

Master Plan

- Research and Development
for Creating the Future of Railways -

RESEARCH 2025

(2020–2024)

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Railway Technical Research Institute

Master Plan

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Reference: RTRI's vision

1. Introduction

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. As such, initiatives and programs have been launched or are planned, aimed at building a sustainable society, which is capable of overcoming the various challenges that lie ahead by using cutting-edge technology, enabling everyone to enjoy the benefits of prosperity. In the field of technology, rapid advances in computing and high-speed, high-capacity communications are driving innovation toward a digital society on a global scale, through the adoption of digital technologies such as the Internet of Things (IoT), big data analytics, and artificial intelligence (AI).

In terms of Japan's railways, while transport volumes are steadily increasing due to factors such as the gradual recovery of the Japanese economy and a growth in inbound demand, there are concerns that the number of railway users will decrease in the long term because of the country's decreasing overall population and working-age population, which are the result of an aging society with a low birth rate and also the consequence of new working practices that have emerged through workstyle reforms. Moreover, there is an urgent need to address a growing number of issues: increasingly frequent and severe natural disasters such as heavy rain, strong winds, and earthquakes, an 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 technology is being increasingly used in the railways, to change systems and as a solution to various problems. As such, it is essential to form partnerships with relevant organizations and share information to solve increasingly complex technical problems.

RTRI has therefore developed a master plan for the fiscal year 2020 and beyond, as a roadmap guiding the Railway Technical Research Institute (RTRI) towards the realization of its vision: "We will develop innovative technologies to enhance the rail mode so that railway can contribute to the creation of a happier society." In addition to anticipating the development of railway technologies over the next 10 to 15 years, this master plan also aims to anticipate changes in the business environment and fundamental technological developments in the railway business in order to avoid squandering the opportunity of sharing the results of its research and development (R&D) with society. The master plan therefore covers a 5-year period up to 2024.

2. Basic Policies

In light of the changes in society and technology and advances in R&D, along with efforts to further improve the safety of railways with a particular emphasis on improving the resilience of the railways against frequent and increasingly severe natural disasters, RTRI is actively encouraging the adoption of digital technologies in all fields of R&D, with a view to stimulating innovation with regard to railway systems. In addition to obtaining high-quality R&D results that demonstrate the competence and expertise of our Institute, we are increasing the visibility of Japanese railway technologies on the international stage, in order to drive the development of railways on a global scale.

In order to realize these objectives, future undertakings will be based on the following fundamental guidelines:

(1) Enhancing safety with an emphasis on improving resilience to natural disasters

R&D that contributes to safer and more reliable railway transportation is essential, and we are placing particular 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. In addition, we are also actively conducting R&D for preventing the failure and aging of ground and vehicular equipment.

We will also actively conduct impartial activities as a third-party organization such as conducting surveys of the damage and causes of disasters and accidents and proposing methods for recovery and measures to prevent recurrence.

(2) Developing innovative railway systems based on digital technologies

While advocating the adoption for railways of digital technologies such as IoT, big data analytics, and AI, which combine high-speed information processing with high-speed, high-capacity networks such as 5G, we will also place emphasis on R&D for labor-saving technologies, such as the autonomous train operation and digital maintenance, in order to respond to labor-shortages in the railway sector. In addition, we will promote R&D that contributes to increasing the speed of high-speed trains while protecting the trackside environment and finding ways to help the railways save more energy. In addition, we will promote initiatives that contribute to the creation of new customer services such as mobility as a service (MaaS) and innovation in railway systems.

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

We will promote research and development for the future of the railways, the development of practical technologies that can yield immediate benefits for railway businesses, and basic research for understanding railway-specific phenomena. In addition, we will promote 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 know-how relating to railway technologies and the development of human resources, using interdisciplinary and cross-cutting approaches for resolving various issues in the railways, and realizing high-quality results and disseminating them both in Japan and internationally.

(4) Enhancing international presence of the Japanese railway technologies

Through partnerships with foreign railway operators and research institutions and strengthening information sharing, we aim to increase the international presence of Japanese railway technologies. In addition, as a base for international standardization activities to support overseas development, we will perform strategic and planned activities that demonstrate leadership.

(5) Creating a motivating workplace where staff can demonstrate their abilities

Based on the recognition that each individual staff member is a valuable human resource, we will train researchers that are able to respond to the needs of railway operators, hold a global perspective, and can creatively drive R&D. In addition to initiatives for workplace health and safety, mental health, and ensuring a proper work-life-balance, we will work to foster an open workplace environment where free and energetic discussions can be held, to create a positive and fulfilling workplace atmosphere.

3. Business activities

RTRI's business activities which serve the public interest fall into eight areas: R&D, surveys, technical standards, information services, publishing and seminars, diagnostic advisory, international standards, and qualification. In addition, we will strategically and systematically promote the activities of the Railway Technology Promotion Center and Railway International Standards Center operated in partnership with other parties involved in railway technology, as well as activities to increase the international presence of Japanese railway technology. At the same time, we will actively advance the commercialization of the results of R&D and promote for-profit projects, necessary for their widespread adoption.

3.1 Public interest activities

3.1.1 Research and development

(1) Advancing R&D

1. Enhancing safety with an emphasis on improving resilience to natural disasters

With an emphasis on R&D that contributes to improving safety, particularly as a response to intensifying natural disasters, we are actively using high-accuracy meteorological and seismic information obtained from state-of-the-art observation networks belonging to public institutions along with simulation technology to evaluate disaster risk in real time, thereby re-enforcing the contribution of R&D to safe and prompt train operation control and early recovery.

2. Developing innovative railway systems based on digital technologies

In addition to accumulating fundamental knowledge and know-how relating to advanced information processing and high-speed communication networks, RTRI sends staff to specialized research institutions either on a short or long-term basis, to fully realize potential synergies in cutting-edge digital technologies for promoting R&D. We also actively employ external expertise in the field of AI.

