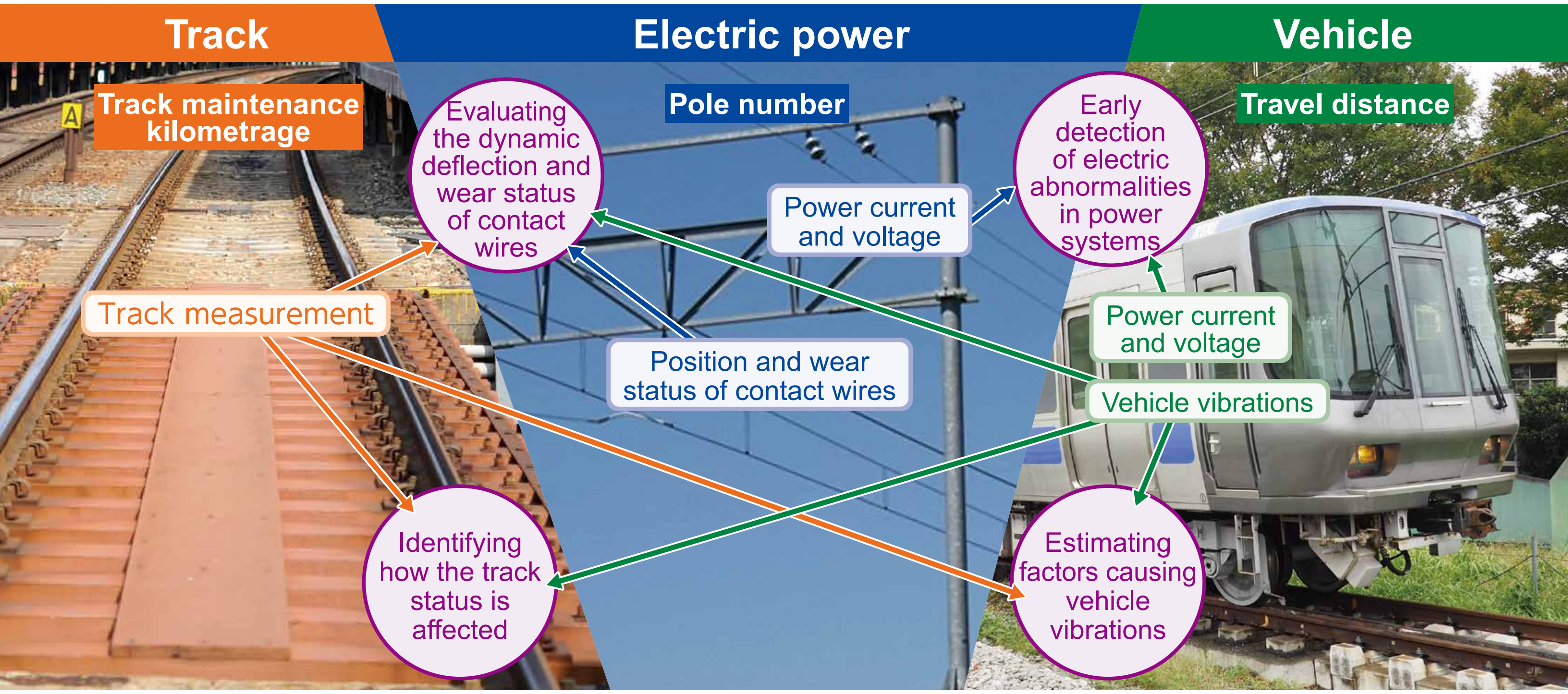
On April 1, 2022, the Information and Communication Technology Division was newly established as a research hub in the organizational reform section of the Railway Technical Research Institute (RTRI) for promoting the cross-sectoral use of digital technologies and developing unmanned and labor-saving railway systems (*Technical fields targeted by the Information and Communication Technology Division*)[1]. We shall briefly overview our subdivisions: Data Analytics, Image Analysis, and Telecommunications and Networking laboratories. The Data Analytics Laboratory carries out R&D related to efficient and sophisticated data analyses, machine learning, demand forecasts, and decision-making to save labor in performing maintenance for tasks such as diagnosing system conditions. The Image Analysis Laboratory is developing safety-enhancement systems and unmanned and labor-saving systems for railway inspection and monitoring with the support of sensing techniques that employ



Technical fields targeted by the Information and Communication Technology Division

cameras and LiDAR(light detection and ranging) sensors along with image processing and machine learning techniques. The Telecommunications and Networking Laboratory is working on applying innovative communication technologies, such as 5G technology, to railway systems and building a shared information infrastructure to support safe and stable railway operations.

Herein, we report recent examples of R&D related to platforms for cross-sectoral data analyses, maintenance data analyses based on machine learning results, safety check support systems at station platforms, and integrated communication networks.

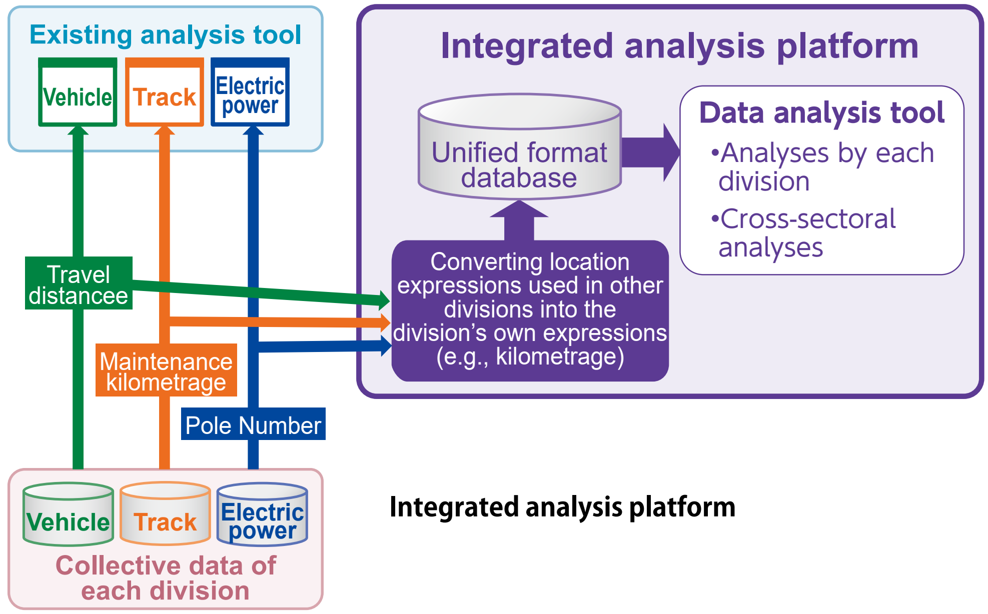


Interaction of mutual technical fields

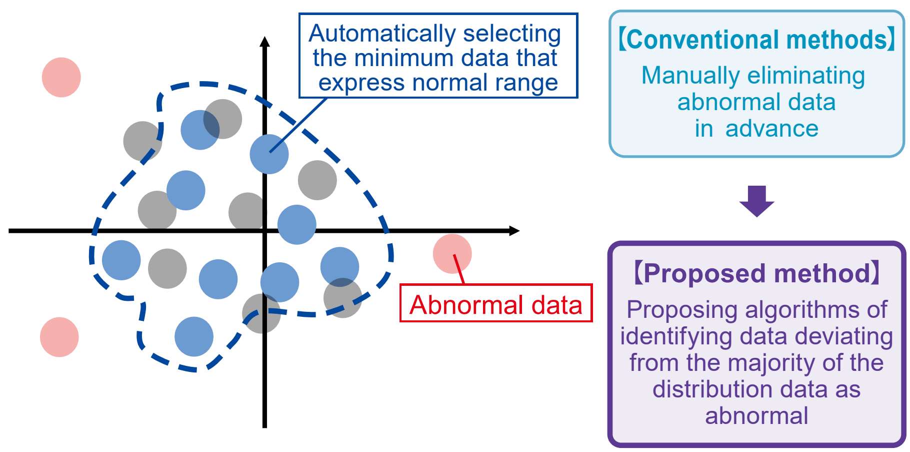
Development of a Platform for Cross-Sectoral Data Analyses

Currently, each technical field have independently acquired and accumulated railway maintenance data and put their heads together to find the best method for analyzing and utilizing these data. Since the railway is a complex system consisting of various interacting components, such as vehicles, tracks, structures, and electric power systems (*Interaction of mutual technical fields*), the underlying factors for any issues may vary across components. Tracks and structures can cause vehicle vibrations, which may further affect overhead contact line systems, including contact wires. The independent analyses conducted in each field showed only one aspect of such complex railway system behaviors. However, if analyzed in a cross-sectoral manner with reference to data from other fields, events that have never been analyzed, such as signs of abnormalities, can be detected.

