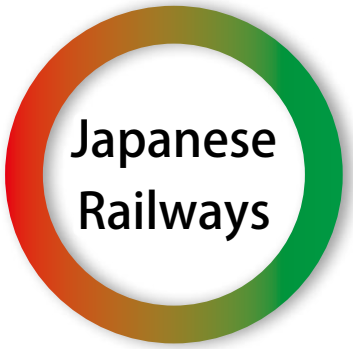
Social and Technological Background

In light of global environmental issues, increasing societal burdens due to the aging population, and the increasing complexity of social issues that need to be resolved such as regional economic inequality, the United Nations adopted a series of targets entitled the "Sustainable Development Goals" (SDGs). The Japanese government is advocating the construction of a "Society 5.0", which outlines a vision of society in the future that Japan should aspire to. In the field of technology, rapid advances in digital technologies such as the Internet of Things (IoT), big data analytics, and artificial intelligence (AI) are driving innovation toward a digital society on a global scale.

There are concerns that the number of railway users will decrease in the long term due to the declining overall population and working-age population which are the result of an aging society. There is also an urgent need to address the issues of increasingly frequent and severe natural disasters, aging railway infrastructure, and labor shortages in the railway sector. The response to these issues must go beyond the framework of conventional approaches. Railways are also playing an increasingly important role in the creation of new services to build a seamless intermodal transportation network.



Digital technologies are being increasingly used in the railways in order to provide solutions to various issues that railways are facing. It is essential to form partnerships on a global scale and to share experience and expertise to cope with increasingly complicated technical issues.

Basic Policies

Enhancing safety with an emphasis on improving resilience to natural disasters

We are proceeding with R&D for safer and more reliable railway transportation, with emphasis on R&D that contributes to increasing the resilience of railways to frequent and increasingly severe natural disasters such as heavy rain, strong winds, and large earthquakes.

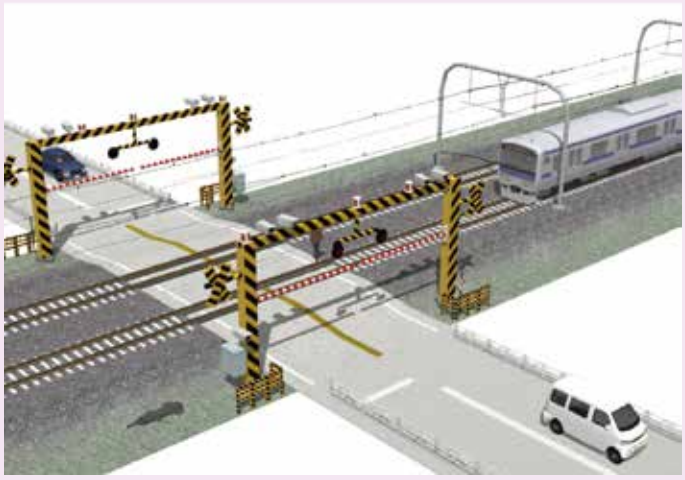
We, as a third-party organization, are also conducting surveys of the damage and causes of disasters and accidents as well as proposing methods for recovery and measures to prevent recurrence.

Developing innovative railway systems based on digital technologies

While advocating the adoption for railways of digital technologies such as IoT, big data analytics, AI, and 5G communication, we are placing emphasis on R&D for autonomous train operation and digital maintenance in order to respond to labor-shortages in the railway sector.

In addition, we are promoting R&D for increasing the speed on Shinkansen while protecting the trackside environment and to achieve further energy saving in railway operations.

We are promoting initiatives that contribute to innovating railway systems through the creation of new customer services such as mobility as a service (MaaS).

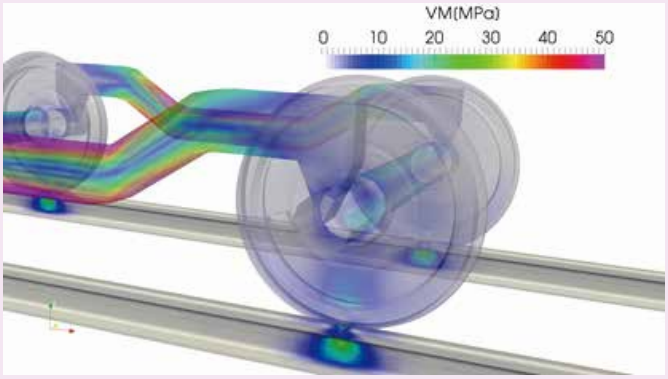


Basic Policies

Creating high-quality results by taking advantage of our collective strength

We are promoting the advancement of simulation technology and the development of original testing and research facilities.

We also aim to further increase trust in RTRI by continuing to acquire expertise relating to railway technologies and to develop human resources, using interdisciplinary and cross-cutting approaches for resolving various issues in the railways, and providing high-quality results at home and abroad.



Enhancing international presence of the Japanese railway technologies

Through partnerships with foreign railway operators and research institutions and strengthening information sharing, we aim to enhance the international presence of Japanese railway technologies.

In addition, as a base for international standardization activities to support overseas development of Japanese rail technologies, we take lead in performing strategic and planned activities.

Creating a motivating workplace where staff can demonstrate their abilities

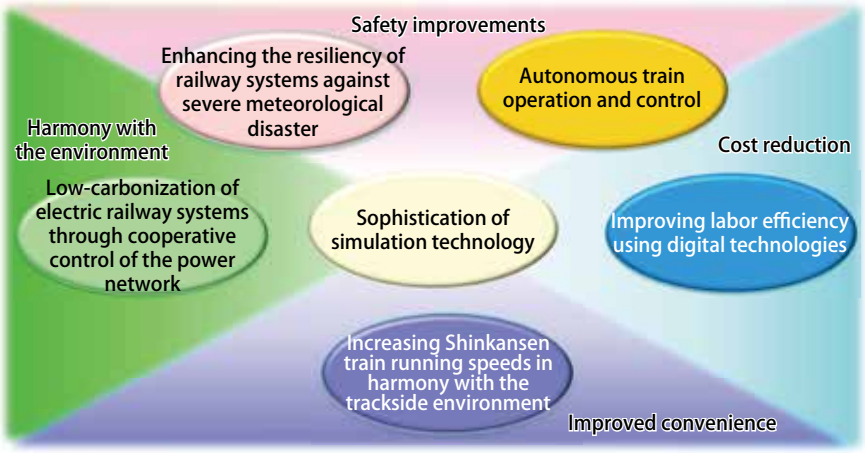
In addition to the initiatives to improve workplace health and safety and mental health and to attain a proper work-life-balance, we will work to foster an open workplace environment where free and energetic discussions can be held and to create a positive and fulfilling workplace atmosphere.