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

In addition to actively addressing basic research linked to solving various problems that are specific to the railways and as a source of innovative technology, we will drive high-impact, challenging R&D, implementing original ideas which could have potentially high impact on railway operations, as well as promote the bolstering of resources required for practical technological developments that are in high demand in the railways. In addition to strengthening initiatives such as joint research among universities in Japan and overseas, research institutes, and relevant companies, we aim to find new solutions to different railway technology issues through more cross-cutting projects. In addition, new large-scale testing

facilities will be used effectively to produce high-quality results. Furthermore, a creative new test facility that is directly linked to R&D will be established.

(2) 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" (Figure 3-1).

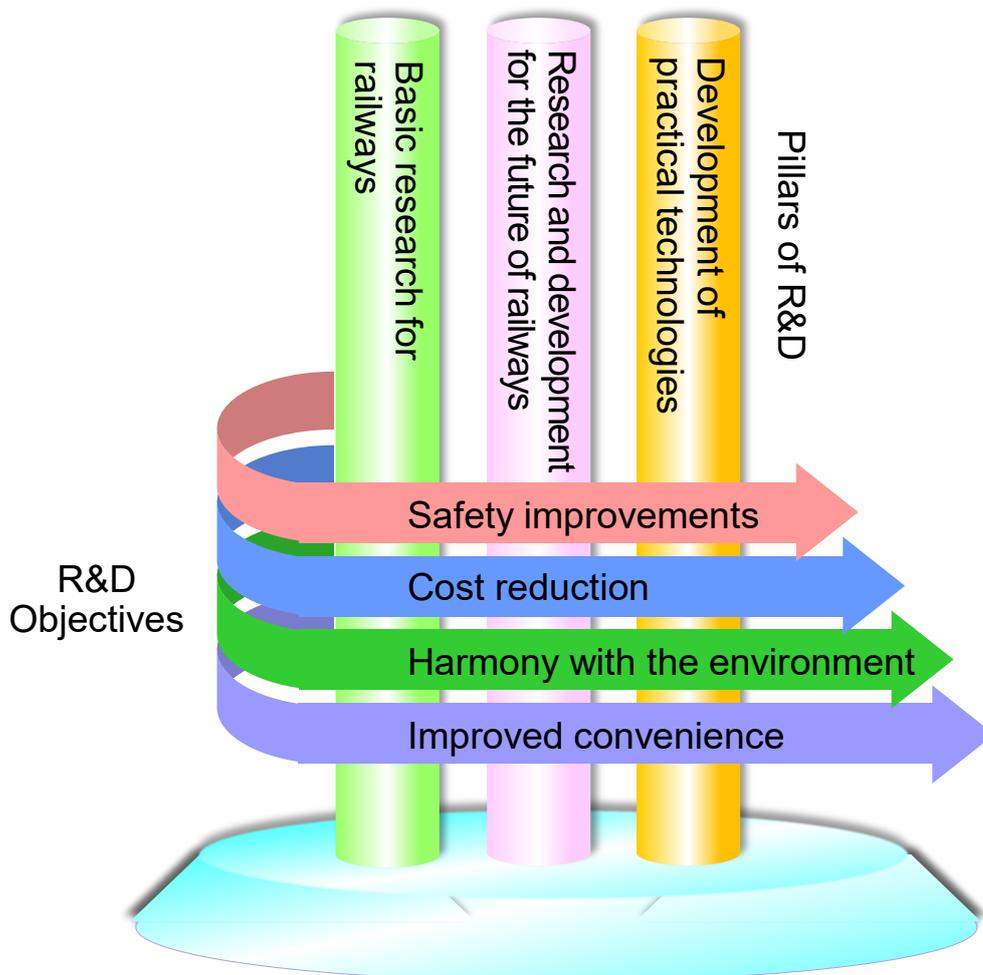


Figure 3-1. R&D objectives and pillars

(3) 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.

The following six major research themes have been specifically defined (Figure 3-2):

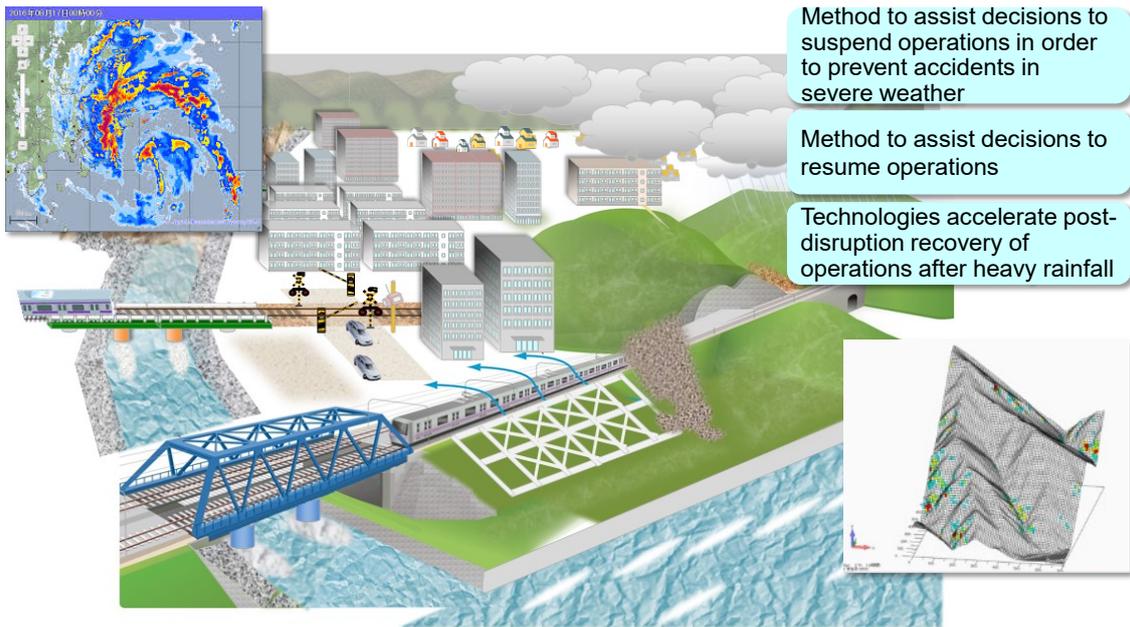
- Enhancing the resiliency of railway systems against severe meteorological disaster
- Autonomous train operation and control
- Improving labor efficiency by digital maintenance
- Low-carbonization of electric railway systems through cooperative control of the power network
- Increasing Shinkansen train running speeds in harmony with the trackside environment
- Sophistication of simulation technology



Figure 3-2 Research and development for the future of railways

○ Enhancing the resilience of railway systems against severe meteorological disasters

RTRI will 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 (Figure 3-3).