Considering these demands, we are proposing to develop an "integrated analysis platform" where multiple-field maintenance data can be consolidated and used for cross-sectoral analyses (*Integrated analysis platform*). In this platform, the interconversion of location expressions (e.g., kilometers), which differ depending on the division, enables a division to analyze the data of other divisions using its own expressions. Currently, we have built an integrated analysis platform for test tracks[2]. The data measured in the running tests on the test tracks at the RTRI can be automatically consolidated on a server; we plan to verify cross-sectoral analyses using the consolidated data.



Integrated analysis platform



Method of automatically eliminating abnormal data

Analyses of Maintenance Data Based on Machine Learning Results

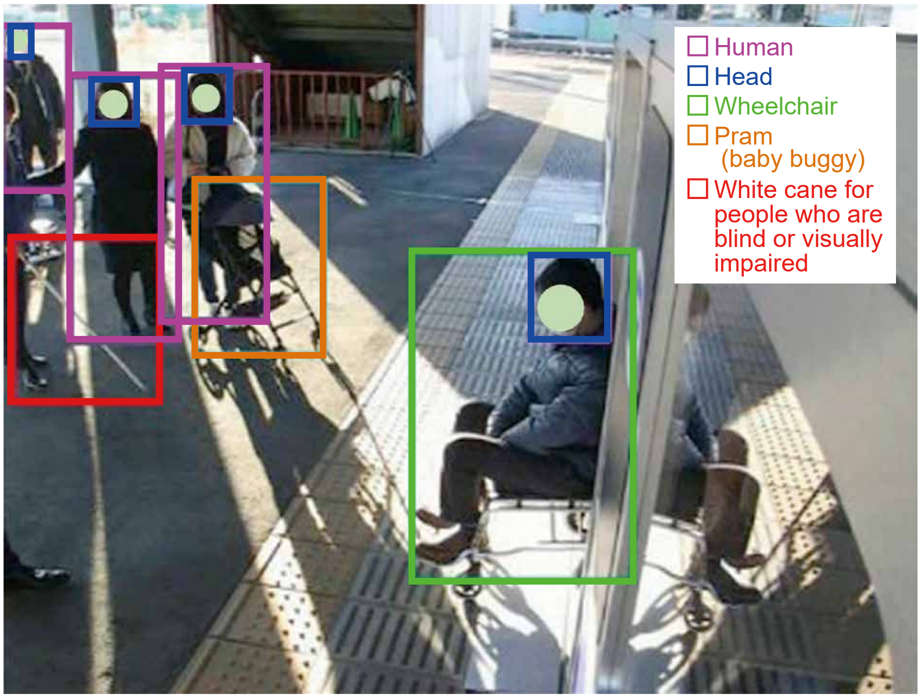
Proactively applying machine learning in analyses of maintenance data can produce benefits, such as promptly detecting abnormal signs. Ensuring successful results in machine learning necessitates plenty of labor such as preparing abundant learning data, manually eliminating abnormal data, and labeling data, which can be barriers to its application. The RTRI has developed machine learning-based methods to detect abnormalities using the vibration data of a vehicle system. Disadvantageously, these methods require manual labor to eliminate abnormal data.

As a countermeasure, we developed a method to automatically eliminate abnormal data in the machine learning process (*Method of automatically eliminating abnormal data*). This method can complete the learning process while identifying and automatically eliminating abnormal data i.e., data that deviate from most of the distribution data. We implemented this method using a commercially available general analysis tool to enable engineers without specialized knowledge in machine learning or programming to analyze maintenance data using machine learning.

Development of Safety Check Support Device for Driver Using Side Camera on Rolling Stock

The safety of passengers on the platform, mainly at departure time, can be visually confirmed by the train crew. In some one-man operation sections, platform safety can be monitored from the cab of a train operator with photographic images captured by cameras installed on the sides of the vehicles; however, the crew is still required to perform visual inspection. To support the inspection, we developed a safety check supporting system[3] that automatically detects passengers approaching vehicles using photographic images captured by cameras installed on the sides of vehicles and notifies the crew thereof. Humans, heads, wheelchairs, perambulators, and white canes for visually impaired people can be detected separately by applying AI models trained on our own data to an algorithm that detects approaching passengers (*AI-based detection of individual detection*).

Through our efforts to improve the high-speed operation and implementation methods specifically designed for each station environment, we developed a system that enables real-time performance with just a CPU, removing the need for an expensive GPU that also generates plenty of heat. Additionally, we downsized the system (to 360 × 260 × 70 mm). If cameras are already installed on the sides of vehicles, the crew can be notified of approaching passengers through this system.