R&D Objectives and Pillars

RTRI has set four R&D Objectives, namely, "safety improvements" including resilience against severe natural disasters, "cost reduction" including labor-saving measures for maintenance, "harmony with the environment", including carbon reduction in power supply networks, and "improved convenience' including higher running speeds.

RTRI has also defined a series of "Pillars of R&D" which are fundamental to ensure efficient use of resources and to drive R&D, and are referred to as "R&D for the future of railways", "development of practical technologies", and "basic research for railway."

Research and Development for the Future of Railways

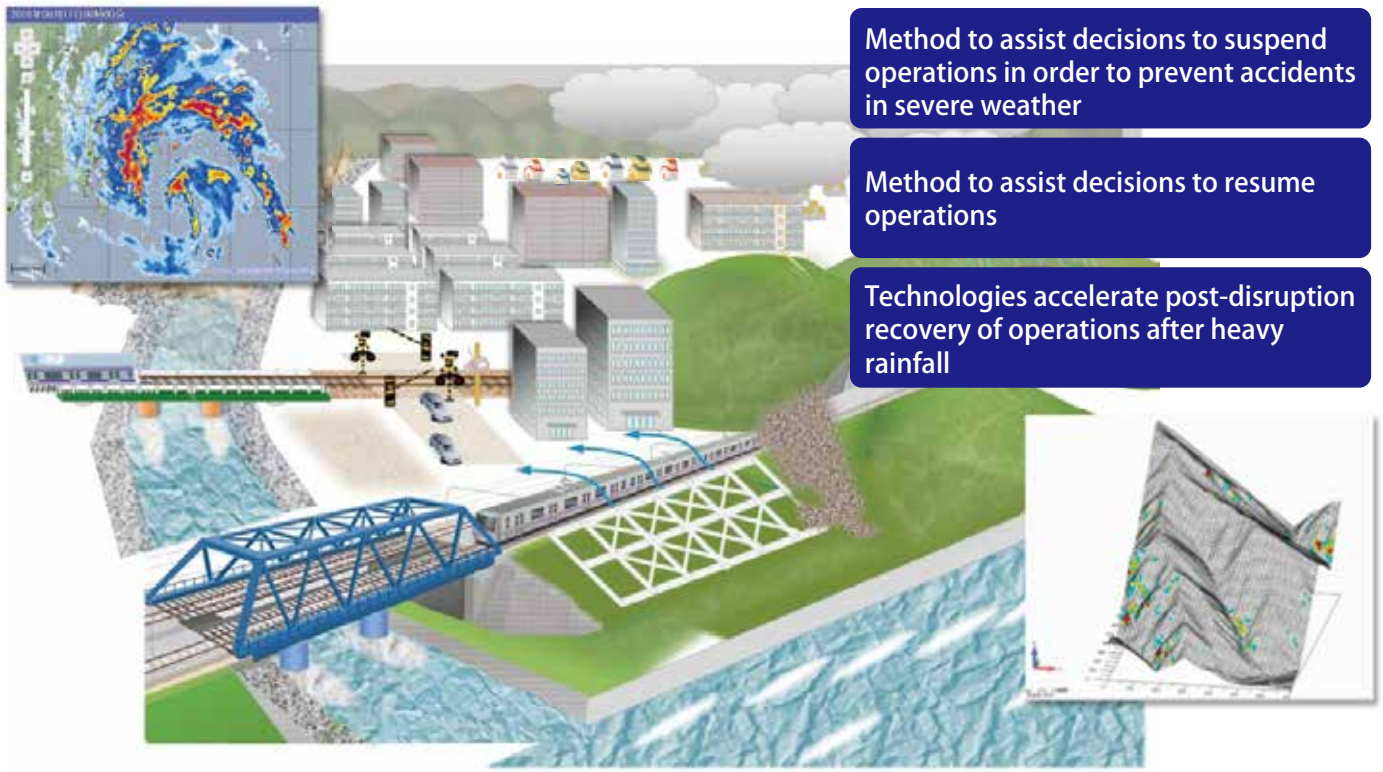


Working with a lead time before practical application of 10 to 15 years, RTRI is already focusing on issues that address the changing needs of railway operators and emerging social trends, making use of the fields in which RTRI has high R&D capability and specialist facilities, as well as demonstrating the collective strength of RTRI.