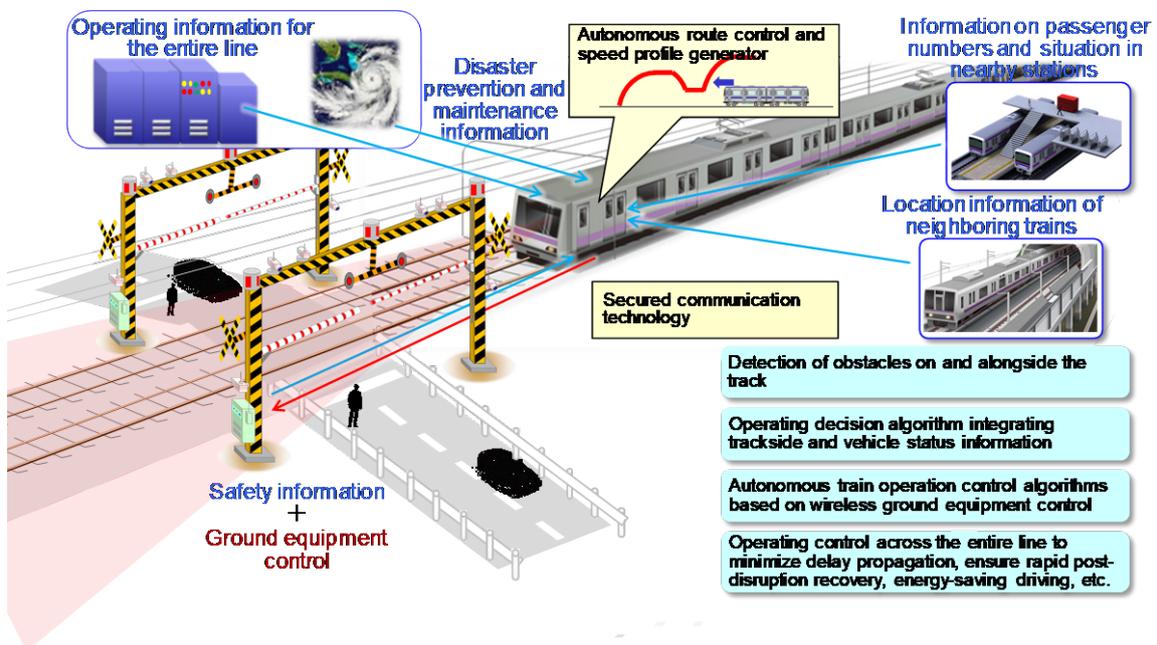


Topic	2020	2021	2022	2023	2024	Expected result
Enhancement of methods to assist decisions to suspend operation in order to prevent the accident in severe weather	Method for selecting representative sites for stability assessments in case of heavy rain					Real-time hazard map in case of heavy rain or strong winds
	Real-time strong wind hazard map					Method to assist decisions to suspend operations
Enhancement of methods to assist decisions to resume operations		Method for assessing slope-stability recovery progress after heavy rain				Method to assist decisions to resume operations
		Method for deciding when to resume operations after strong winds				
Development of technology to allow prompt restoration work following damage caused by heavy rain						Method for assessing damaged embankments for restoration
					Temporary safeguarding measures according to scale of embankment or slope collapse	Manual of proactive and reactive measures

Figure 3-3. Overview of "Enhancing the resilience of railway systems against severe meteorological disasters"

○ 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 (Figure 3-4).

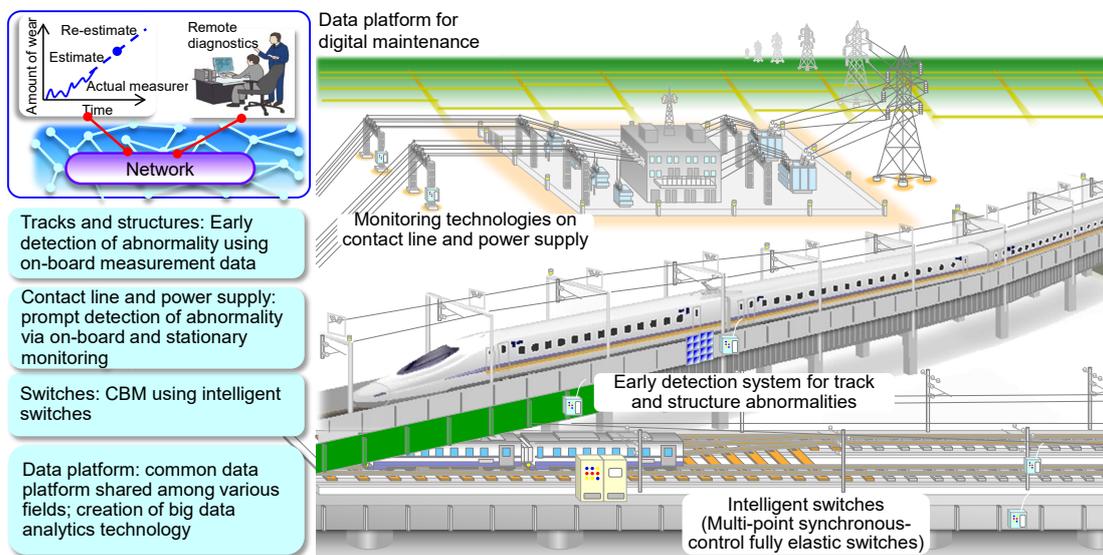


Topic	2020	2021	2022	2023	2024	Expected result
Development of track and trackside obstacle detection methods	Technology for the detection of obstacles on and alongside the track		On-track anomaly detection system			Method to detect obstacles on the track ahead
Creation of operating decision algorithms	Operating risk assessment methods		Operating decision algorithms		Autonomous train operation control system	Operating decision methods
Development of autonomous operation decision algorithms	Autonomous ground installation control methods		Autonomous operation control algorithms			
	Real-time inter-train communication technology					Autonomous operating control methods
Development of operating control methods for the entire line section	Methods for multidimensional evaluation of train operation		Operation management algorithms for autonomous train operation			Methods for controlling operations along entire line sections

Figure 3-4. An overview of "Autonomous train operation and control"

○ Improving labor efficiency by digital maintenance

A platform will be 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 (Figure 3-5).