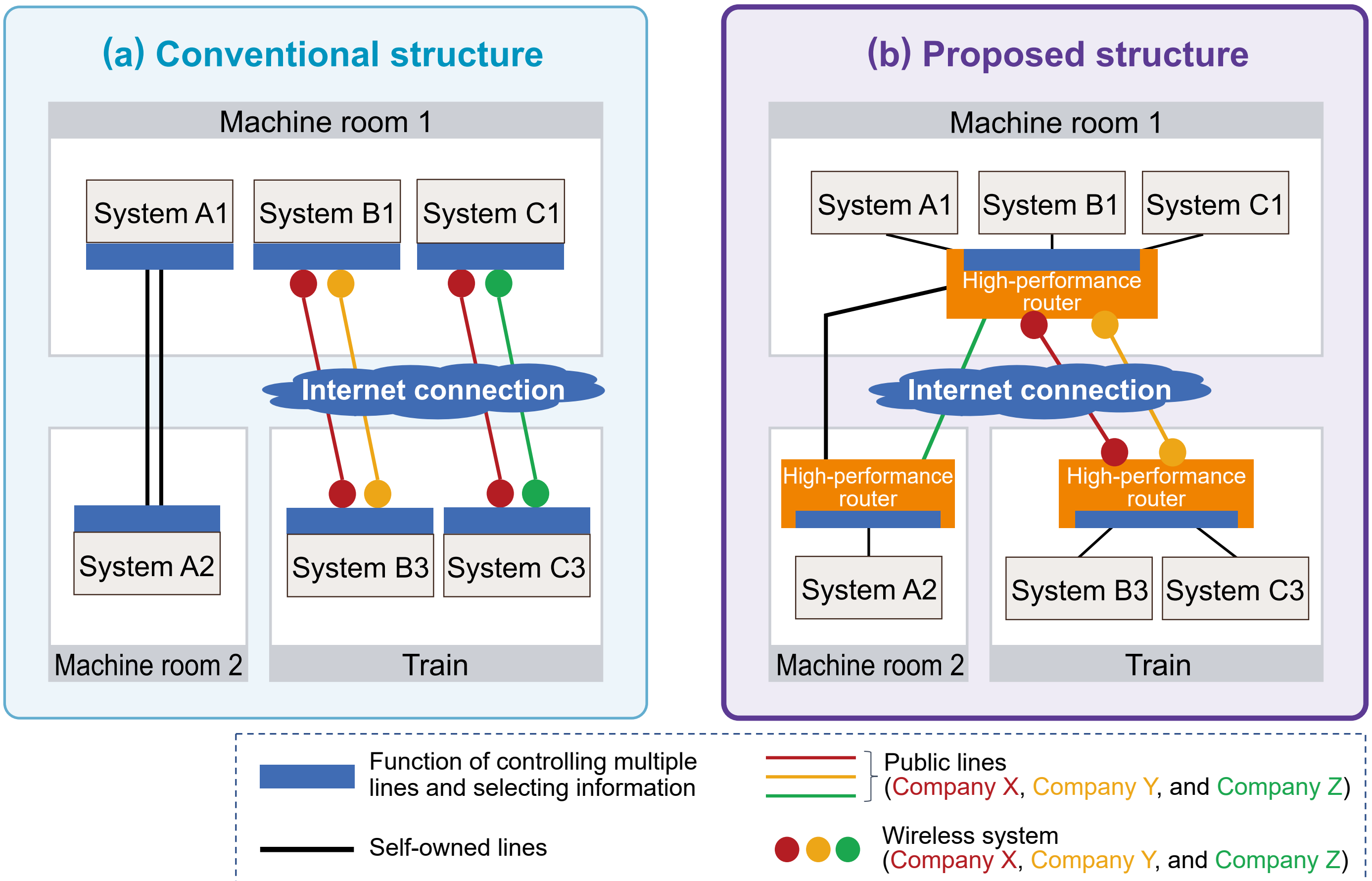


AI-based detection of individual detection

Improving Facility-Saving Strategies and Communication Quality Through an Integrated Communication Network

Many railway-related systems communicate information over networks, most of which are independent and self-constructed (*Method of integrating communication networks*, left). Safety-critical systems often incorporate redundancies by using multiple lines. Redundancy is becoming increasingly important, particularly in systems that use cellular phone networks[4]. Considering the growing use of network-based communications in the future, many wireless systems and communication cables need to be installed in machine rooms and vehicles. Moreover, each system is required to implement control functions that determine the information to be selected from redundant lines, which can impede the efficiency of the procedures.

To help resolve these issues, we have proposed a method of integrating communication networks and switching communication lines depending on factors such as level of importance, priority or network traffic conditions[5] (*Method of integrating communication networks*, right). We performed running tests on the test tracks at the RTRI, in which multiple lines had been combined, and we confirmed that the communication quality of even congested communication networks could be improved. This router mainly consists of a general-purpose router with a function of controlling multiple lines and selecting information added thereto. The general-



Method of integrating communication networks

purpose router can be updated to produce continuous enhancements in the security features.

Conclusions

In this report, we covered relating to maintenance data analyses, as well as applying still image-based methods and the other related to communications networks. For more information on our other research achievements, please refer to the official RTRI website (https://www.rtri.or.jp/rd/division/rd62/).

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Dr. Motohide Matsui
Director,
Head of Materials Technology Division

The Materials Technology Division is currently working on extending the service life and developing high-performance materials for use in railways, identifying the causes of material deterioration, constructing deterioration evaluation and maintenance methods, and developing and researching new materials. We conduct research and development across diverse areas, from basic to applied research, on frictional sliding materials. In this article, we introduce the latest examples of our research and development efforts.

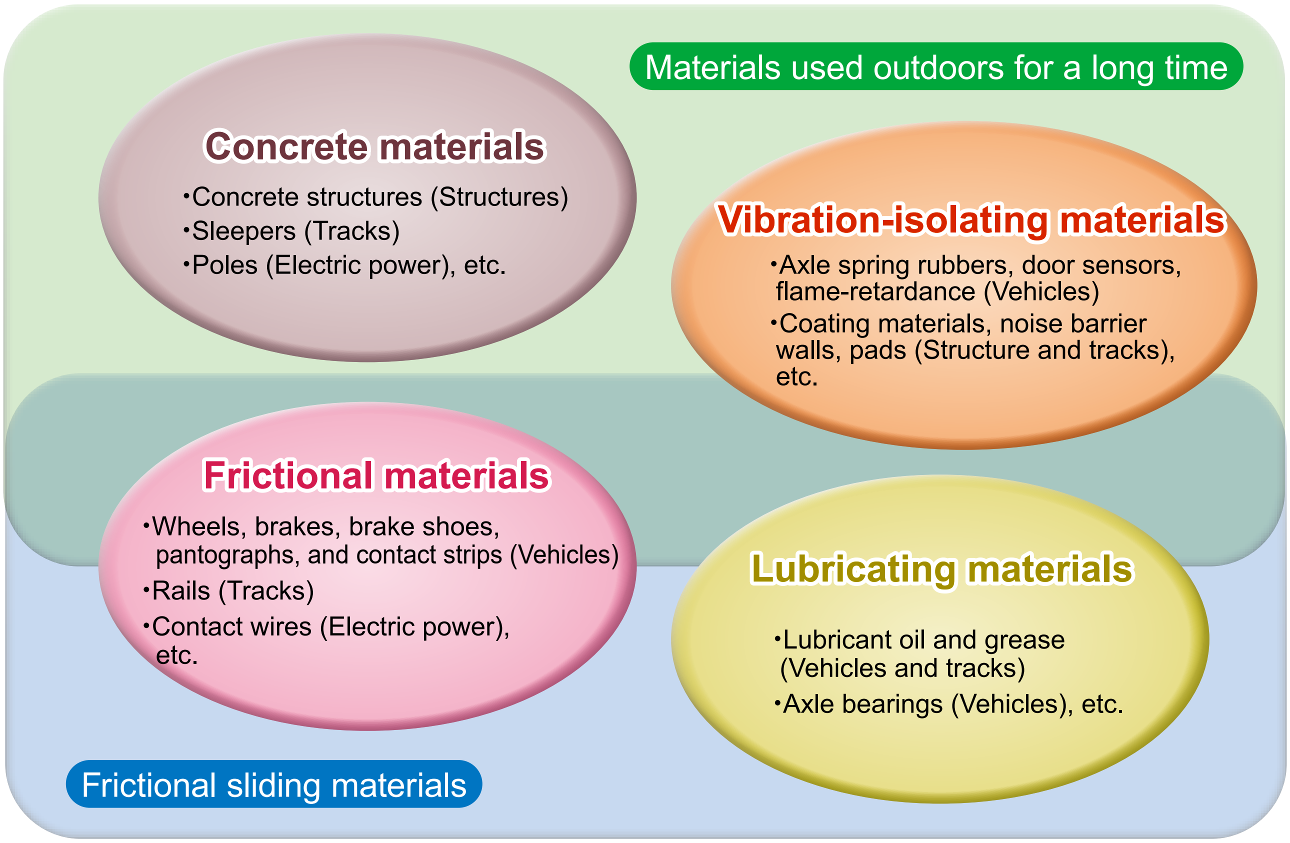
Recent Research and Development of Materials Technology Division

Introduction

Several combinations of metallic (iron and steel, aluminum, copper, etc.), inorganic (concrete, ceramics, etc.), organic (rubber, coating materials, lubricant oil, etc.), and carbon-based materials are employed in railways based on the specific structural and functional requirements and study objectives. These materials have been developed over 150 years of the Japanese railway history through persistent efforts for overcoming the lack of durability and meeting the demands for new functions. However, the environment surrounding railways has continued to change significantly owing to changes in working conditions, such as the decline in the working-age population attributed to the decreasing birthrate and aging population, coronavirus-induced changes in the working environment, digital innovations, and decarbonization. Therefore, future material technologies need to realize flexible responses to these changes in the surrounding environment.

The Materials Technology Division has directed its research and development (R&D) efforts in "concrete materials," "vibration-isolating materials," "lubricating materials," and "frictional materials" laboratories to improve railway safety and respond to the changing surrounding environments. To this end, these laboratories have focused on extending service life, developing high-performance materials and frictional sliding materials that can be used outdoors over extended periods, investigating the causes of deterioration, constructing evaluation and maintenance methods for deterioration, and applying the new materials for construction (*Technical fields targeted by the Materials Technology Division*).

We report on some recent examples of our R&D efforts: mitigation measures for responding to changes in working conditions, measures against aging caused by decarbonization, adding high functionality to materials for improving railway safety,



Technical fields targeted by the Materials Technology Division

and improving simulation technologies for applying new materials in the future.

