Master Plan
Aiming at Creation of Innovative Technologies

RESEARCH 2020

(April 2015 to March 2020)

November 2014

Railway Technical Research Institute

Master Plan

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Reference Material: Vision of the Railway Technical Research Institute

1. Introduction

In Japan, we are experiencing a great change in circumstances surrounding the society. The railway industry is not an exception. The general public has passed through unprecedented damage and electricity shortage triggered by the Great East Japan Earthquake, so that people are now expressing an increasing interest in safety, security and securement of energy. In addition, the nation faces ongoing deterioration of a huge number of infrastructures and needs to cope with a declining birth rate and aging population. In this situation, the superiority of the railways is appreciated not only in Japan but also abroad for its merits concerning high-speed and volume transportation and from the viewpoint of global environmental protection. Accordingly, Japanese railway technologies are rapidly deploying overseas.

As a result, the Railway Technical Research Institute (RTRI) is strongly expected to respond to the trust placed in it by the railway industry and the general public by carrying out research and development (R&D) that can quickly correspond to a change in social situations and technical trends, producing high-quality results, and providing them for the wider public.

To promote its R&D, RTRI has formulated a new clear vision titled "We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society." to set the direction of the future, and it also defined the missions and strategy needed to make this vision tangible. This Master Plan "RESEARCH 2020" is the mid-term action plan intended to lend shape to this vision.

On the basis of the above recognition, we will here formulate the MasterPlan for the five-year period from April 2015 to March 2020. Following this Plan, the Railway Technical Research Institute will enhance its R&D ability to effectively and strongly drive R&D toward technical innovation and carry out steady operation based on sound financial plans. The Institution also remains committed to the observance of related regulations and its own articles of incorporation.

2. Basic Policies

To contribute to advancement of railways and realize an affluent society, RTRI effectively and strongly promotes R&D oriented to railway innovation and creates high-quality results by fully demonstrating its comprehensive capabilities.

In addition, to fulfill its social responsibilities as a public interest incorporated foundation, RTRI promotes thorough compliance and performs neutral activities, such as technical support in a time of disaster or an accident, based on technical common sense. Moreover, in order to be the leader in global railway technologies, RTRI helps effectively deploy the Japanese railway technology in foreign countries and simultaneously increases its presence in the global market.

To achieve these goals, RTRI adopts the following basic policies.

(1) Dynamic R&D to encourage railway innovation

RTRI should respond to changes of the times and various needs of the society and carry out innovative technical development without delay. It should strongly promote advanced R&D and R&D in new fields, including enhancement of the simulation technology and active use of information and communication technology, by allocating more resources to such activities. And it should steadily pursue basic research that can be a source of innovative technology.

(2) Creation of high-quality results by fully demonstrating its comprehensive capabilities

RTRI should vigorously accumulate know-how and pursue human resource development in preparation for solving various problems in the railway industry and developing innovative technology, and at the same time combine strength of researchers and experts in different fields. Along with such an effort, original facilities and equipment for research should be newly built or revamped.

Based on these arrangements, RTRI should create high-quality results and provide them widely around the world.

(3) Trusted activities based on technical common sense

RTRI should accumulate deep insights across the railway industry and engage in investigation into accident causes and damage by disasters, presentation of measures against them, and formulation of technical standards based on its technical common sense as an independent third-party specialist organization.

(4) Support for overseas deployment and enhancement of international presence of the Japanese railways

To become a leader in the global railway sector, RTRI should effectively support overseas deployment of Japanese railway technology and simultaneously enhance its global presence by transmitting information while constructing close relationships with foreign railway business operators and research institutes and by actively proposing international standards from Japan.

(5) Creation of pleasant working environment to inspire personnel with a sense of pride and fulfillment

RTRI should set an environment where free-minded researchers and experts can perform at their full potential and produce results that will bring a sense of accomplishment. It should promote a pleasant workplace culture that allows unfettered discussions while respecting diversity in terms of human individuality, culture and other considerations.

3. Business Activities

3.1 Basic Stance on Activities

(1) Business for public interest purposes

RTRI promotes eight categories of business for public interest purposes such as R&D, investigation, and technical standards. In R&D, it should strongly pursue R&D activities aimed at railway innovations. It should also appropriately carry out investigation into accidents and disasters and bring proposals into effect while enhancing dissemination of information.

Furthermore, RTRI should cooperate and tie up with parties concerned in railway technologies to push ahead with activities based on the Railway Technology Promotion Center and the Railway International Standards Center and other international activities in a planned and strategic manner.

(2) Profit-Making Business

RTRI should promote profit-making business to actively put results of R&D to practical use and into wider application. RTRI should also directly provide R&D results for clients and thus enhance diversity, enhancement, and morale and a sense of responsibility among its researchers. At the same time, RTRI should perform rigorous income and expenditure management as a means for reinforcement of business infrastructures.