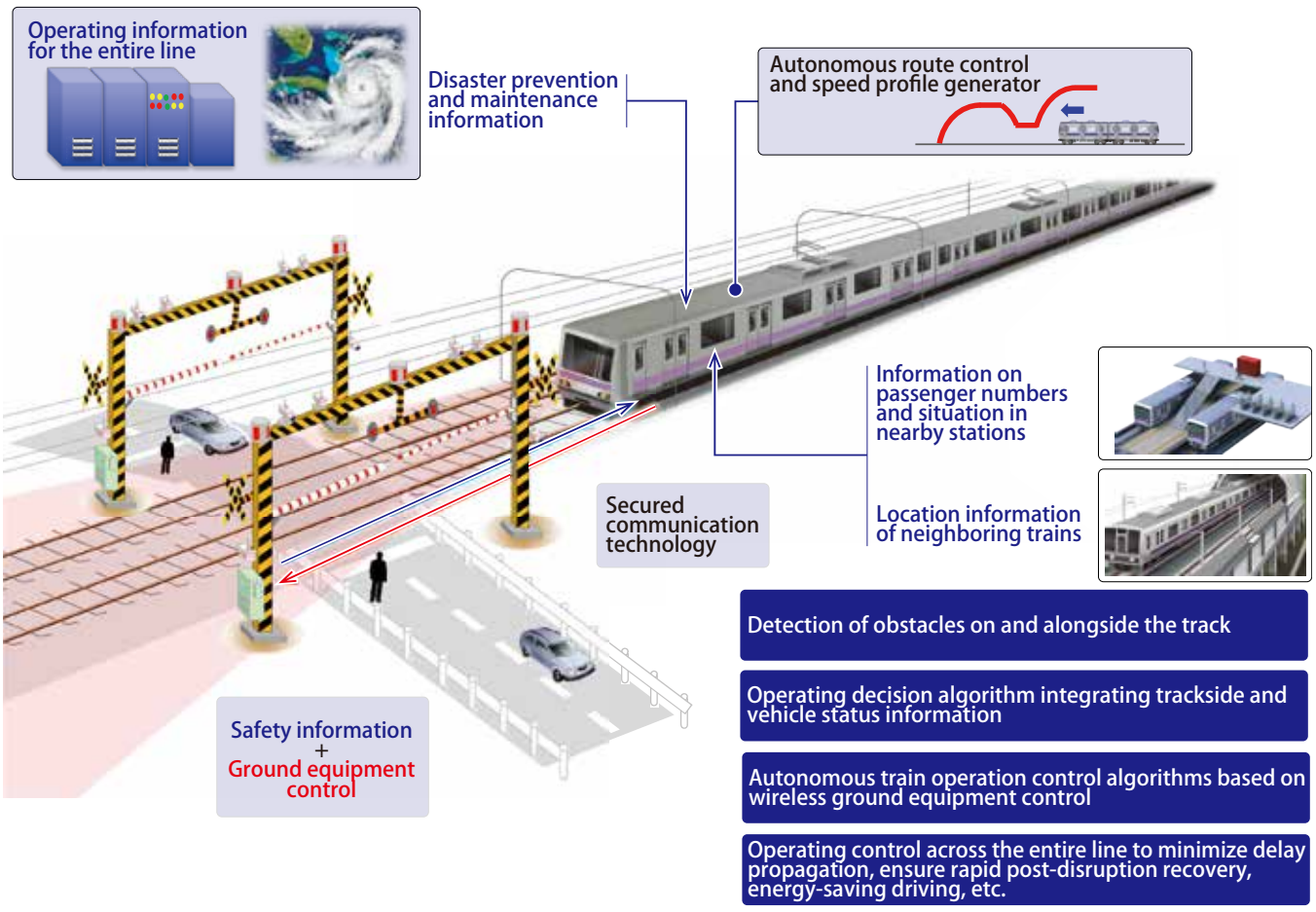
Six major research projects have been specifically defined as are depicted in the figure.

Enhancing the Resilience of Railway Systems against Severe Meteorological Disasters

RTRI aim to design measures to reduce the downtime in railway systems in the case of heavy rain and strong wind, by optimizing decisions to suspend and resume operations, based on results of meteorological disaster risk assessments using high-density and real time meteorological data. We will also establish methods to ensure rapid and targeted repairs considering the residual strength of slopes and embankments which suffer damage from heavy rain.

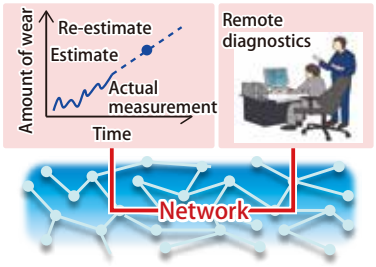


Autonomous Train Operation and Control



Autonomous train operation depends on a number of control systems including speed control, monitoring of track status and the surrounding area and ground equipment control, such as level crossings. RTRI is therefore developing methods to assist operational decisions, based on trackside information and data obtained from ground equipment controls, and from rolling stock using wireless vehicle-mounted positioning sensors, as well as satellite positioning devices and sensors to detect obstacles on the tracks or in the surrounding area. In addition, operation control methods are also being developed to prevent delays, ensure rapid post-disruption recovery, and save energy in urban areas.

Improving Labor Efficiency by Digital Maintenance

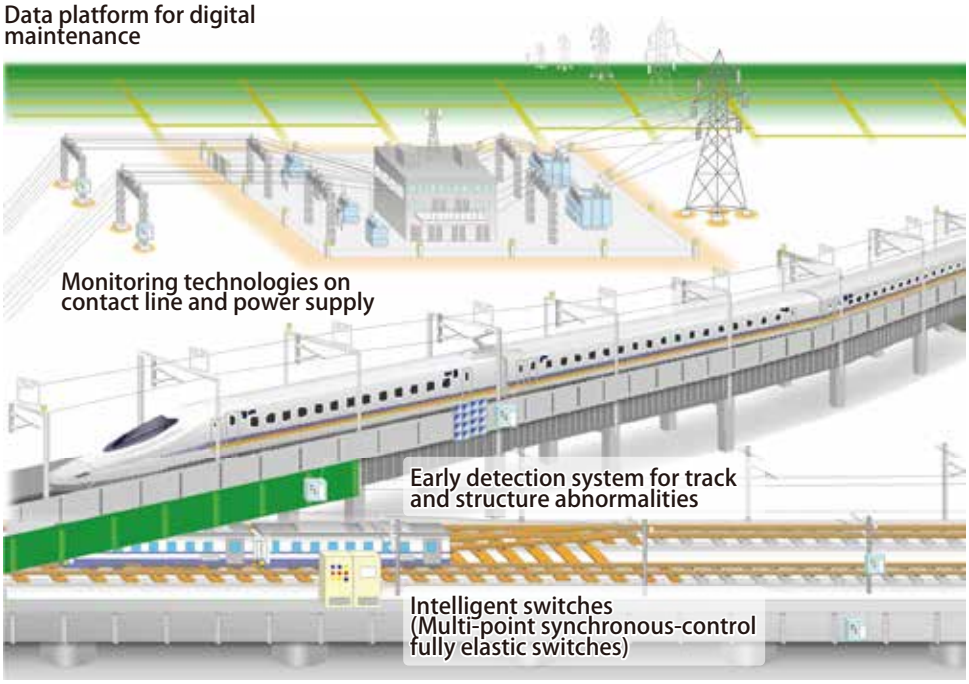


Tracks and structures: Early detection of abnormality using on-board measurement data