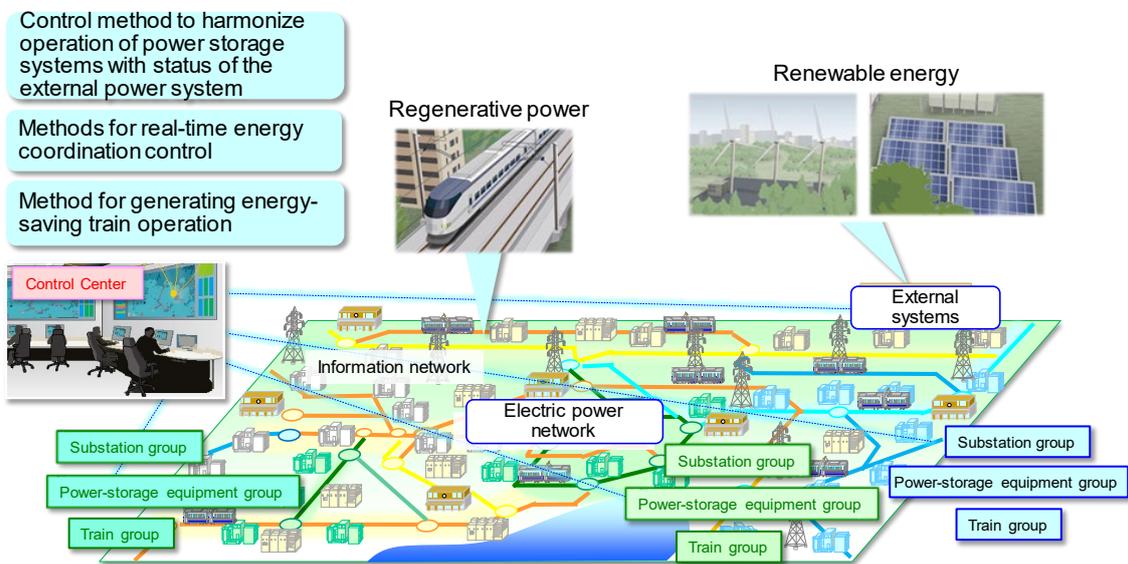


Topic	2020	2021	2022	2023	2024	Expected result
Development of track and structure condition-monitoring technology			Method for the early detection of track and structure abnormalities			Early track and structures abnormality-detection system
				Early detection system for track and structure abnormalities		
Fabrication of technology for monitor power-equipment status			Technology to detect and mitigate a damage in power collection system			Technology for monitoring power-equipment condition
		Technology for monitoring train line equipment and condition of power equipment			Digital data platforms	
			Method for early detection of abnormalities using power network monitoring			
Development of low-maintenance switches		Basic specifications for intelligent switches		Basic configuration of intelligent switches		Multi-point synchronous-control fully elastic switches
Developing technology for the sharing and use of digital data		Basic technology for data analysis and evaluation				Data platform for digital maintenance
			Construction of data servers and data collection			

Figure 3-5. An overview of "Improving labor efficiency by digital maintenance"

○ Low-carbonization of electric railway systems through cooperative control of the power network

To achieve low-carbonization of railway systems through active use of renewable energy connected to the external power system, we will develop 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 will develop 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 (Figure 3-6).

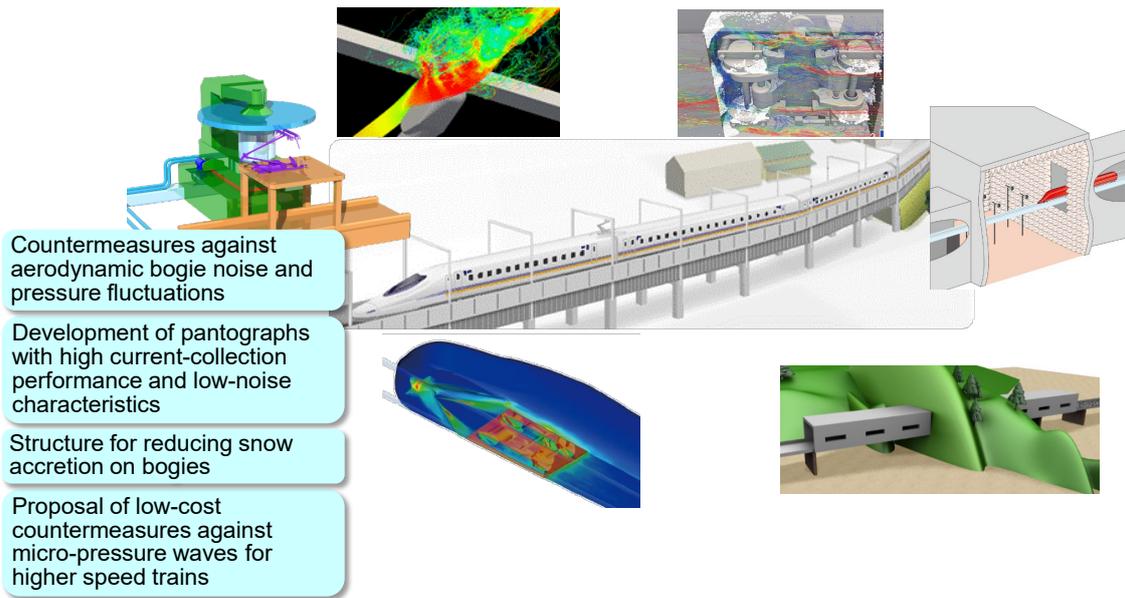


Topic	2020	2021	2022	2023	2024	Expected result
Effective use of renewable energy				Control method to harmonize operation of power storage systems with status of the external power system		Control method to harmonize operation of power storage systems with status of the external power system
Efficient use of regenerative power				Real-time cooperative control method for energy-saving devices		Real-time cooperative control method for energy-saving devices
Development of dynamic energy-saving driving operation method			Derivation method of energy-saving train schedule considering usefulness for passengers			Method for generating energy-saving train operation
			Dynamic energy-saving driving operation method			