3.2 Business for Public Interest Purposes

3.2.1 Research and Development

(1) Basic principles of R&D

RTRI pursues (1) improvement of safety with strengthening measures against natural disasters of a large scale and derailment prevention measures; (2) cost reduction of maintenance and other factors; (3) harmony with the environment by improving energy use efficiency; and (4) enhancement of convenience through further increase of train speed. Based on these efforts, RTRI will create innovative technologies that can contribute to railway advancement while solving various problems confronting the railway industry now. These challenges constitute the four "R&D Objectives" RTRI should follow.

R&D Objectives:

- ○ Improvement of Safety
- ○ Cost Reduction
- ○ Harmony with the Environment
- ○ Improvement of Convenience

In order to promote R&D, resources should be augmented in leading-edge technical fields such as advanced simulation and information and communication technologies, unique technical fields concerning safety, energy, and speeding-up of trains, and other new fields.

In addition, to produce high-quality results, original facilities and equipment for research and testing should be enriched; studies should be carried out across various areas of specialty; accumulated know-how and data should be actively used; and comprehensive strength should be leveraged through networks with railway business operators and domestic and overseas universities and research organizations.

Furthermore, aiming at balanced distribution of resources and realization of effective R&D, the following three agendas are adopted as the "Pillars of R&D" (Figure 3-1).

Pillars of R&D:

- ○ R&D toward the future of railways
- ○ R&D of technology for practical use
- ○ Basic research for railways