Contact line and power supply: prompt detection of abnormality via on-board and stationary monitoring

Switches: CBM using intelligent switches

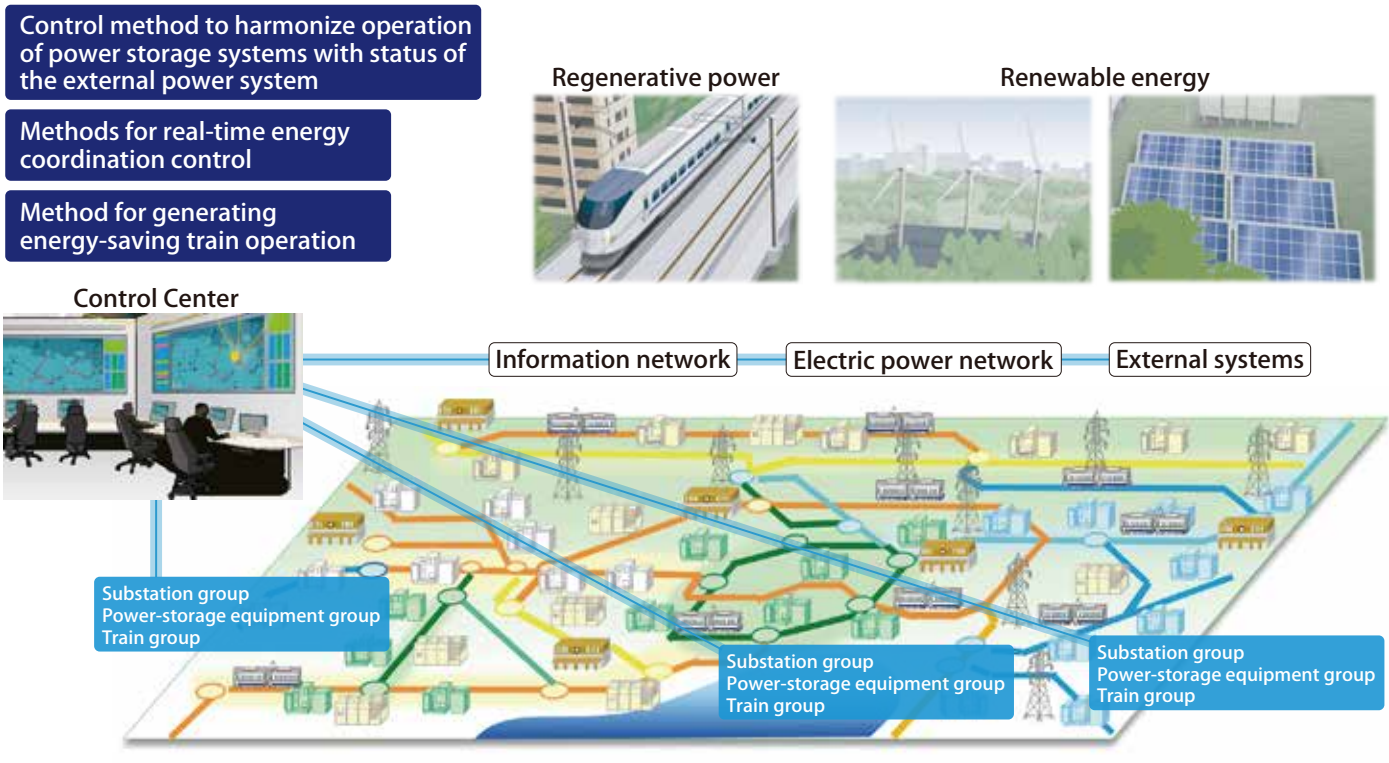
Data platform: common data platform shared among various fields; creation of big data analytics technology



A platform is being built to integrate the analysis of data collected from various sources which can be input to a digital maintenance system that detects abnormalities and predicts changes in the condition of tracks and structures based on the data obtained from sensors. The system will be able to determine when and what appropriate repair or maintenance work is required. The integrated data analysis platform will also be used to develop automatic diagnostic technologies for track and structures, using on-board sensing devices including on-board sensors for the overhead contact line system. In addition, technologies will be developed for the timely detection of abnormalities, such as high-resistance ground faults, by monitoring power supply networks.

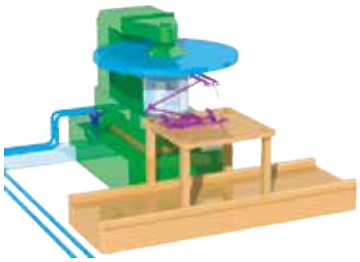
Low-Carbon Railway Systems through Cooperative Control of the Power Supply Network

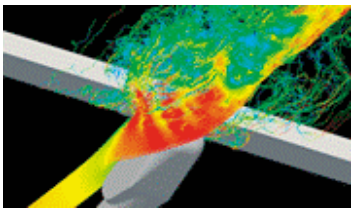
To achieve low-carbonization of railway systems through active use of renewable energy connected to the external power system, we are developing new control methods to harmonize operation of energy storage systems with status of the external power system. Furthermore, in order to achieve further energy-saving of railway systems through more effective use of regenerative power, we are developing real-time cooperative control methods for energy-saving devices, such as energy storage systems and controlled rectifiers, as well as developing a method for energy-saving driving operation depending on train operating status.

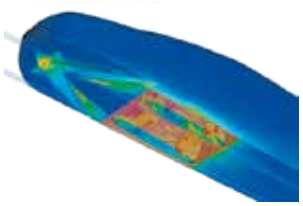


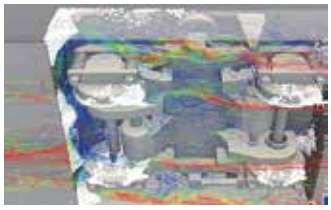
Increasing Shinkansen's Speeds in Harmony with the Trackside Environment

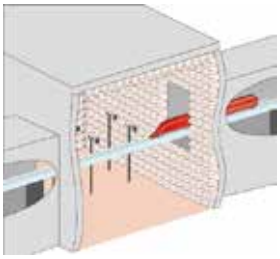
We are developing technologies for reducing aerodynamic bogie noise and tunnel micro-pressure waves by using a newly installed low-noise moving model facility. We are also developing a pantograph with high current collection performance and low-noise characteristics for high-speed trains by using RTRI's new high-speed pantograph test facility. Furthermore, we are developing a technology for reducing snow accretion on bogies by controlling the airflow around bogies during high-speed train operation.