Figure 3-6. Overview of "Low-carbonization of electric railway systems through cooperative control of the power network"

○ Increasing Shinkansen train running speeds in harmony with the trackside environment

We will develop technologies for reducing aerodynamic bogie noise and tunnel micro-pressure waves by using a newly installed low-noise moving model facility. We will also develop 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 will develop a technology for reducing snow accretion on bogies by controlling the airflow around bogies during high-speed train operation (Figure 3-7).

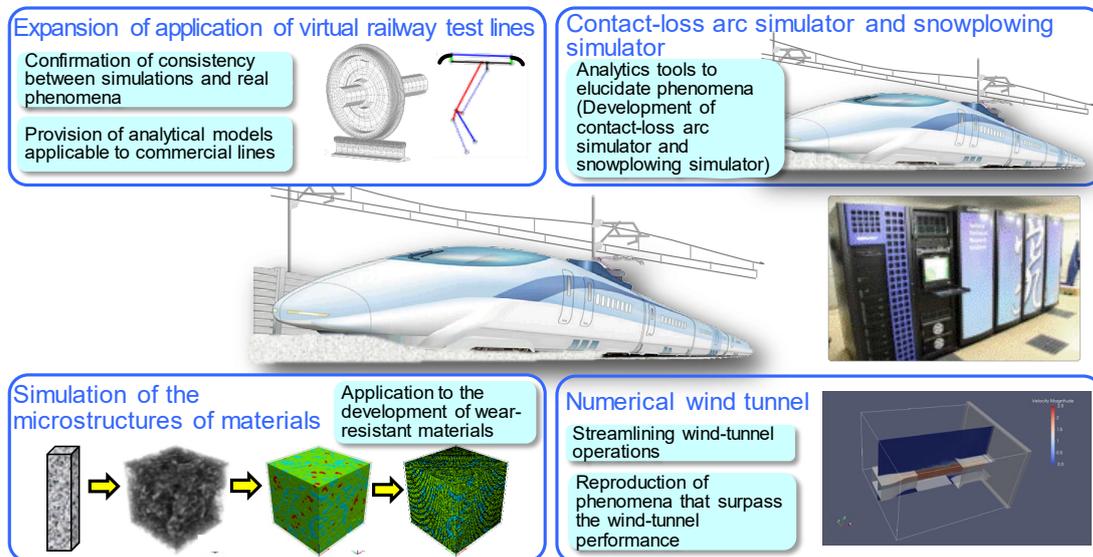


Topic	2020	2021	2022	2023	2024	Expected result
Development of countermeasures against aerodynamic bogie noise and pressure fluctuations	Estimation of contribution of noise sources to wayside noise		Prediction and evaluation of wayside noise generated by higher train speeds			Measures for reducing aerodynamic bogie noise and pressure fluctuations
	Measures for reducing aerodynamic bogie noise and pressure fluctuations			Technology for reducing noise and pressure fluctuations		
Development of measures for reducing pantograph noise				High current collection performance and low noise pantograph		High current collection performance and low noise pantograph
Development of measures for reducing snow accretion on bogies in extremely cold regions			Measures for reducing snow accretion on bogies using air flow control			Structures for reducing snow accretion on bogies
				Risk assessment of accreted snow dropping from Shinkansen bogies		
Proposal of countermeasures against micro-pressure waves			Cost-reduction of countermeasures against micro-pressure waves		Extension of application range of countermeasures against micro-pressure waves	Low-cost countermeasures against micro-pressure waves

Figure 3-7. Overview of "Increasing Shinkansen train running speeds in harmony with the trackside environment"

○ Sophistication of simulation technology

We will create 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 will also develop 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 will develop 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 (Figure 3-8).



Topic	2020	2021	2022	2023	2024	Expected result
Expansion of application of virtual railway test lines	Improved consistency between the simulator and real phenomena		Practicality verification using an analytic model applicable to commercial lines	Analytics models applicable to commercial lines		
	Method for coupled analysis of snowplowing and vehicle dynamics			Contact-loss arc simulator and snowplowing simulator		
Development of contact-loss arc simulator and snowplowing simulator	Elucidation of contact-loss arc phenomena		Contact-loss arc simulator	Efficient development methods for wear-resistant materials		
	Microstructural simulations		Application to the development of wear-resistant materials		Numerical wind tunnel	
Creation of numerical wind-tunnel technologies	Development of constituent technologies		Scale-up and expansion of functions			

Figure 3-8. Overview of "Sophistication of simulation technology"

(4) Development of practical technologies

In order to provide timely practical results, we are addressing topics with immediate relevance to the railway business (Table 3-1).

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.

Table 3-1. Example topics for "Development of practical technologies"

R&D Objectives	Topic
Safety improvements	<ul style="list-style-type: none">○ 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	<ul style="list-style-type: none">○ Railway monitoring technologies comprising the use of sensors○ Methods for confirming safety using vehicle-side cameras
Harmony with the environment	<ul style="list-style-type: none">○ Application of superconductor technologies such as superconducting power cables to conventional railways○ Practical application of fuel-cell hybrid trains
Improved convenience	<ul style="list-style-type: none">○ Brake equipment that contributes to reduced braking distance○ Vertical vibration control systems for high-speed trains

(5) Basic research for railways

We will actively engage in basic research to provide solutions to various issues that affect railways specifically and can serve as a source for innovative technologies. In the field of "Elucidation and prediction of phenomena," we will conduct basic research into forecasting meteorological disasters, vehicle running safety and stability, and improvements in the trackside environment. With regards to "Creating methods of analysis, experimentation and assessment," we will conduct research into damage and degradation mechanisms, inspection methods, and human factors. Finally, in terms of "Adoption of new technologies, materials, and research methods," we will conduct basic research into friction, wear, prolonging the serviceable life of parts, and Artificial intelligence (AI) (Table 3-2).