Simulation Technologies for Applying New Materials in the Future

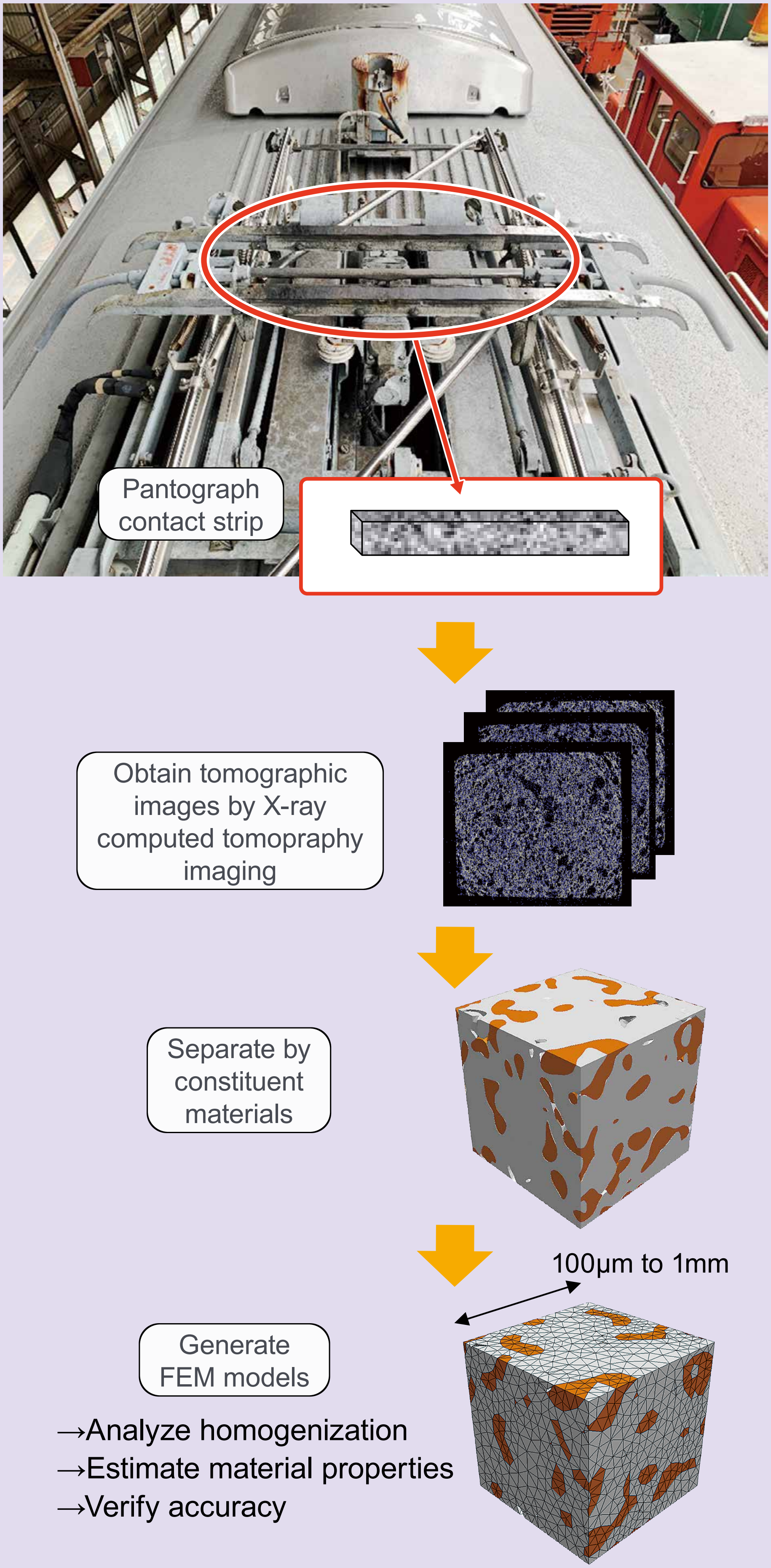
"Material simulations for developing abrasion-resistant materials."

Developing new materials requires considerable trial-and-error efforts for identifying target materials. Unlike this traditional approach, which is labor intensive, time-consuming, and expensive, we effectively employ material simulations to proceed with our research and development. When used effectively, material simulations can minimize the need for trial-and-error experimentation and facilitate the material design required for developing new materials and estimating material properties.

An example of the material simulations currently under study are shown in *Examples of material simulations*. As shown in *Examples of material simulations*, tomographic images of pantograph contact strips made of frictional sliding materials are obtained using X-ray computed tomography imaging. Microscopic models constructed based on the obtained images are incorporated into the simulations and homogeneously analyzed for estimating material properties. The estimated accuracy of the simulations of known material properties are currently being verified. The results confirm that the simulations can successfully estimate the Young's modulus and electrical resistivity, which are important material properties associated with abrasion-resistant materials. In the future, we plan to apply the aforementioned simulation technologies to other abrasion-resistant materials and contribute to more in-depth research.

Enhancing Material Performance to Improve Safety

"Oil for axle bearings of Shinkansen trains that offers excellent low-temperature performance and maintainability"



Examples of material simulations

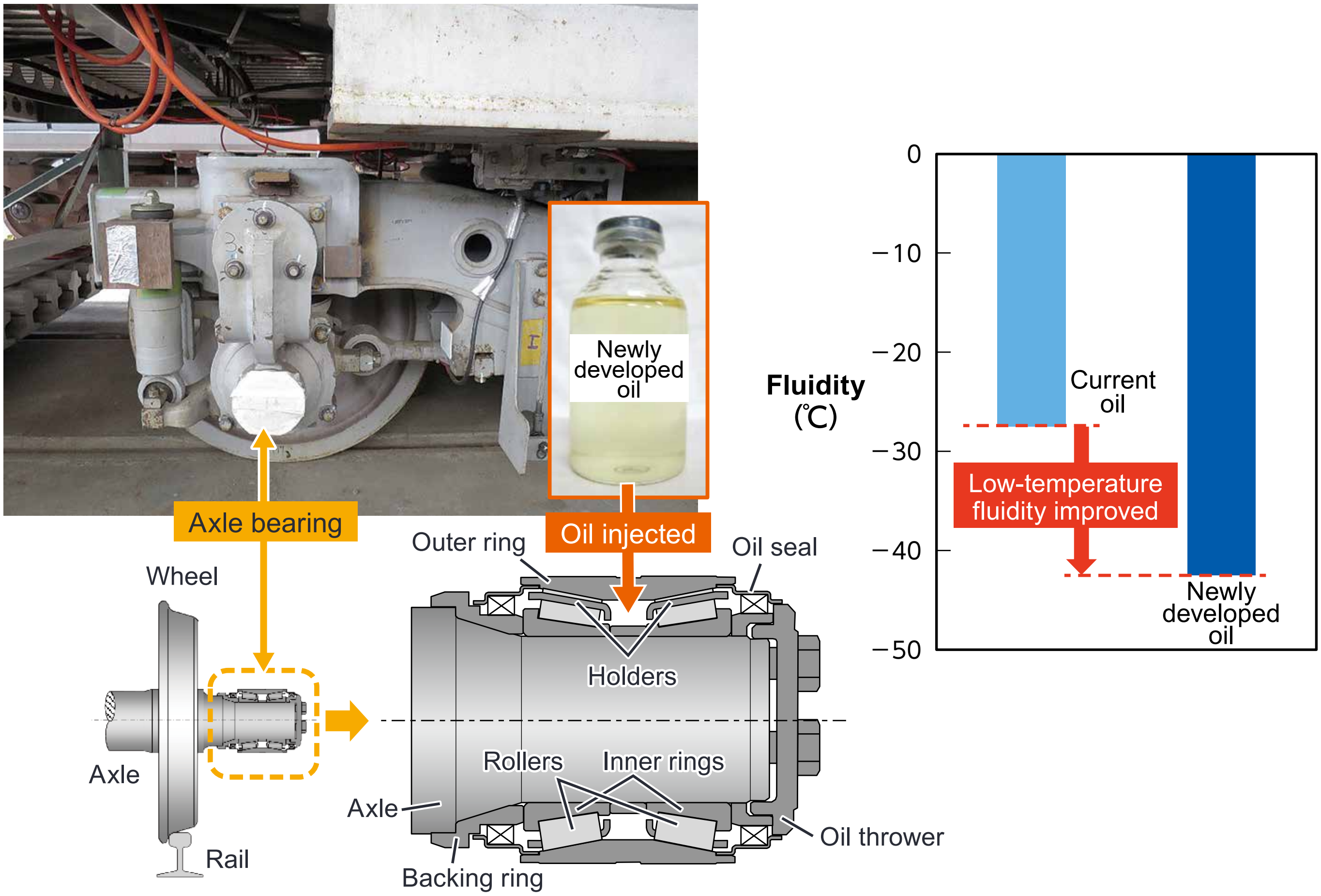
Axle bearings, which consist of frictional sliding materials, support the rotating axles from both sides and lubricate the inside of the bearings with oil to ensure smooth axle rotation. Improving the fluidity[*1] of the oil for axle bearings has become necessary with the expansion of the Shinkansen network into extremely cold regions.