Pillars of R&D

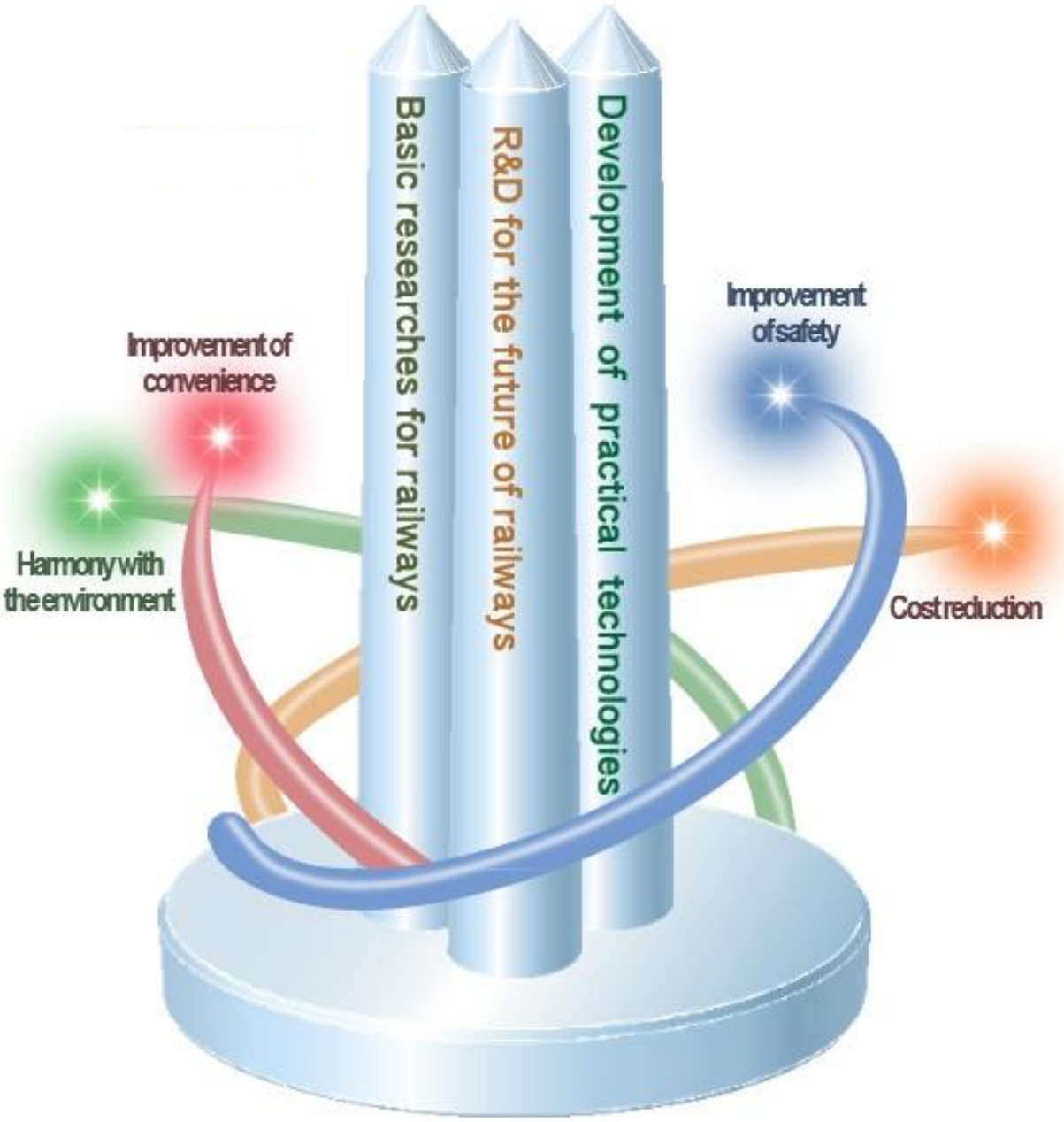

Figure 3-1. Objectives and Pillars of R&D

(2) R&D toward the future of railways

For the target of realizing practical use in 10 to 20 years in mind, research topics should be carefully selected according to the following principles of selection.

○ Respond to the needs of JR companies and other railway business operators and respond to social trends.

○ Point to advanced R&D and the future of railways.

○ Leverage RTRI's expertise in fields and areas where RTRI has higher R&D capability and unique features.

○ Pave the way for practical R&D and realize solutions of critical problems in practical R&D. Allow expectation of making academic contributions.

○ Pursue challenges that will have a large spillover effect when put to practical use.

In FY 2015, RTRI will start to carry the four major subjects into execution: "pursuit of further safety of railway systems," "renovation of railway systems using information and communication technologies," "speed-up of the Shinkansen," and "building of railway simulators." In each major subject, two or three individual issues will be set while constituting each issue with two or more R&D themes, and these individual issues will be interlinked among them properly for schematization in their implementation (Figure 3-2 and Table 3-1).

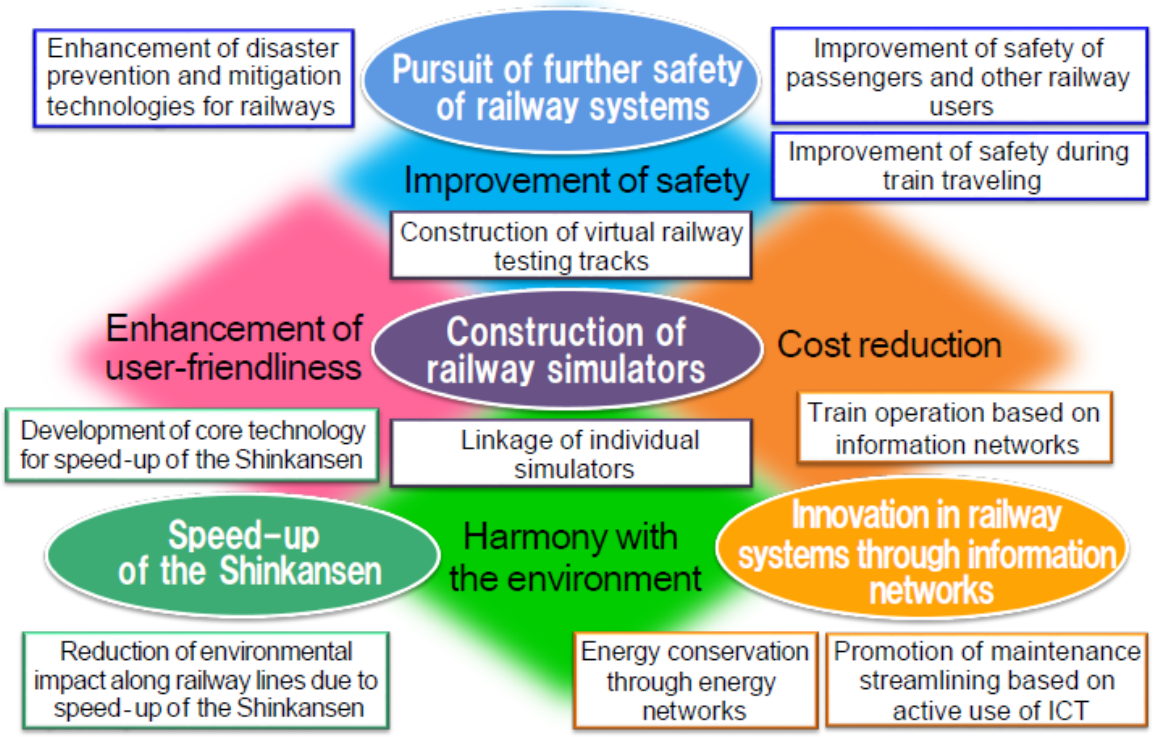

Figure 3-2. R&D toward the Future of Railways

Table 3-1. Summary of the major subject “R&D toward the future of railways” and individual issues

Major Subject 1: Pursuit of further safety in railway systems
In order to further improve railway safety, R&D should be pursued with a focus on prevention and mitigation of natural disasters that would inflict enormous damage, accident prevention from a human-factor viewpoint and damage-mitigation measures taken in the event of accidents, and derailment-prevention countermeasures applicable to conventional lines.