Table 3-2. Example topics of "Basic research for railways"

Item	Topic
Elucidation and prediction of phenomena	<ul style="list-style-type: none"> ○ Forecasting meteorological disasters <ul style="list-style-type: none"> • Methods of estimating the properties of snow cover on the lines • Methods for predicting weather phenomena using big data analysis to publicly available information ○ Running safety and stability of rolling stock <ul style="list-style-type: none"> • Methods for analyzing conditions that cause hunting and methods for assessing stability • Assessing vehicle behavior at the moment a vehicle reaches the overturn limit due to crosswinds ○ Improvements to the wayside environment <ul style="list-style-type: none"> • Study on the generation mechanism of squealing and bridge noises and development of the mitigation measures • Methods for estimating and visualizing radio noise caused by running trains
Creating methods of analysis, experimentation, and assessment	<ul style="list-style-type: none"> ○ Degradation mechanisms and inspection methods <ul style="list-style-type: none"> • Assessment of the fatigue crack growth rate and inspection intervals of railway axles • Elucidation of crack propagation mechanisms in bogie frames and development of inspection methods • Study on crack propagation mechanisms in rail heads and maintenance methods for cracks ○ Human factors <ul style="list-style-type: none"> • Clarifying physiological indices for assessing mental and physical condition • Total evaluation method of railway passenger comfort based on factor analysis
Adoption of new technologies, materials, and research methods	<ul style="list-style-type: none"> ○ Friction, wear and increasing longevity of materials <ul style="list-style-type: none"> • Elucidating mechanisms underlying increased adhesive wear of contact wires and pantograph contact strips • Elucidation of the frictional deterioration factors of wheel treads and proposals for new materials for wheels and brakes ○ Artificial intelligence (AI) <ul style="list-style-type: none"> • A model for introducing human technical skills into AI • A method for tracing control and decisions by AI

R&D of superconducting maglev will be conducted as research activities while focusing mainly on the ongoing application of technologies such as superconductors and linear

motors to conventional railways. At the same time, R&D for maintaining necessary technological capabilities will be conducted as fundamental research.

(6) 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.

1. Establishing a new large-scale testing facility

Two large-scale testing facilities will be constructed to assess the safety of the ground and embankments against earthquakes and heavy rains and to assess the response and durability of tracks and structures during high-speed train operation.

○ Centrifuge test facility

In order to assess the state of the ground during earthquakes and heavy-rain, and to solve various related problems, such as performing a collapse analysis, we will install a facility to assess the behavior of the ground and structures that reproduce stress states equivalent to those observed in the actual ground within a scale model by applying a centrifugal force using high-speed rotation against a reduced-scale model ground.

○ High-speed movement loading test facility

In order to develop a vibration-controlled track for high-speed rail and a maintenance-free track for regional railways, we will install new facility to assess the response and durability of tracks and structures by reproducing the loads borne by tracks with high-speed trains (maximum speed 360 km/h) while using multiple actuators installed at sleeper intervals on the real track structure.

2. New installation and renewal of test equipment

We are installing new test facilities that are required for conducting high-quality R&D. In addition, we are updating the test equipment that has exceeded its useful life and has deteriorated significantly, with priority given to what is needed most and most urgently for R&D.

3.1.2 Survey

In addition to understanding changes in society, the economy, and technology, we will collect and analyze information concerning mid- to long-term trends in Japan and overseas, in the fields of safety, the environment, and the transportation economy, as they relate to railways and trends in cutting-edge technologies such as digital technology. The results of these surveys will be used for R&D, and we will actively disseminate these findings. In addition, we will conduct survey activities to predict the future of rail and to identify technical items for R&D.

3.1.3 Technical standards

With the increasing importance of the maintenance and management of social infrastructure and with consideration for the shrinking labor force, we are strategically promoting the development of design standards, maintenance and management standards, and examples of design calculations such that the design can be conducted while reflecting construction and maintenance management efficiency perspectives.

3.1.4 Information services

We will collect, compile, and actively disseminate Japanese and foreign technical railway information. In addition, using various media such as mass media and the Internet, in addition to providing society with timely and accurate technical rail information, including high-quality R&D results and activities, we will act as a base for information transmission and disseminate information that contributes to rapid recovery following earthquakes.

3.1.5 Publication and seminar

We will further improve the content of periodical reports such as RTRI reports, Railway Research Review (RRR), Quarterly Report of RTRI (QR,) and Ascent, as well as educational activities such as lectures and technical forums, while striving to disseminate the results of R&D in society. In addition, we will provide systematic training courses on topics such as railway technology for all levels of knowledge, from beginner to expert.

3.1.6 Diagnostics advisory

We will meticulously respond to the needs of all railway operators and continue to actively support them. With regards to consultations on disasters, accidents, and equipment failures, we will promptly survey the damage and causes and propose methods for recovery and the prevention of recurrence. We will respond to severe natural disasters by forming cross-cutting teams.

3.1.7 International standards

We will develop 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.

3.1.8 Qualification

In addition to creating an environment that makes it easy for railway engineers to apply for professional railway design engineer examinations through the verification of entire processes under examination, we will contribute to the development of human resources for the entire railway industry with the aim of maintaining and improving the technical knowledge level of railway engineers.

3.1.9 Railway Technology Promotion Center

With a focus mainly on the systematization of technologies, problem solving, and the maintenance and improvement of technological know-how and technical information service activities, in addition to partnering with the Japanese government and relevant institutions to undertake activities that contribute to safe and reliable railway transport, we will contribute to improving the technical level of those involved in railways. In particular, we will focus on technical support to revitalize regional railways through measures such as providing advice based on site visits. In addition, through investigative research into topics of particular interest to railway operators, we will promote information sharing between railway operators.