To meet this demand, we developed an oil for axle bearings that exhibits excellent low-temperature fluidity. The developed oil is based on highly purified mineral oil that is not susceptible to oxidation and shows little change in viscosity at temperatures ranging from low to high (*Oil for axle bearings of Shinkansen trains with excellent low-temperature fluidity*). As shown in *Oil for axle bearings of Shinkansen trains with excellent low-temperature fluidity*, the newly developed oil for axle bearings has a lower fluidity than the currently used oil, and it can retain its fluidity at temperatures below -40℃ . We conducted a bench test with real axle bearings operating for 800,000 km of travel and verified the superior durability of the newly developed oil with no abnormalities. We realized efficient maintenance by facilitating the visual management of oil for axle bearings. Thus, we controlled the reddening of oil in axle bearings caused by ultraviolet light, thereby making it easier to promptly locate changes in oil color caused by abnormalities in axle bearings.

Countermeasures Against Aging for Responding to Changes in Working Conditions

“Prefabricated noise barrier walls for railway viaducts”

Planning replacements is a suitable countermeasure against the aging of noise barrier walls in railway viaducts that have been used outdoors over extended periods. High workability and good sound insulation properties are necessary to efficiently



Oil for axle bearings of Shinkansen trains with excellent low-temperature fluidity

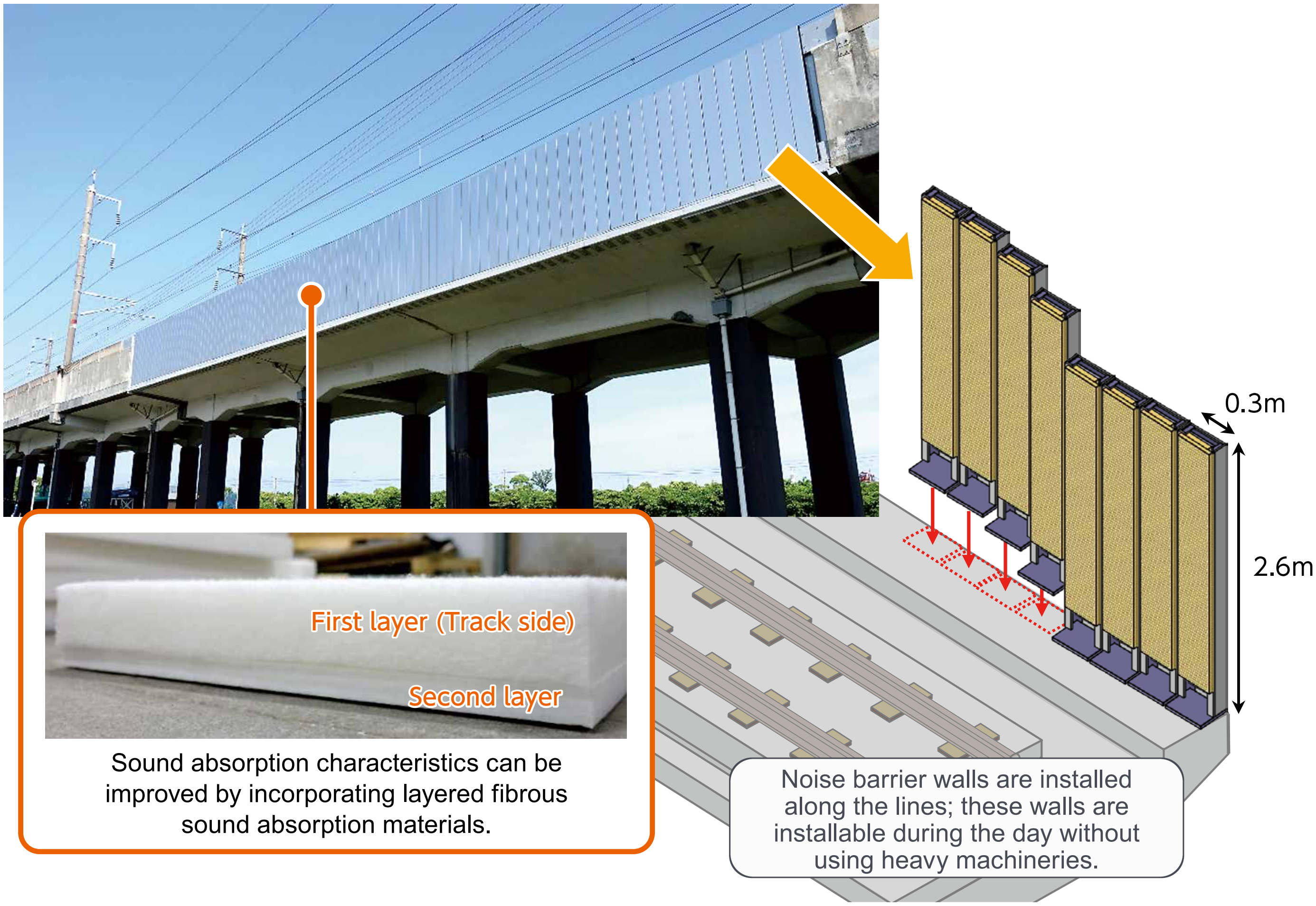
perform replacement work when installing new noise barrier walls.

To meet these requirements, we co-developed a new sound-insulating wall with a prefabricated steel noise barrier wall containing fibrous sound absorption materials (*Prefabricated noise barrier walls for railway viaducts*). The new-sound insulating walls consist of columnar members with predetermined widths connected to each other and installed along the lines to form noise barriers. Each columnar member formed one unit, and sound absorption materials with layers of polyester fibers were used inside columnar members. These materials sufficiently improved the sound absorption performance and satisfied the performance requirements for noise barriers in Shinkansen trains. In addition, heavy machinery is not required to install the newly developed noise barrier walls because their weight is approximately one-third that of concrete noise barriers of the same height. Thus, the new noise-barrier walls can be installed during the day without the use of heavy machinery if appropriate security measures are implemented. We plan to conduct further research and development to realize further noise reduction in commercial railway lines and surrounding areas using the newly developed prefabricated noise barrier walls.

Countermeasures Against Aging for Responding to Decarbonization

"Geopolymer mortar for repairing plastering damage with low CO_2 emissions."