Individual Issues	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Enhancement of disaster prevention and mitigation technologies for railways	Detection/evaluation technologies for gusting winds and				
	Detection/evaluation technologies for short-term local heavy rainfall		Hazard map drawing techniques		
	Railway resilience evaluation techniques from earthquakes of unprecedented scales		Techniques to detect large-scale earthquakes/support recovery Structural measures		
			Technique for mitigation of catastrophic disasters caused by external forces		
Improvement of safety for passengers and other railway users	Decision-making ability issue evaluation		Techniques to evaluate decision-making abilities		
	Level-crossing sensing technologies Level-crossing passing model		Level-crossing group control methods Crossing control system to improve safety		
		Collision safety evaluation method	Vehicle design guide for collision safety		
Improvement of safety during train traveling	Track irregularity control methods Flange climbing evaluation methods Derailment-resistant bogies		Running safety improvement methods in consideration of vehicle-track reciprocal influences Running safety improvement methods for earthquakes		
	Guard angle management guidelines				

Major Subject 2: Innovation in railway systems through information networks
R&D aimed at developing a railway system which realizes highly convenient traffic service, efficient maintenance at costs and energy saving should be pursued through active use of information network and information and communication technology (ICT).

Individual issues	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Train operation based on information networks	Integration technology of operation information		Base technology for information network infrastructure		
	Real-time train operation forecasting method Basic design of train control system		Radio based train operation and control system using information networks		
	Simulation of run over temporary turnouts for maintenance		Structure of temporary turnouts for maintenance		
Promotion of maintenance streamlining based on active use of ICT	Risk evaluation for overhead contact lines Life cycle cost calculation method		Lower maintenance overhead contact lines		
	Advanced technology for current collection system monitoring			Method of formulating overhead contact line maintenance plans	
	Risk-based maintenance model Fatigue crack monitoring method Wear of switch rails measuring method			Method of formulating track maintenance/renovation plans with minimized LCC	
	Image acquisition technology for structural deformation diagnosis			Imaging-based general inspection method	
	Cover concrete quality evaluation method			Operation and maintenance method based on RC-structure deformation prediction	
	Distributed autonomous system for truck condition monitoring Lower-maintenance bogies				
Energy conservation through energy networks	Development of an energy network controlling method based on energy consumption prediction			Estimation of the energy-saving effects using a sophisticated traction power simulation system	
	Rectifier for variable voltage			Power converter for high feeding voltage	
	Superconducting feeding cables for actual railway lines		Feeding system with superconducting cables		

Major Subject 3: Speed-up of the Shinkansen
R&D should be made on the environmental impacts along railway lines, the braking system, and the current collecting system that require big breakthroughs as the base technology for further speed-up of the Shinkansen.

Individual issues	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Reduction of environmental impacts along railway lines due to speed-up of the Shinkanse	Understanding of generation mechanism of aerodynamic noise and pressure variations in open air sections				
			Reduction of aerodynamic noise and pressure variations in open air sections		
	Prediction and reduction of tunnel micro-pressure wave with increased train speed				
			Understanding of ground vibration behavior with increased train speed and investigation of countermeasures		
	Anti-vibration measures based on track structure			Vibration-reducing slab tracks for Shinkansen trains	
Development of core technology for speed-up of the Shinkansen	Method of deceleration control				
	Development of disk brake system with heat-resistant disk, lining and high-power calipers				Evaluation by stopping-performance simulator
	Development of aerodynamic brakes and linear rail brakes				
	Lift estimation/compensation method		Pantographs for speed-up		
		High-strength contact wires	Catenary system for speed-up		

Major Subject 4: Construction of railway simulators
Coupling of individual simulation tools which analyze physical behavior of train operation characterising a railway system, to realize a comprehensive analysis.

Individual issues	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Construction of virtual railway testing tracks	Elastic track simulator / Elastic vehicle vibration analysis model Automatic model generation tool for overhead contact line Pantograph/catenary simulator Rolling contact analysis for one-bogie model Development of constitutive law for evaluation of deterioration behavior of rail and wheel Large-scale practical model of ballast and roadbed structures Ballast deterioration analysis model Virtual railway testing tracks				
Linkage of individual simulators	Common platform Coupling interface between simulators Airflow simulator for train sets Reliability evaluation of simulators Train operation/passenger behavior simulator for sophisticated train control Train operation/passenger behavior simulator including passenger's seating/standing position Elemental simulation technology for evaluation of telecommunication quality and electromagnetic environment along the railway lines Coupling technology of simulators				

(3) R&D of technology for practical use

Quick-impact issues on railway business should be tackled in order to timely and adequately provide practical results.