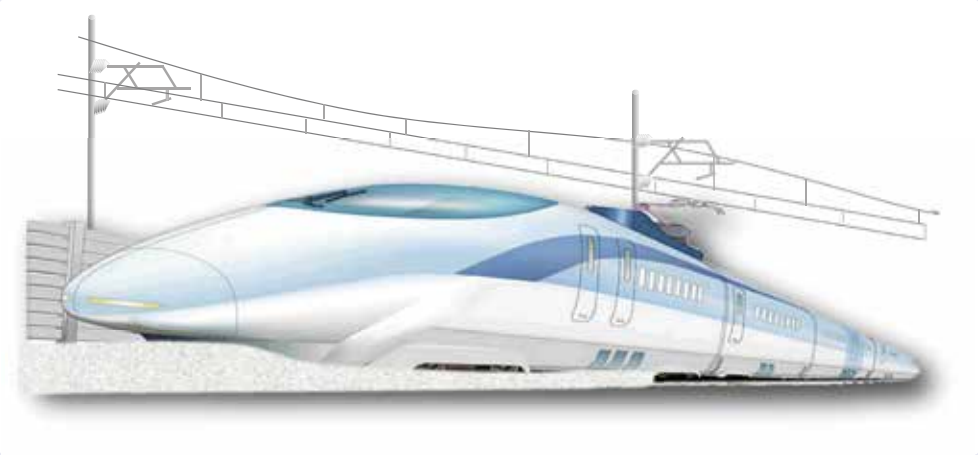




- Countermeasures against aerodynamic bogie noise and pressure fluctuations
- Development of pantographs with high current-collection performance and low-noise characteristics
- Structure for reducing snow accretion on bogies
- Proposal of low-cost countermeasures against micro-pressure waves for higher speed trains

Sophistication of Simulation Technologies

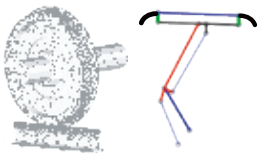
We are creating an analysis model that is applicable to commercial railway lines and that comprises a virtual railway test line which simulates vehicle motion, overhead lines, pantographs, and rolling contact between wheels and rails. We are also developing a simulator that evaluates the state of wear of current-collecting materials when contact loss arcing occurs on pantograph and that evaluates the safety of vehicles operating at high speed while also self-snowplowing. Furthermore, we are developing a microstructural simulation of materials that can contribute to the development of wear-resistant materials and a numerical wind tunnel that simulates large-scale, low-noise wind tunnel experiments using numerical calculations.



Expansion of application of virtual railway test lines

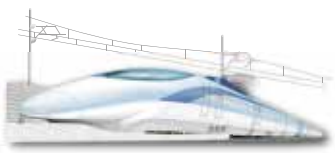
Confirmation of consistency between simulations and real phenomena

Provision of analytical models applicable to commercial lines



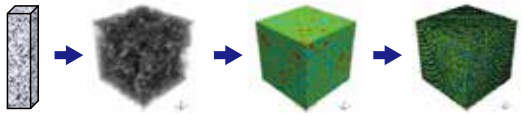
Contact-loss arc simulator and snowplowing simulator

Analytics tools to elucidate phenomena (Development of contact-loss arc simulator and snowplowing simulator)



Simulation of the microstructures of materials

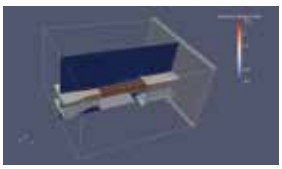
Application to the development of wear-resistant materials



Numerical wind tunnel

Streamlining wind-tunnel operations

Reproduction of phenomena that surpass the wind-tunnel performance



Development of Practical Technologies

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

1. Technical developments requested by Japan Railway (JR) companies

Upon receiving a specific request, we will rapidly provide technological development results that contribute to the resolution of issues at various sites while taking into consideration specific local features such as cold regions. Particularly, we will focus on the allocation of resources to issues that are considered to produce a strong ripple-effect when commercialized and are greatly needed among railway operators and promote their commercialization.

2. Development of practical technologies implemented independently by RTRI

By fully understanding the needs of railway operators and using the facilities, analytic technology, and know-how, which are the strengths of RTRI, we will address topics that can be rapidly adapted to solving on-site issues.

3. Research and development commissioned by the government

As part of the practical application and dissemination of the results of R&D, we are conducting R&D that has been commissioned by the government.