In tunnels used over a long period, acidic underground water can seep out or exhaust gas soot particles emitted from die-



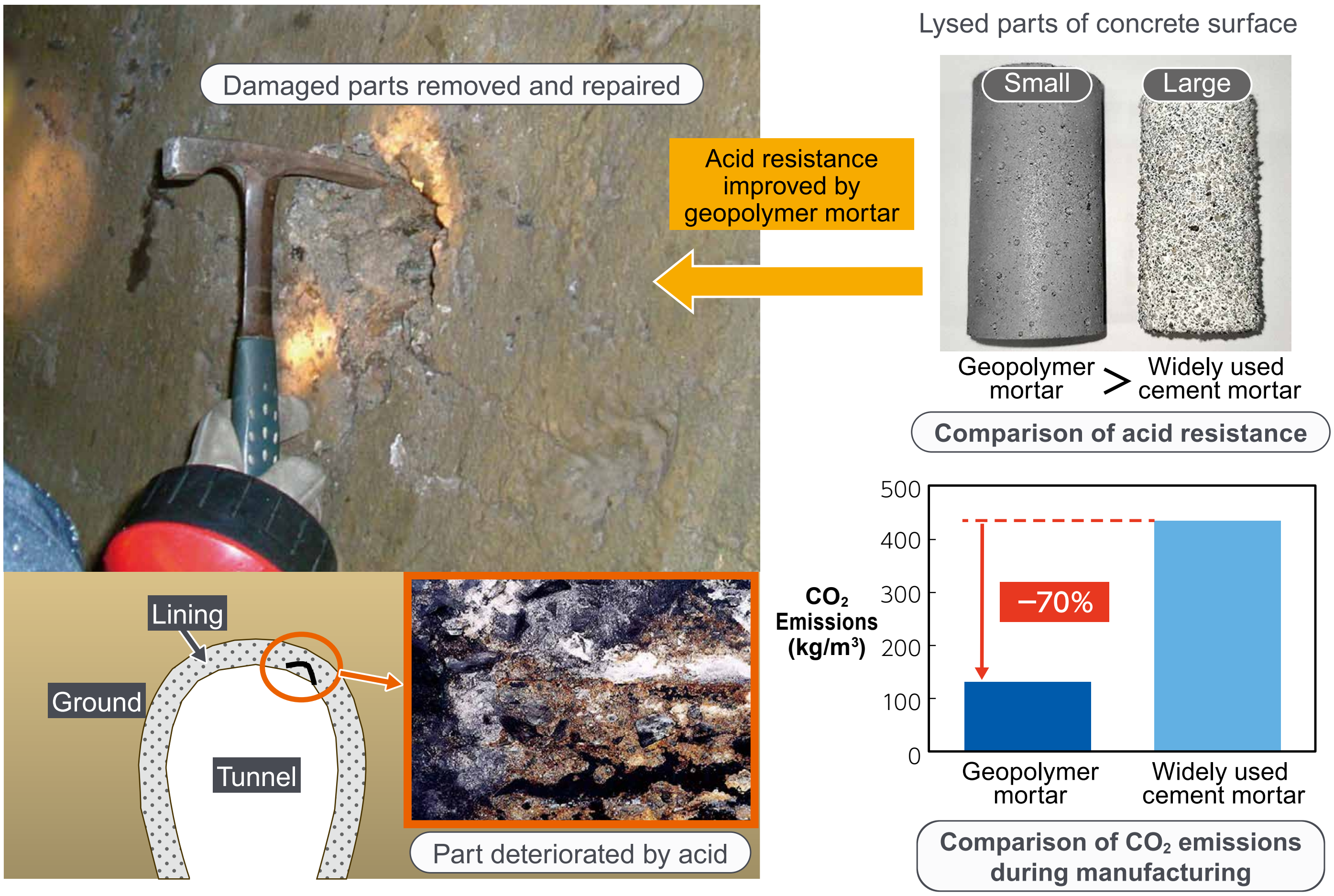
Prefabricated noise barrier walls for railway viaducts

sel vehicles can adhere to the wall, thereby causing the concrete tunnel walls to be lysed by the acid adhering to the tunnel walls. The lysed and damaged parts of the concrete surface need to be removed and repaired using mortar. Although cement mortar is frequently used for maintenance and repair, a highly acid-resistant mortar is required to repair acidified locations.

To meet this demand, based on the acid resistance of geopolymers[*2], we developed a mortar for repairing plastering damage. Compared to the cement mortar widely used for maintenance and repair, geopolymer mortar is rarely lysed and maintains a high acid resistance (*Improved acid resistance of (newly developed) geopolymer mortar and comparison of CO_2 emissions during manufacturing*). Compared to the widely used cement mortar for repair, the geopolymer mortar can reduce CO_2 emissions during production by ~70 %, which helps meet the increasing social demands for decarbonization (*Improved acid resistance of (newly developed) geopolymer mortar and comparison of CO_2 emissions during manufacturing*). Further, we confirmed that the same amount of workability as that of the widely used cement mortar can be maintained by adjusting the types and blending ratios of raw materials in the geopolymers.

Conclusions

We presented examples of the latest research and development approaches in the Materials Technology Division. For further information on other research achievements, please refer to the RTRI website (https://www.rtri.or.jp/rd/division/rd49/).



Improved acid resistance of（newly developed）geopolymer mortar and comparison of CO_2 emissions during manufacturing

*[1] **Fluidity**

The temperature at which the lubricant is less likely to flow.

*[2] **Geopolymer**

Inorganic polymer prepared with an amorphous pulverized body containing silica, alumina, and alkaline solution.

*[3] **Homogenization analysis**

A method to analyze a heterogeneous microstructure as an equivalent homogenous model.

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ISO/TC 269 12th Plenary Meeting Takes Place in Japan

The Railway Technical Research Institute (RTRI) established the Railway International Standards Center (RISC) and engages in international standardization activities while cooperating with other organization members to promote international standardization in the railway sector.

The 12th Plenary Meeting of ISO (International Organization for Standardization)/TC 269 (Railway applications) was held, and RISC was honored to host the plenary meeting of the technical committee and sessions of the subcommittees.

This was the second time the meeting was held in Japan, the first time being in November 2013. Due to the COVID-19 pandemic, we were obliged to have only online meetings during the last three years, but this time many joined the meeting held mainly face-to-face.

Participants

12th Plenary Meeting

Date: June 9, 2023
Note: Subcommittee sessions were held from June 6 to 8, 2023.
Venue: Bellesalle Jinbocho, Chiyoda-ku, Tokyo
No. of delegates: 134 (82 in person, 52 online)
Overseas: 108 delegates from 17 countries
(59 in person, 49 online)
Japan: 26 delegates (23 in person, 3 online) from railway operators, manufacturers, RTRI, and, as observers, officials from the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) as well as the Ministry of Economy, Trade and Industry (METI)

Outline of the Meeting

The plenary meeting was held to share among the members the outcomes of deliberations conducted over the past year and the progress status of ongoing projects relating to ISO/TC 269. It also served as a kick-off meeting where new standardization projects were discussed and the new deliberation committee was organized.

The meeting was launched with the opening speech of Chairperson, Hiroshi Tanaka (RTRI), followed by the deliberations below:

- The progress status of deliberations for standardization was reported and discussed for the nine projects started under the direct responsibility of ISO/TC 269, and the progress status of deliberations for standardization on the wheel-rail contact geometry was approved.
- Based on the reports released by the subcommittees under ISO/TC 269, the participants discussed new work item proposals and the progress status of deliberation projects relating to 34 projects. The 34 projects included the following six projects led by Japan, specifically:

"Railway applications — Heating, ventilation and air conditioning systems for rolling stock — Part 4: Basic design parameters, test and inspection items for the HVAC unit"
"Railway Applications — Running time calculation for timetabling — Part 2: Distance-speed diagrams and speed curves"
"Railway Applications— Concepts and basic requirements for the planning of railway operation in the event of natural disasters"

- 12 infrastructure-related projects, including "switches and crossings" and "switch machines."
- 15 rolling stock-related projects, including "luggage racks" and "electrical lighting for rolling stock."
- 7 operation- and service-related projects, including "rolling stock relevant operation and maintenance documentation" and "transportation of unusual cargoes."

Many participants attended the meeting from Japan and successfully demonstrated to other participating countries the leading role Japan plays for international standardization through discussions on the progress status of deliberations for standardization and new work items. Consequently, Japan's presence in ISO/TC 269 has been significantly enhanced.

At the meeting, Sweden (Stockholm) was chosen to host the next plenary meeting scheduled in June 2024.