1) R&D designated by JR companies

R&D that can contribute to on-site solution of problems should be carried out, responding to various requests from JR companies and receiving concrete designation from them. In R&D, sufficient resources should be mobilized so as to meet needs of railway business and provide results promptly.

2) RTRI's voluntary R&D of technology for practical use

R&D on high-originality technology should be pursued, fully grasping railway business operators' needs, leveraging RTRI's characteristic facilities and analysis technology, and aiming at practical application to actual fields of railway business.

In addition, as for issues requiring high responsiveness, such as an accident or a disaster, an organization should be formed to manage two or more issues in a cross-sectorial manner to handle them, and solutions should be proposed quickly.

3) R&D commissioned by the Government or the public sector

R&D commissioned by the Government or the public sector should be undertaken in order to put results in practical use and make them widely used.

Examples of issues for R&D of technology for practical use are shown below (Table 3-2).

Table 3-2. Issues in "R&D of Technology for Practical Use"

R&D direction	Issue
Improvement of safety	Sophisticated railway damage simulator based on real-time earthquake waveform prediction
Cost reduction	Track-structure improvement planning system for regional railways
Harmony with the environment	Method of reducing micro-pressure waves through in-tunnel measures
Improvement of convenience	System to reduce vertical and rolling vibration on Shinkansen trains

(4) Basic research for railways

In order to solve various problems in railways and address challenges related to sources of innovative technologies, basic research for railways should be powerfully driven, aiming at clarification of mechanisms and phenomena; establishment of analytical, experimental, and evaluation methods; sophistication of simulation technology; and new technologies, material and research approaches. In the process of promoting research, the following five items should be tackled with higher priority, while research in new areas is pursued (Table 3-3).

- Prediction, detection, and prevention of phenomena of disasters
- Clarification of dynamic phenomena caused by train-traveling
- Elucidation of deterioration/damage mechanisms
- Improvement of the environment along railway lines and the global environment
- Improvement of safety with a focus on human factors

Table 3-3. Examples of "basic research for railways with higher implementation priority"

Item	Example
Prediction, detection, and prevention of phenomena of disasters	•Development of an algorithm for determination of frequency properties of a seismic source to support a new earthquake early warning method based on prediction of structural damage. •A snow distribution model considering snow transportation by winds is built to estimate the distribution of snowfall using meteorological data and an atmospheric simulation model.
Clarification of dynamic phenomena caused by train-traveling	•Clarification of the mechanism behind reduction phenomena of traction force based on evaluation of factors influencing traction characteristics in a cooled environment through experimental and numerical simulation. •Elucidation of safety of the ballasted track in earthquakes by coupled numerical simulation tools evaluating dynamic interaction between structures, tracks and vehicles.
Elucidation of deterioration/damage mechanisms	•Evaluation of fatigue crack propagation using axle stress histograms and crack growth testing under valuable stress condition in order to assess inspection interval for railway axles. •Elucidation of the wear mode transition mechanism of current collecting materials for wear reduction measures and material development. •Verification of the applicability of alkalization-suppressing hydrogen ion-exchange material to mitigate forms of deterioration such as concrete cracking caused by high alkalization reaction
Improvement of the environment along railway lines and the global environment	•Establishment of a noise prediction method for complex landscapes based on numerical simulation, acoustic model experimentation and other approaches for use in the environment along railway lines •To grasp characteristics of radio frequency disturbance such as frequency spectrum distribution and time variation of field strength to improve signaling equipment and radio communication systems in characteristics of immunity to electromagnetic disturbances.
Improvement of safety with a focus on human factors	•Experimentation with various physiological indices evaluation (such as brain activity monitoring) to clarify physiological and psychological changes that may interfere with train operation toward the development of a method for monitoring operational status for driver support •Clarification of the mechanism of insufficient contact among railway workers and miscommunication between them to prevent accidents caused by these factors.

Furthermore, research activities on Maglev Systems should be conducted continuously with a focus on application of superconductivity, linear motors, and other technologies to conventional railways as a main axis, and simultaneously perform, as basic research, R&D for maintaining technical capabilities needed for such activities.

(5) Facilities and equipment for research and testing

Original facilities and equipment for research should be newly introduced; those facilities should be directly connected to R&D activities in fields where RTRI intends to realize railway innovation. In addition, as for test facilities whose performance has declined over time too grossly to meet R&D needs, their functional improvement or renewal should be carried out, in addition to new construction of experiment buildings (Table 3-4).