3.1.10 Railway International Standards Center

With the aim of maintaining and further improving Japan's railway technologies and their overseas expansion, we will act as a central organization responsible for international standardization activities while closely cooperating with the Japanese government, Japanese standards organizations, railway operators, and railway-related companies.

In addition to strengthening the cooperation with organizations conducting standardization activities in Europe and Asia and promoting the use of standards developed and issued at Japan's initiative, including standards for railway project planning and promoting the understanding and adoption of Japanese railway technologies, we will increase awareness about international standards among Japanese stakeholders and promote human resource development.

3.1.11 International activities

In order to further enhance the technological prowess and global presence of RTRI, we will expand joint research with and staff secondment to overseas universities and research institutions as well as improve 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.

3.2 For-profit projects

We will promote for-profit projects in order to commercialize R&D outcomes, and drive their widespread popularization. To this end, in addition to strengthening marketing and promotional activities and accurately understanding the needs of customers including the railway operators, we are actively implementing initiatives for promoting the commercialization of the results of research and providing results that are perceived by clients as being high-quality.

Securing revenue and promoting business efficiency to ensure stable and solid income, and management of expenditures will help to strengthen the management foundations of RTRI.

4. Management

4.1 Management concepts

As a public interest incorporated foundation, we comply with laws and regulations and our articles of incorporation, and we encourage sound management.

In addition to increasing staff numbers in technological fields, placing a priority on R&D, we shall make efficient use of the limited human resources to respond appropriately to solving various problems in railway technology.

In order to cultivate researchers that can perform the R&D sought by RTRI in response to the needs of railway operators in addition to enhancing level-specific training programs for staff, ranging from new recruits to executives, and to ensure the reliable transfer of technological skills and knowledge, we are also actively exchanging personnel with railway operators such as JR companies.

In order to complete the new installation, and update of RTRI's testing facilities, and renovation of research buildings based on a mid- to long-term plan, we aim to further increase efficiency across all aspects of operation based on sound financial planning.

4.2 Compliance

We will promote continuous development through training courses and on-the-job training (OJT) with the aim of raising the ethical awareness of staff and strengthening compliance with laws, regulations, and ethical codes.

4.3 Information management

In addition to the strict management of R&D information, we are strengthening security measures used for the management and use of information communications and data.

4.4 Human resources

4.4.1 Recruitment

In addition to promoting initiatives to further understanding of the activities of RTRI by strengthening collaboration with universities and research institutes and proactively offering internships and ensuring a supply of skilled employees to meet the demand in the technical fields highlighted in the mid- to long-term plan, we are hiring strategically in order to avoid skills gaps in the various fields of technology.

In order to ensure a sufficient supply of skilled experts in cutting-edge technical fields such as digital technologies and advanced simulation technologies, we intend to diversify recruitment to include mid-career recruitment of experts.

4.4.2 Developing human resources

In addition to ensuring the transfer of technological skills and knowledge accumulated over many years to the next generation, we will train researchers able to perform creative R&D to respond to the needs of railway operators. Therefore, we will enrich OJT and level-specific training programs offered at various career stages, from new recruits through to executives. We will also actively conduct personnel exchanges with railway operators including JR companies, not only among younger employees but also at managerial level.

We will conduct short- and long-term staff secondment to specialist research institutes involved in cutting-edge technical fields such as digital technology.

From a global perspective, we are actively engaging in joint research with foreign universities and research institutions and personnel exchanges in order to develop a pool of highly skilled employees that can raise the presence of Japanese rail technologies on the international stage.

To promote the self-development of researchers in order to accumulate specialist knowledge and raise the international presence of RTRI, we will encourage the acquisition of higher qualifications (PhDs and professional engineers) and promote participation in academic and professional association activities.

4.4.3 Creating a motivating workplace

We will strengthen efforts to improve workplace health and safety, mental health, and reform working practices, as well as support employees with childcare, and creating a workplace where employees can benefit from flexible working, and where they can work safely and healthily both in mind and body.

We will nurture a culture of openness that allows researchers in various technical fields to have free and vigorous discussions irrespective of differences in age and position, and we will create motivating workplaces where all employees, from junior staff to veterans, can have a high degree of motivation to work.

4.5 Personnel

Based on current recruitment performance, about 20 new employees should be recruited each fiscal year, to maintain staffing at its current level of 550 (Table 4-1).

In R&D activities, we will reinforce technical fields that have been prioritized, such as increasing resilience to natural disasters, promoting the adoption of digital technologies, improvement of energy-saving technologies, and advancement of simulation technologies.

We will increase the number of staff in international standardization activities in order to strengthen cooperation with international railway-related organizations and respond to certification needs.

We will continue to assign staff to appropriate positions with the aim of increasing the efficiency of their work including other activities not mentioned above.

Table 4-1 Number of personnel

(Units: Persons)

	FY2019	FY2020 – FY2024
Research and development	440	442
Survey	18	13
International standards	10	13
For-profit projects	40	40
Administration duties	42	42
Total	550	550

4.6 Revenue and expenditure

In estimating the contribution income from JR companies, we take into consideration changes in the rail transport revenue of JR companies in recent years and the anticipated economic situation of the society in the future. Although the repayment of loans from the Development Bank of Japan will be completed within the period covered by this master plan, strict income expenditure management will still be adopted with the intention of ensuring effective budget management. One reason for this is that R&D expenditure is increasing as priority issues need to be addressed and practical application of research results also need to be promoted. Another reason is that we should reserve funds for the creation of new large-scale testing facilities, the renovation of old facilities, and reconstruction of the head office building in *Kunitachi* (Table 4-2).

4.6.1 Revenue

(1) Contribution revenue

In regards to the contribution revenue, revenue for each year is expected to remain at 2019 levels, as the revenue growth of JR companies over the past few years has been consistently high.

(2) Business revenue

In regards to the business revenue, because the current scale of revenue is expected to continue into the future, the revenue for each year is expected to be the same as that in 2019.

(3) Subsidy revenue

We continue to request subsidies to cover interest on repayments of money borrowed from the Development Bank of Japan. Subsidies from the Japanese government in addition to competitive grants will be actively sought, to ensure that RTRI can continue to engage actively and creatively in R&D.