Activities of RISC on International Standardization in the Railway Field

Dr. Toshiki Kitagawa
General Director,
Railway International Standards Center

Introduction

The Railway International Standards Center (RISC) of the Railway Technical Research Institute (RTRI) was established and commenced its activities on April 1, 2010. RISC is a membership organization which is mainly composed of the railway operators, railway-related industries and JIS drafting committees in Japan. The purpose of the work in RISC is to develop a safer, more eco-friendly and more technologically advanced railway systems for both Japan and the world in the future. In the activities of RISC, the management and deliberation related to international standards of the railway technologies are included. In addition, RISC also gathers and provides information, which is closely related to international standardization, to the members of RISC, and promotes the development of human resources engaged in the standardization. In this article, the summary of the activities of RISC related to standardization are shown.

Advisory Group	Ad-Hoc Groups	Working Group	Project Teams		Maintenance Teams	
CAG	**AHG 19** Studying and reporting on ACEE Guides	**WG 40** Urban Guided Transport Management and Command/Control Systems	**PT 62848-3** D.C. surge arresters and voltage limiting devices – Part 3: Application Guide	**PT 63453** Validation of simulation of the dynamic interaction between pantograph and overhead contact line	**MT 60349** Rotating electrical machines for rail and road vehicles	**MT 62128** Revision of IEC 62128 series
SLG IEC-UIC	**AHG 20** Study ACSEC Guide 120 in view of implications on the work of TC 9	**WG 43** Train communication network	**PT 62973-2** Batteries for auxiliary power supply systems – Part 2: NiCd batteries	**PT 63477** Coordination requirements and energy-saving performance evaluation for EFS in DC Traction Power Systems	**MT 61373** Shock and vibration tests	**MT 62973-1** Batteries for auxiliary power systems – Part 1: General requirements
- SG Trainet	**AHG 28** Safe transmission protocol	**WG 46** Onboard multimedia systems for railways	**PT 62973-3** Batteries for auxiliary power supply systems – Part 3: Lead acid batteries	**PT 63488** Technical criteria for the coordinations in neutral-section passing system for train	**MT 60310** Traction transformers and inductors on board rolling stock	**MT 62888** Energy measurement on board trains
- SG Multimedia	**AHG 30** IEC/TC 9 Standards map	**WG 48** On board driving information system	**PT 62973-4** Batteries for auxiliary power supply systems - Part 4: Secondary sealed nickel - metal hydride batteries	**PT 63495** Interoperability and safety of dynamic wireless power transfer (WPT) for railways	**MT 62278** RAMS	**MT 62427** Compatibilitybetween rolling stock and train detection systems
- SG Fixed Installations	**AHG 31** Sustainable electrified transportation	**WG 50** Electronic power converter	**PT 62973-5** Batteries for auxiliary power supply systems - Part 5: Lithium-ion batteries	**PT 63498** System Energy Efficiency	**MT 60913** Electric traction overhead contact lines	**MT 62486** Technical criteria for the interaction between pantograph and overhead line
- SG Prognostics Health Management	**AHG 32** Lightning protection for traction power supply system of rail transit	**JWG 51** Fuel cell systems for railway applications	**PT 63341-2** Fuel cell systems for propulsion - Part 2: Hydrogen storage system	**PT 591** Specification and verification of energy consumption	**MT 62425** Safety related electronic systems for signaling	
	AHG 33 SCADA for railways		**PT 63438** Protection principles for AC and DC electric traction power supply systems	**PT 641** Requirements for the validation of simulation tools used for the design of traction power supply		
	AHG 34 Gaseous hydrogen filling stations		**PT 63452** Cybersecurity	**PT 63536** Signalling and control systems for non UGTMS Urban Rail systems		

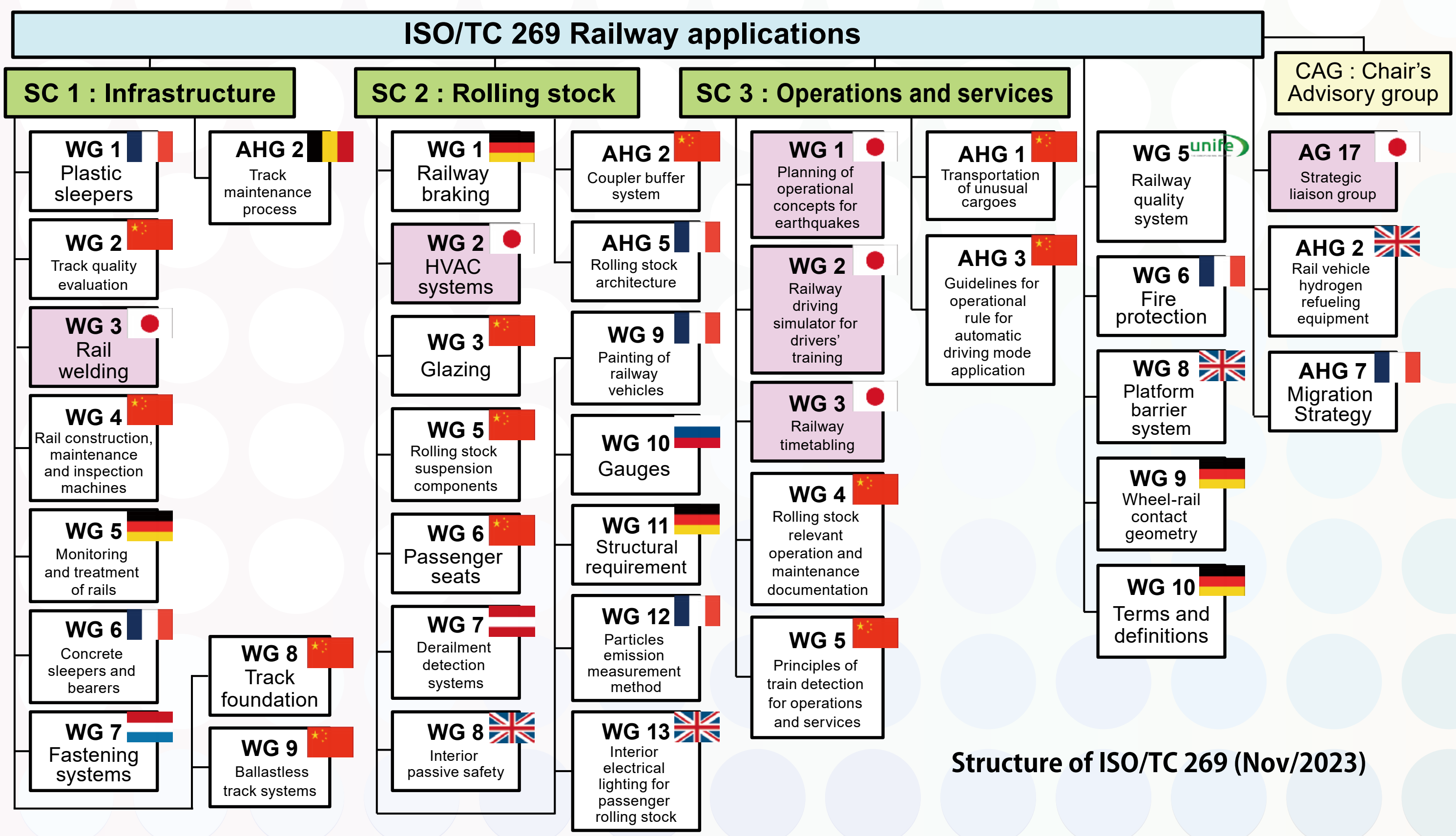
Structure of IEC/TC 9 (Nov/2023)

International Standardization Activities

Since 2010, RISC has taken on the role of the national secretariat of IEC's Technical Committee 9, which is dedicated to electrical equipment and systems for railways (IEC/TC 9). As for ISO, a new technical committee (ISO/TC 269: Railway applications) was established in April 2012, and in 2016, it was followed by three Sub Committees (SCs). In order to manage this movement appropriately, RISC has also acted as the national secretariat for ISO/TC 269 and its SCs, as well as ISO/TC 17/SC 15. RISC has been able to quickly understand the global trends relating to both IEC and ISO standards in the railway field and to keep up with the growing need for the standards worldwide.