Table 3-4. Summary of major test facilities

Type	Outline
Pantograph testing equipment	Conduct evaluation tests on current collection performance of a pantograph during high-speed running by a rotating disk simulating dynamic behavior of an overhead contact line.
Model apparatus for testing to clarify aerodynamic phenomena	Construct a 1/30-scale model train to shoot out and reproduce aerodynamics phenomena observed during train running, including sound generated from a train during high-speed running.
Bogie/wheelset load test equipment	Evaluate fatigue strength and dynamic properties for railway bogie parts and wheelsets by applying vertical and horizontal loads onto full-scale bogies.
Renewal of large-scale low-noise wind tunnel equipment	Renew the control panel, the main motor for the main fan and the air cooling system.

3.2.2 Investigation

RTRI should grasp social, economic, and technological changes, and then collect and analyze various types of information generated in Japan and foreign countries that is necessary for its contribution to technical development of railway business operators. To make sure, results of such activities should be transmitted to parties concerned. RTRI should also predict the future status of railways and conduct necessary investigations to choose technical issues for its R&D objectives.

3.2.3 Technical Standard Services

In accordance with the rising importance of management and maintenance of society's infrastructure and the Japanese Government movement toward performance specification of technical standards, RTRI should promote formulation and arrangement of design standards, maintenance management standards, and design calculation examples of infrastructure. Technical fields, such as vehicles, where new technical standards should be formulated and thus systematization is needed should be clarified, so that tasks such as formulation of design standards in these fields can proceed smoothly.

3.2.4 Information Services

RTRI should collect and accumulate information on Japanese and foreign railway technologies. It should also leverage various channels, such as mass media and the Internet, and transmit R&D results

and activity status in a planned and timely manner. It should play a role as a source to send timely and precise railway technical information to the public.

3.2.5 Publishing and Training

RTRI should make more complete the contents of its periodicals, such as the RTRI Report and RRR, lecture presentations, and technical forums. Through these instruments, R&D results of RTRI should be offered widely to the public. The courses of lectures on railway technology and other lecture presentations should be systematic, corresponding to levels of beginners to experts.

3.2.6 Diagnosis and Consulting

RTRI should respond to requests from railway companies to continuously and positively carry out its mission. Especially in offering a consulting service on response to a disaster or equipment failure, quick response should be taken in a tie up with the railway company involved. Furthermore, consulting services for local railway companies should be enhanced by making site visits and giving technical advice.

3.2.7 International Standardization

RTRI should promote, in a strategic way, activities related to the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO). In particular, RTRI should actively participate in operation of TC 269 (Railway Applications), newly established in ISO in April 2012, strengthen its resources, and press on projects such as "rail project planning" which Japan proposes. And at the same time, RTRI should exercise leadership in standardization activities in the fields of operations and services where Japan has technical predominance.

3.2.8 Qualifications

With a focus on accreditation tests for Professional Railway Design Engineers, RTRI should build up and arrange improvements of examination opportunities for applicants through overall verifications of the tests, thereby contributing to the enhancement and maintenance of the technical level of railway engineers.

3.2.9 Railway Technology Promotion Center

RTRI should contribute to a technical level increase in the railway industry by promoting related business while taking, as pillars, systematization of technologies and problem solving, enhancement and maintenance of technical capabilities, and technical information services. For this purpose, it should tackle new research and study useful for systematization of the vehicle technology, and simultaneously offer technical support to local railways and encourage technology succession by

positively applying knowledge of "Rail Advisers." In addition, contents of the safety database should be enriched through intensified research and analysis activities in the human factor field.

3.2.10 Railway International Standard Center

RTRI should promote strategic activities aimed at introducing Japanese technical specifications and concepts into international standards. It should actively exchange information with European and Asian standardization bodies and intensify the partnerships with them, and also boost up educational activities on international standards for parties concerned and human resource development activities.

3.2.11 International Activities

For the purpose of further improvement of technical capabilities and presence of RTRI, joint studies with foreign universities and research bodies should be expanded. Exchange of researchers should be promoted by sending more RTRI researchers abroad and receiving more foreign experts. Specifically, RTRI should actively take part in the World Congress on Railway Research (WCRR) as a member of the Organizing Committee, going ahead with preparation and management of the WCRR meeting to be held in Tokyo in FY 2019. RTRI should also aspire to organize international workshops and join various types of international conferences to exchange information on the latest railway technologies. RTRI researchers should be sent overseas to investigate global railway conditions and technologies.

RTRI should contribute to wider application of Japanese railway technologies in the world by providing active support for railway business operators and railway-related businesses, assisting overseas deployment of intellectual properties, and offering guidance to engineers in foreign countries.

3.3 Profit-Making Business

RTRI should promote R&D to respond to individual requests, including those related to unique technical issues of each railway business operator, in order to put R&D results to practical use and spread them widely to the public. RTRI should carry out these activities with focus on system integration and technology consulting as main pillars, while meeting needs outside the railway industry.