4.6.2 Expenditure

(1) Personnel expenditure

Personnel expenditure is based on the number of personnel.

(2) R&D expenditure

We will strengthen initiatives for priority issues such as data collection and validation testing for various meteorological conditions required to advance the R&D contributing to enhancing the resilience of the railways to natural disasters, promoting practical applications such as validation experiments for superconducting power transmission cables, and bolstering R&D expenditure for establishing test methods for new large-scale testing facilities.

(3) Fixed asset acquisition expenditure

In addition to installing and renewing testing facilities, we will update and expand general facilities to improve safety and address the issue of the aging of general equipment.

(4) Repayments to DBJ

Repayments are made under contract with the Development Bank of Japan and will conclude in 2022.

(5) Purchase of reserve assets for reconstruction of the *Kunitachi* head office building

After examining what functions the new office building will need to ensure an environment conducive to creative research, the building will be redesigned to a similar scale as the current building, but with higher earthquake resistance.

The " Reserve assets for reconstruction of the *Kunitachi* head office building " will be set aside as a fund for use in this reconstruction.

Table 4-2: Revenue and expenditure

(Units: billion JPY)

		FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	Total
Revenue	Contribution revenue	15.1	15.1	15.1	15.1	15.1	15.1	75.6
	Business revenue	3.0	3.0	3.0	3.0	3.0	3.0	15.2
	<i>For-profit projects revenue</i>	2.9	2.9	2.9	2.9	2.9	2.9	14.5
	<i>Public-interest activities revenue</i>	0.1	0.1	0.1	0.1	0.1	0.1	0.7
	Subsidy revenue	0.1	0	0	0			0
	Membership revenue	0.2	0.2	0.2	0.2	0.2	0.2	1.1
	Other revenue	0.1	0.1	0.1	0.1	0.1	0.1	0.9
	Proceeds from secured assets for <i>Yamanashi Maglev Test Track</i> construction debt	1.1	0.9	0.5	0			1.5
	Balance carried forward from the previous period	2.4						
	Total revenue	22.3	19.5	19.1	18.6	18.6	18.6	94.5
Expenditure	Personnel expenditure	5.9	6.2	6.3	6.5	6.5	6.9	32.6
	Non-personnel overhead expenditure	2.7	2.7	2.7	2.7	2.7	2.7	13.8
	R&D expenditure	3.0	3.4	3.4	3.4	3.4	3.4	17.2
	<i>Research and development for the future of railways</i>	0.8	0.9	0.9	0.9	1.2	1.0	4.9
	<i>Development of practical technologies</i>	1.3	1.4	1.4	1.4	1.1	1.3	6.8
	<i>Basic research for railway (Within parentheses, Technical development requested by JR companies)</i>	0.8	1.1	1.1	1.1	1.1	1.1	5.5
	<i>(Within parentheses, Technical development requested by JR companies)</i>	(1.2)	(1.4)	(1.4)	(1.4)	(1.4)	(1.4)	(7.0)
	Other public-interest activities expenditure	0.7	0.6	0.6	0.6	0.6	0.6	3.3
	For-profit project expenses	1.9	1.9	1.9	1.9	1.9	1.9	9.8
	Fixed asset acquisition expenditure	3.8	1.7	1.7	1.7	2.7	2.7	10.5
	<i>(Of which, large-scale testing facilities)</i>			(0.3)	(0.6)	(2.0)	(1.9)	(4.9)
	<i>(Of which, testing facilities)</i>	(0.2)	(0.7)	(0.7)	(0.7)	(0.5)	(0.5)	(3.1)
	<i>(Of which, general facilities)</i>	(0.2)	(0.3)	(0.6)	(0.3)	(0.1)	(0.3)	(1.8)
	Repayments to DBJ	1.1	0.9	0.5	0			1.5
	Purchase of reserve assets for reconstruction of the <i>Kunitachi</i> head office building	2.8	1.5	1.6	1.3	0.3		4.9
	Emergency funds	0.1	0.1	0.1	0.1	0.1	0.1	0.5
Total expenditure	22.3	19.5	19.1	18.6	18.6	18.6	94.5	

- (Note) • FY 2019 figures represent amounts budgeted at the beginning of the fiscal year.
• Subsidy revenue is recorded only for subsidies against interest due to the Development Bank of Japan. (It should be noted, however, that FY2019 includes a national treasury subsidy for research and development (110 million JPY))
• FY2019 research and development expenditures include the national treasury subsidy (110 million JPY).
• The totals may not add up due to rounding up.

5. Conclusion

The labor shortage caused by a shrinking working-age population in Japan, and unprecedented meteorological disasters are pressing issues that cannot be addressed through conventional frameworks.

Radical technological innovation is essential to overcoming these challenges. RTRI plays acts as a leader in technological innovation for railways, partnering with railway operators, universities, and research institutes in Japan and overseas, as well as related companies to overcome difficult problems encountered by railways, and it pursues research and undertakes development to create the future of railways for the realization of a sustainable society.

In addition, we are accumulating know-how related to railway technology and proactively undertaking impartial activities as a third-party organization including the investigation of damage due to and causes of disasters and accidents and proposing measures for recovery, and to prevent their reoccurrence.

As a public interest incorporated foundation, we adhere to the law and to our articles of incorporation, and we are working to strengthen compliance and further deepen trust in RTRI. RTRI, which is not an operator itself actively engages in personnel exchanges with railway operators, and strives to build a pool of trained personnel that are able to grasp the status and issues that are specific to the railways, while encouraging the transfer of technological skills and knowledge to the next generation.

Based on the vision of "We will develop innovative technologies to enhance the rail mode so that railway can contribute to the creation of a happier society", we promise that RTRI pledges to invest its utmost efforts to realized its Master Plan RESEARCH 2025: R&D for creating the future of railways.

RTRI's 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

- ① To intensify research and development activities so as to improve railway safety, technology and operation, responding to customers' needs and social change
- ② 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
- ③ To pioneer cutting-edge technologies for Japanese railways and become a world leader

Strategy