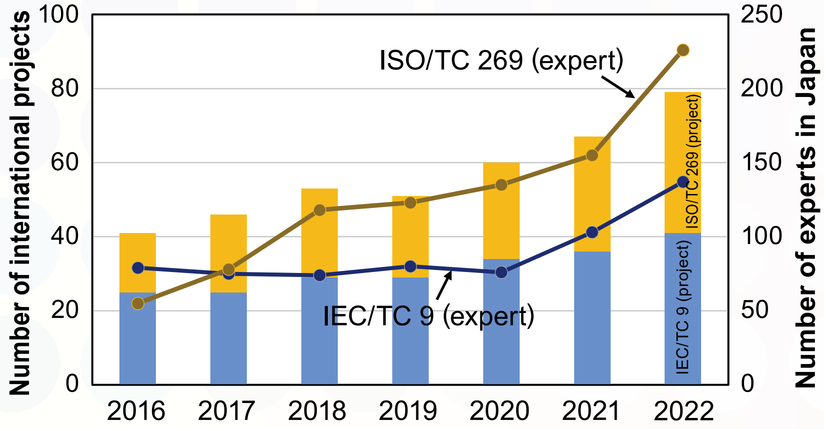
Structure of IEC/TC 9 (Nov/2023) and *Structure of ISO/TC 269 (Nov/2023)* show the organizations in ISO/TC 269 and IEC/TC 9. It is found that more than eighty projects are ongoing in the two technical committees and that the scopes covered in the field are also wider. *Changes in number of the international projects and the changes in number of the experts who have participated in these projects in Japan* shows the changes in the number of the international projects that RISC has worked on since 2016. In *Changes in number of the international projects and the changes in number of the experts who have participated in these projects in Japan*, the changes in the number of the experts who have participated in these projects in Japan are also shown. It can be observed that the number of the international standards has almost doubled in six years and the number of the international experts is also increasing accordingly.

In recent years, some important international standards, such as fire protection of railway vehicles and crashworthiness requirements for rail vehicles, have been discussed. The scope of the standards of fire protection is to prevent and reduce the hazards associated with fires in the vehicles, and the standards for the protection have been developed on the migration strategy of EN standards. In EN standards, in order to ensure the safety of passengers and staff to the maximum extent possible, the design requirements for the vehicles are specified which take into account the time period for the passengers and staff to move to a safe place. However, in Japan, there are regulations which state that the performance of fire resistance materials shall be verified through combustion tests, which are determined depending on the parts of the vehicle. This suggests that there is a difference in approach



Structure of ISO/TC 269 (Nov/2023)

on fire protection between Europe and Japan. For the crashworthiness requirements for the vehicles, the standards have been also developed based on EN standards. In EN standards, the safety requirements are prescribed in the case of train collision accidents. However, in Japan, there are no national standards for train collision because the accidents can be prevented by the railway signaling system appropriately. This also indicates a difference in approach on crash safety between Europe and Japan. These points suggest that, in order that Japanese and European experts might reach a consensus on the technical issues through deliberations of the standards, it is important for both experts to explain railway technologies carefully and reasonably, ranging from basic to advanced research.



Changes in number of the international projects and the changes in number of the experts who have participated in these projects in Japan

It is necessary that all the experts play a leading role by improving both presence and influence in the deliberations on international standardization in the railway field, such as by providing appropriate opinions, and by strategically ensuring that more advanced railway systems developed worldwide are reasonably included in the standards. This requires the development of not only human resources who actively participate in the deliberations related to international standards in the railway field, but also human resources who can play a leading role in deliberations in the future. Therefore, RISC has set out the program to develop human resources working on international standardization and has been putting it into practice for the staffs in RISC.

In addition, to enhance the presence of Japan in the international standardization activities, the 12th Plenary Meeting of ISO/TC269 and 8th Plenary Meetings of its SCs were held from June 6 to 9, 2023, in Tokyo, and RISC hosted the plenary meeting of the technical committee and its subcommittees (see *The 12th Plenary Meeting of ISO/TC269 from June 6 to 9, 2023, in Tokyo*). Whereas in recent years, they had been held in a web format due to the Corona disaster, these meetings were held in a hybrid format that also allows face-to-face participation for the first time in four years. At these plenary meetings, both the progress of the standards and the proposals on new standards were discussed energetically. Through the meetings, RISC showed that Japan plays an important role in international standardization in the countries which attended them.

Conclusion

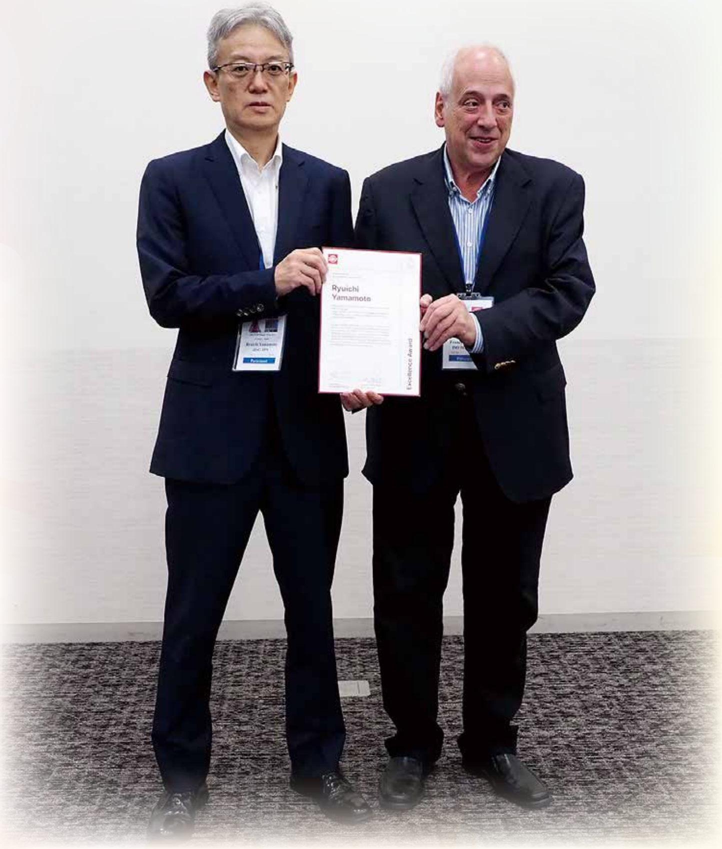
Through these activities, RISC has been strategically working on the international standardization of railway systems, which has been developed worldwide. And RISC will continue to contribute to the sustainable future development of the railway worldwide.

The 12th Plenary Meeting of ISO/TC269 from June 6 to 9, 2023, in Tokyo

Dr. Ryuichi Yamamoto Awarded ISO Excellence Award

We are delighted to announce that Dr. Ryuichi Yamamoto of the Railway Technical Research Institute has been awarded the ISO Excellence Award by ISO (the International Organization for Standardization) for his contributions to the development of the world's first international standard for rail welding.

Award winner :
Dr. Ryuichi Yamamoto,
Senior Chief Manager, Railway International Standards Center



Left, Dr. Ryuichi Yamamoto (Award Winner)
Right, Mr. Francisco Parente (Chairperson)
(ISO/TC 269/SC 1)

What is the ISO Excellence Award?

The ISO Excellence Award was created to reward the achievements of technical experts for their outstanding contributions to the development of the international standards published by ISO.

Summary of Dr. Yamamoto's Major Contributions (as released by ISO)

Dr. Yamamoto is the international convenor of ISO/TC 269-Railway applications, ISO/TC 269/SC 1-Infrastructure, and ISO/TC 269/WG 3-Rail welding, and the project leader for the development of the world's first international standard for rail welding, "ISO 23300-1:2021 Rail welding". Using his technical experiences and expertise in the field of rail welding, which he has gained during his 30-year career, Dr. Yamamoto has been contributing to the development of the international standards that provide general requirements and test methods for rail welding.

Railway Technical Research Institute