In pursuing business, RTRI should acquire clients by linking together various types of information transmission activities such as lecture meetings and presentation sessions and win the confidence of clients by rigorously boosting quality control of its R&D results. Furthermore, RTRI's business base should be reinforced by bringing into execution exhaustive income and expenditure management while securing its financial revenues and pursuing business efficiency.

4. Management

4.1 Basic Stance on Management

As a public interest incorporated foundation, RTRI should be committed to sound management, observing laws and regulations and its articles of incorporation. At the same time, it should consolidate confidence of the public in RTRI through fulfillment of its social responsibilities and enhancement of researchers' morality and conduct.

RTRI should reinforce personnel in technical fields where to attach higher priority in its R&D, so that its limited human resources will be effectively deployed and business efficiency will be further increased.

Aiming at fostering researchers capable of meeting needs of railway business operators and tackling R&D activities necessary for innovation, RTRI should enrich educational programs and promote steady technology succession while making active personnel exchanges with JR companies and other railway business operators. In addition, by sending researchers abroad, it should foster human resources that can keep up with global expansion of railways.

Though RTRI has decreased the amount of debt repayment to the Development Bank of Japan, Inc. (DBJ), more efforts to streamline the entire management are necessary along with a sound financial plan, in order to construct or update test facilities according to a long-term plan.

4.2 Compliance

In view of its status as a public interest incorporated foundation, RTRI should endeavor to reinforce compliance, more strictly observing laws and regulations and its articles of incorporation. In particular, RTRI should encourage its researchers and experts to respect ethical values more and provide continuing education through training and OJT with an emphasis on fairness and honesty in R&D. In addition to this policy, RTRI should control information in a strict manner.

4.3 Human Resources

4.3.1 Human Resource Securement

RTRI should secure human resources needed in technical fields it attaches importance to from medium- and long-term standpoints and also hire new personnel according to the plan.

It should also enhance partnerships with universities and research institutes to make RTRI better known and recruit from a variety of sources to secure necessary human resources. Experienced personnel should be also employed, taking into account a balance of age structure and fields of specialization to be strengthened.

4.3.2 Human Resource Development

RTRI should foster researchers who will become familiar with railway situations on site and capable of actively participating in R&D projects corresponding to needs of railway business operators or aimed at advanced technologies. For this purpose, OJT should be actively introduced in each technical field, and systematic educational programs should be implemented to realize steady technology succession.

Personnel exchange with JR companies and other railway business operators should be more positively pursued, involving not only young researchers but also managerial officials.

Toward the development of human resources that can cope with globalization, RTRI should promote personnel exchange with foreign universities and research institutes engaged in unique technical challenges through collective research, overseas contract research schemes, etc.

Researchers should be encouraged to acquire relevant qualifications and participate in activities of academic society and related associations so as to enlighten themselves and accumulate expertise.

4.3.3 Work Climate

RTRI should reinforce its efforts such as on workplace safety, mental health, and work-life balance, so that it can offer an environment to its personnel where they can work without undue worries and enjoy health both physically and mentally. The environment should be managed with a goal that diversity concerning age, gender, and culture is respected; unfettered discussions are habitually conducted by researchers in various fields with a feeling of unity; and personnel can tackle R&D with a sense of living worthwhile lives.

4.4 Personnel

In order to produce innovative and high-quality R&D results, RTRI should enhance personnel in advanced, unique, and new technical fields of its R&D activities. However, outside R&D operations, the current personnel number should be the norm except in international standards services, which

should be strengthened with additional personnel. To avoid discontinuity in technology, RTRI should recruit 15 or so new staff every fiscal year. In the latter half of the Master Plan implementation period, the number of personnel should be 550 (Table 4-1).

Table 4-1. Numbers of Personnel

(Unit: persons)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
R&D, etc.	424	420	430	435	440	440
Investigation/International standards services, etc.	23	25	25	25	25	25
Profit-making business	40	40	40	40	40	40
Management	47	45	45	45	45	45
Total	534	530	540	545	550	550

Note: The figures of FY 2014 are those planned at the fiscal year beginning.

4.5 Balance of Payments

Income for shared services should be handled with consideration of the uncertain outlook for the future economy, including an influence of raised consumption tax. Though RTRI has decreased the amount of debt repayment to DBJ, it needs to increase personnel in focused technical fields and furthermore construct original test facilities and update aged equipment. Accordingly, stringent control should be made on income and expenditure management so as to maximize budget efficiency. Deficit revenue should be compensated by a reversal of reserves on the construction loan for the Yamanashi Maglev Test Line (Table 4-2). New reserves for future equipment renewal should also be booked.

4.5.1 Revenue

(1) Income from shared services

With reference to business performance of JR companies in the first half of FY 2014, this income in each fiscal year from FY 2015 to FY 2017 is estimated to be the same as the actual business result in FY 2014. After this period, the influence of raised consumption tax is taken into account.