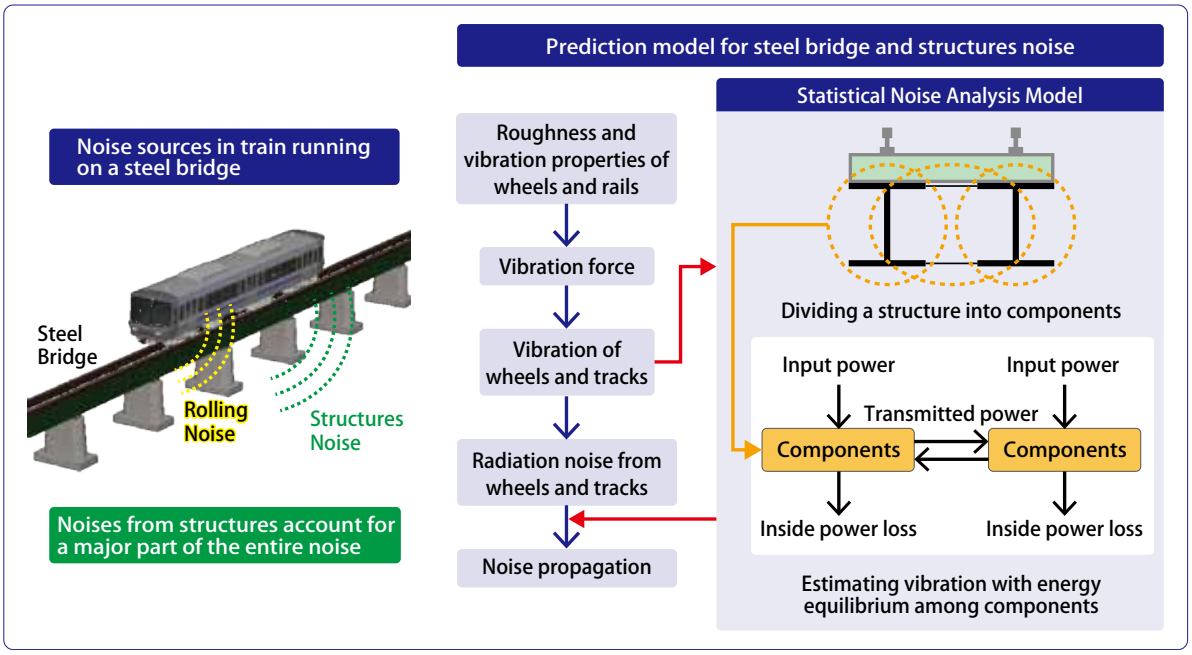
The table exemplifies the research topics related to practical technologies development.

Fuel-cell hybrid trains

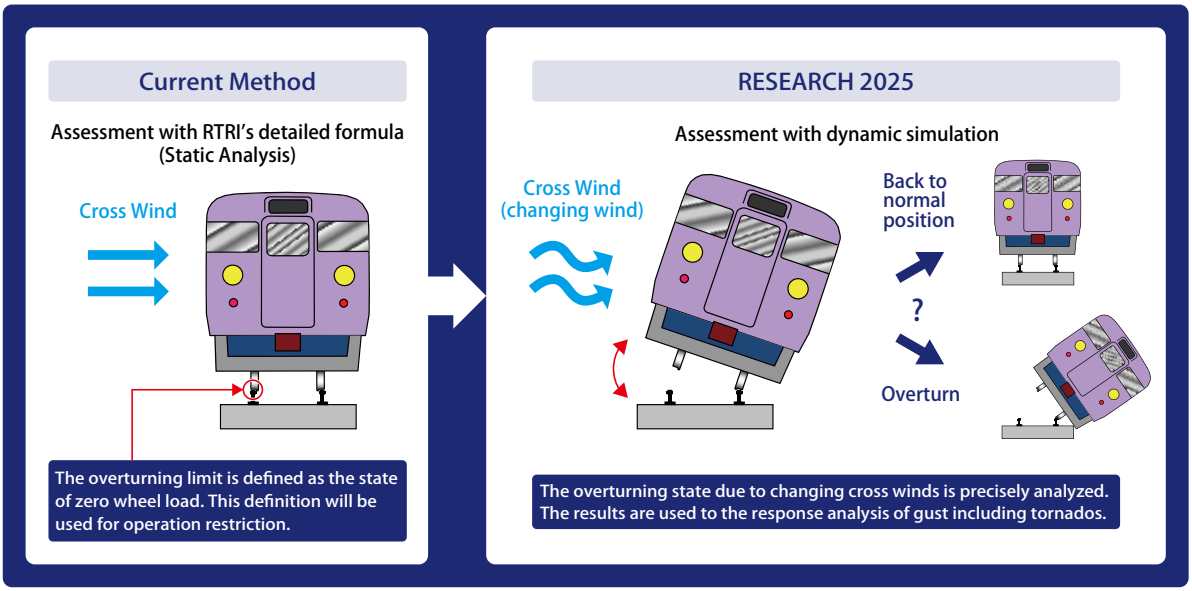
R&D objectives	Research topics
Safety improvements	• Earthquake early warning system for nearfield earthquakes • Enhanced seat safety in the event of a collision • Methods of maintenance and repair that extend the lifespan of ground equipment
Cost reductions	• Track monitoring technologies comprising the use of sensors • Methods for confirming safety using vehicle-side cameras
Harmony with the environment	• Application of superconductor technologies such as superconducting power cables to conventional railways • Practical application of fuel-cell hybrid trains
Improved convenience	• Brake equipment that contributes to reducing braking distance • Combined vertical vibration control systems

Basic Research for Railways

We are addressing basic research to provide solutions to various issues that affect railways specifically and can serve as a source for innovative technologies. As part of the basic research, we are studying the methods for the analysis and prediction of railway-specific phenomena as is illustrated in the figures as well as the methods of analysis, experiment and assessment as is illustrated in the figures.

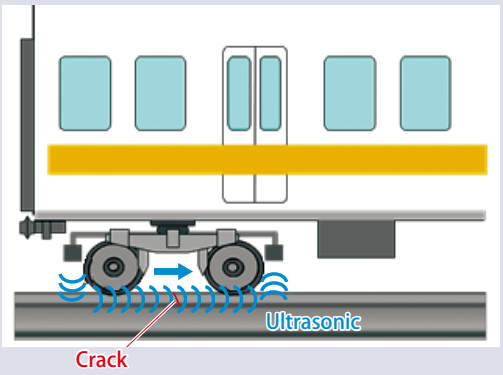


Study on the generation mechanism of squealing and bridge noises and development of the mitigation measures



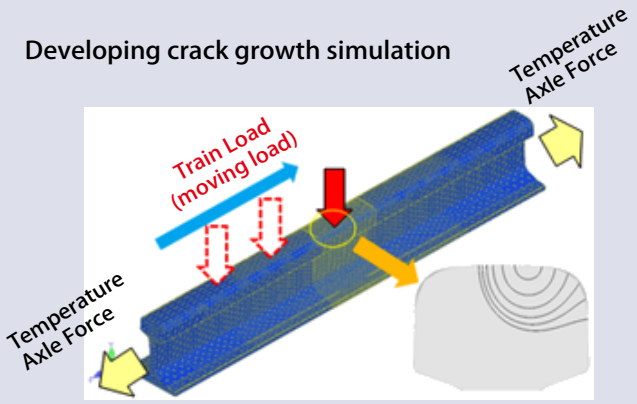
Assessing the behaviors of a vehicle at the overturning limit due to crosswinds

Basic Research for Railways



Contactless probing device to be mounted on commercial-service trains

Developing crack growth simulation



Simulation based on moving load and persisting stress

Analysis of the rail-head crack development mechanism and maintenance methods

Measurement of Physiological indices

- High-density brain waves
- Cardiac electrogram
- Breathing and body motions
- Line of sight
- Pupils
- Perspiration

Using the data to prevent errors

Learning normal health conditions indicated by the data

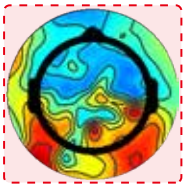
Detecting the deviation from the normal conditions

- Prompting the drivers' awareness
- Information to the control center
- Training for emergency handling

Detecting mental disturbance immediately after an accident with brain activities

Before recognizing an obstacle in front

Right after recognizing an obstacle



Brain activity image from above

Estimating driver's mental and physical conditions based on physiological indices

Preventing human errors

Analyzing physiological indices to assess mental and physical conditions of railway drivers

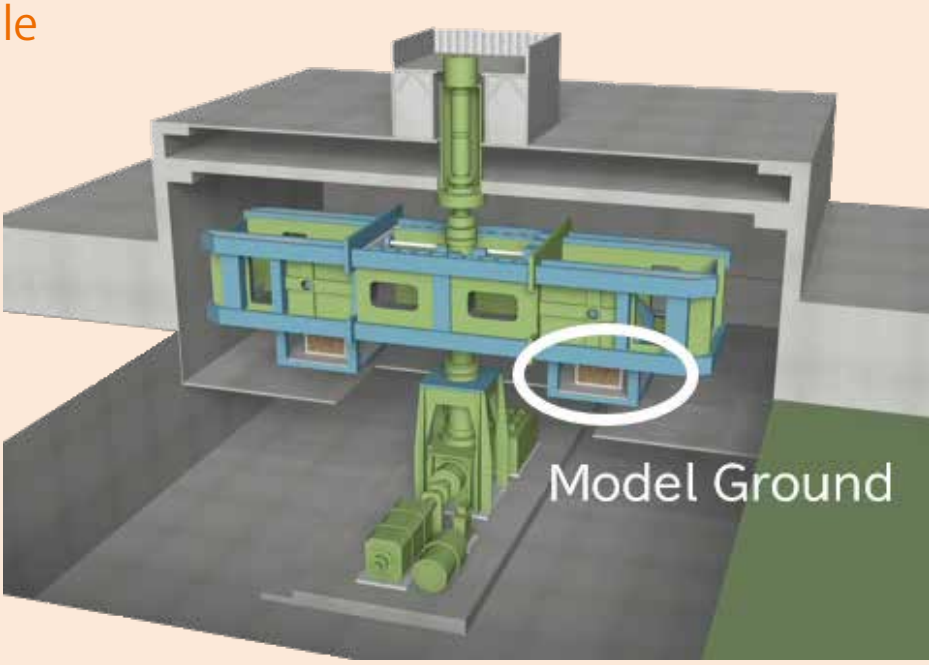
Testing Facilities

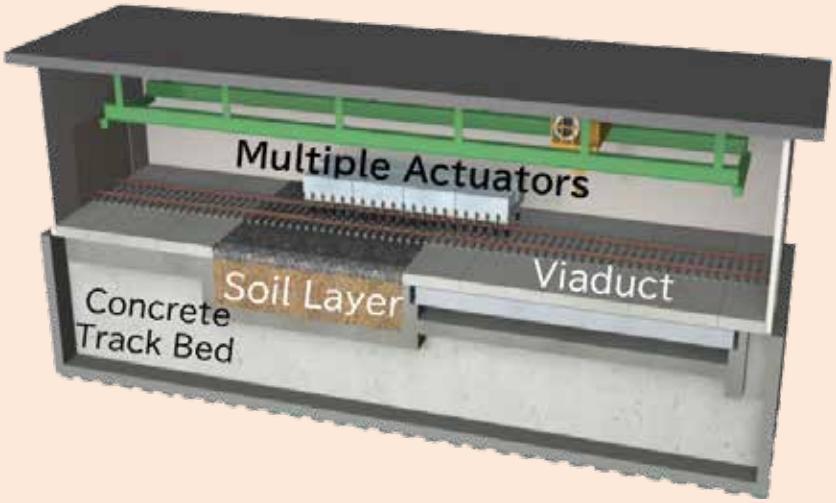
We will install two new large-scale testing facilities as proprietary testing facilities directly tied to R&D, and we will also install new and highly demanded testing facilities and renew existing aging facilities.

Establishing a new large-scale testing facility

Centrifuge test facility

Behaviors of ground and structures are assessed in order to solve various ground-related problems. On this machine, high centrifugal force acts on the model ground and the stressed-state ground is reproduced.





High-speed moving-load test facility

Multiple actuators installed at the sleeper's interval on the real track structure reproduce the load acting onto the track under high-speed train running. The responses and durability of tracks and structures are assessed.

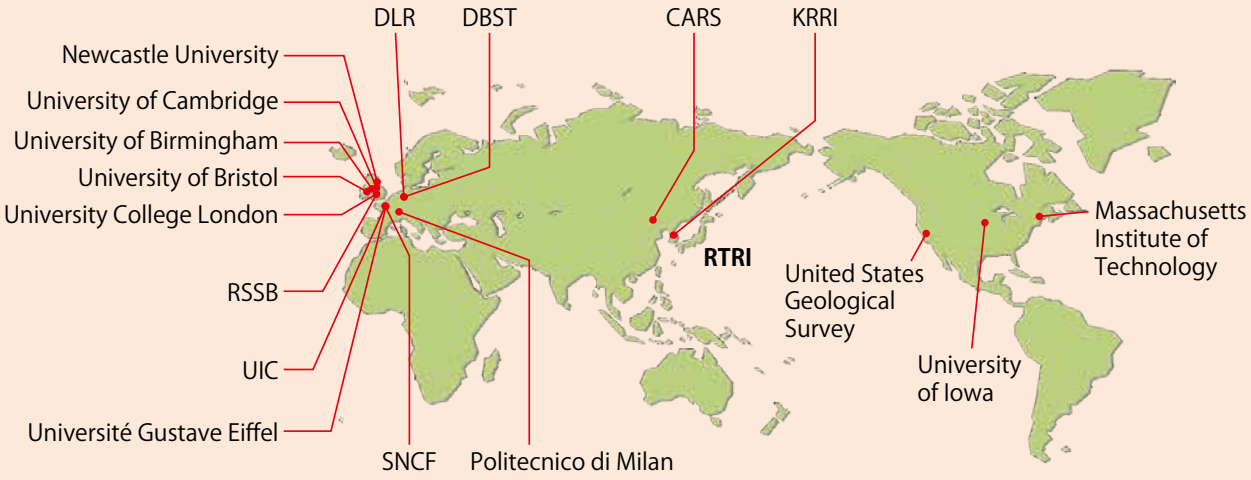
New installation and updating of test equipment