(2) Operating revenue

Though profit-making business is being made in a tough situation, RTRI should make more marketing efforts to secure revenue.

(3) Subsidies and other income

RTRI should request DBJ to continue to grant subsidies for interest related to repayment of debt to the Bank. In addition, government grants and competitive funds should be proactively introduced for continued and constructive efforts in original and creative R&D.

4.5.2 Expenditure

(1) Personnel expenses

Personnel expenses should be subject to a staffing plan.

(2) Research and development expenses

For this disbursement, consideration should be given to the enhancement of R&D activities toward the future of railways, initiative in R&D of technology for practical use, and powerful advancement of basic research for railways.

(3) Expenditure on fixed asset acquisition

These expenditures should be used for new construction and renewal of test facilities and other activities that are needed to take safety measures and deterioration countermeasures. The amount of expenditures for fixed asset acquisition in each fiscal year should be decided, taking into consideration an equipment plan and a repayment state to DBJ.

(4) Repayments to DBJ

A contractual amount of repayment to DBJ should be covered by this budget.

4.5.3 Special Assets

The amount of reserves for the construction loan for the Yamanashi Maglev Test Line should be reduced in stages through appropriation for repayment to DBJ. Incidentally, new reserves for future construction and renewal of test facilities and the like should be earmarked.

Table 4-2. Expenditures

(Unit: billion yen)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	Total
Revenues	Income from shared services	13.6	13.7	13.7	13.7	13.2	13.2	67.7
	Operating revenue	3.4	3.0	3.0	3.0	3.0	3.0	15.2
	Profit-making business revenue	*3.3*	*2.9*	*2.9*	*2.9*	*2.9*	*2.9*	*14.5*
	Revenue of business for public interest purposes	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.7*
	Subsidies and the like	0.3	0.1	0.0	0.0	0.0	0.0	0.3
	DBJ-related interest	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.3*
	Membership fees	0.2	0.2	0.2	0.2	0.2	0.2	1.1
	Other income	0.2	0.1	0.1	0.1	0.1	0.1	0.9
	Reduction of special assets	0.3	1.0	1.1	1.3	0.7	0.2	4.5
	Gross income	**18.4**	**18.3**	**18.5**	**18.6**	**17.4**	**16.8**	89.9
Expenditures	Personnel expenses	5.6	5.5	5.7	5.8	5.8	6.0	29.0
	Equipment expenses	2.6	2.6	2.6	2.6	2.6	2.6	13.4
	Research and development expenses	2.6	2.6	2.6	2.7	2.7	2.7	13.3
	R&D toward future railways	*0.7*	*0.7*	*0.7*	*0.8*	*0.8*	*0.8*	*3.8*
	R&D of technology for practical use	*0.8*	*1.1*	*1.1*	*1.1*	*1.1*	*1.1*	*5.5*
	Basic research for railways	*0.9*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*4.0*
	(R&D designated by JR companies)	*(1.0)*	*(1.0)*	*(1.0)*	*(1.1)*	*(1.1)*	*(1.1)*	*(5.3)*
	Profit-making business costs	2.2	1.9	1.9	1.9	1.9	1.9	9.8
	Technical standard service costs	0.1	0.1	0.1	0.1	0.1	0.1	0.7
	Other operating costs	0.3	0.2	0.2	0.2	0.2	0.2	1.3
	Expenditure on fixed asset acquisition	0.7	1.1	1.2	1.6	1.7	1.8	7.4
	Repayments to DBJ	3.7	3.9	3.8	3.4	2.0	1.1	14.3
	Reserve fund	0.1	0.1	0.1	0.1	0.1	0.1	0.5
	Total expenditure	18.4	18.3	18.5	18.6	17.4	16.8	89.9

Note: The figures of FY 2014 are budget amounts planned at the fiscal year beginning.
FY 2014 R&D expenses include expenditures from governmental subsidies
Rounding of fractions may cause inconsistency in total values.

5. Concluding Remarks

The Master Plan RESEARCH 2020 is an implementation plan we have finalized for RTRI's activities from April 2015 to March 2020.

The Shinkansen has achieved great innovation while increasing the value of railways and contributing to social development, which has given a big incentive to us.

Therefore, we have adopted R&D aimed at further railway innovation in our basic action policies. We will dynamically promote R&D activities and create high-quality results to earn the trust of society. We think it is important in pursuing R&D to leverage comprehensive strength of our institute by mobilizing, for example, vibrant researchers, original research equipment, and accumulated data and know-how. Moreover, RTRI respects motivation in life of each researcher and staff member.

We promise that RTRI will make an all-out effort in implementing the Master Plan RESEARCH 2020, following the vision "We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society."