We are installing highly-demanded new test facilities essential to produce high-quality research outcomes.

In addition, we are updating the test equipment that has exceeded its service life and has deteriorated significantly, prioritizing the necessity and urgency.

International Collaboration

In order to further enhance the technological prowess and global presence of RTRI, we are expanding joint research with and staff secondment to overseas universities and research institutions as well as improving both the quality and quantity of information disseminated overseas. In addition, we will strengthen our capability to investigate the latest trends in research overseas and actively promote the intake of researchers from overseas with the aim of invigorating R&D. Furthermore, we will contribute to the uptake of Japanese rail technologies by providing active support for the overseas expansion of railway operators and railway-related companies, providing support for human resource development, and through the international expansion of technologies developed by RTRI.



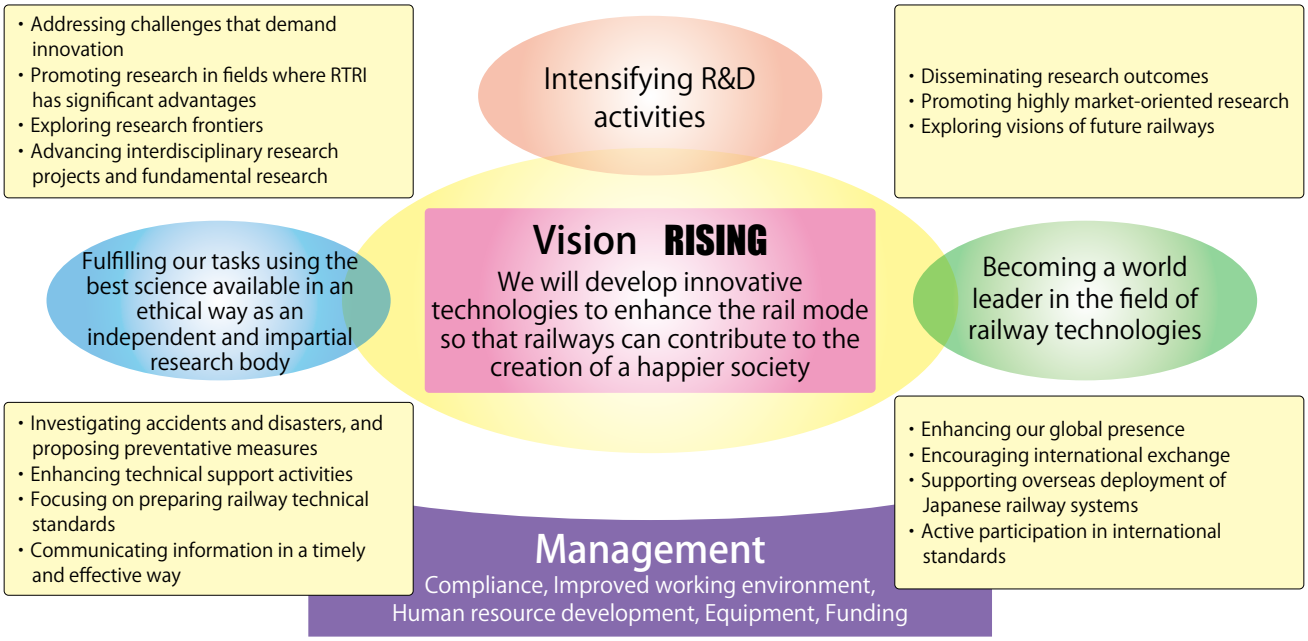
RTRI's research partners

International Standardization

We are developing strategic international standardization activities to maintain and further improve Japanese railway technology and expand it overseas. With regards to the development of ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) standards, in addition to continuing to promote proposals from Japan as a secretariat for the National Mirror Committee, we will actively incorporate Japanese design ideas and technologies in our response to standards proposed by other countries. In addition, we will also investigate trends in standardization activities being promoted by rail-related organizations that may be able to exert international influence and engage with them as necessary.

Furthermore, with regards to various issues relating to standardization in the Japanese railway industry, such as the stipulation and systematization of Japanese technologies and know-how and examination of the state of the domestic certification system, we will work with related parties to develop standards.

Innovation for the Future of Railways and Sustainable Society



Since the unprecedented meteorological disasters and the labor shortage are pressing issues that cannot be addressed through conventional frameworks, radical technological innovation is essential to overcome these challenges. RTRI will act as a leader in technological innovation for railways, overcome the challenges railways are facing in cooperation with railway operators and universities and pursue the research and development to create the future of railways in order to achieve a sustainable society.

We will undertake impartial activities as a third-party organization including investigations of damage and causes of disasters and accidents and proposing recovery and preventive measures.

We observe laws and regulations and our articles of incorporation, work to strengthen compliance and build trust in RTRI.

We will actively promote personnel exchanges with railway operators, develop personnel capable of understanding accurately the status and issues of actual train operation and ensure the transfer of technical skills and knowledge to the next generation.

Based on the vision "We will develop innovative technologies to enhance the rail mode so that railway can contribute to the creation of a happier society", we will make our best efforts to implement the "Master Plan - Research and Development for Creating the Future of Railways - RESEARCH 2025".