

The Tenth Five-year Plan and 2015 Long-term Programs of the Railway Scientific and Technological Development

Ministry of Railways, P. R. China

Abstract: This paper elaborates the principles of preparation for the Tenth Five-Year Plan & the 2015 Long-term Programs of the railway scientific and technological development, and it describes the objectives of the development, key tasks and supporting conditions. It points out that major technical equipment on the Chinese railways will come close to the 20th century international level by the end of Tenth Five-year Plan period.

Key words: railway development; progress of science and technology; technical innovation; high-speed technology; information technology; safety technology; environmental protection technology; design and construction technology; urban rail mass transit technology; fast passenger transport; rapid freight transport; heavy-haul transport

1. The Guiding Principles for the Preparation Work:

- (1) Highlighting the objectives of the railways and enhancing market-oriented concept
- (2) Improving the innovation ability and realizing great technical advances.
- (3) Persisting in stressing the key tasks and optimizing the allocation of resources.
- (4) Intensifying system integration and increasing comprehensive capacity

2. Objectives:

- (1) To popularize the relevant technologies of train maximum traveling speed at 160km/h. The maximum running speeds of passenger trains shall reach 140-160km/h on the existing busy trunk lines and 120km/h on the other lines, forming up a fast passenger transport network covering the major cities in China.
 - (2) To successfully design and manufacture the complete technical equipment for dedicated passenger service line of over 160km/h and build the Jingshen fast passenger transport corridor.
 - (3) To breakthrough the complete technology of high-speed railway, successfully design and manufacture high-speed electric multiple unit (EMU) train of 270km/h and to master the relevant technology of building high-speed railways and to start construction of high-speed railways.
 - (4) To further improve the freight heavy-haul system and actively develop the 25t low dynamics 4-axle heavy-duty wagons.
 - (5) To form up a preliminary rapid freight transport network with maximum running speed of rapid freight train at 120km/h and ordinary freight train at 90km/h.
 - (6) To promote the railway informatization with full efforts, develop the broadband digital communication network for synthetic business, and to basically set up railway management information system for comprehensive operation.
 - (7) To make substantial progress in the technical equipment for train running safety, and to set up a safety monitoring network by integrating the monitoring, controlling and management with high-level informatization.
 - (8) To accelerate the development of electric traction and AC transmission technology. By adopting electric traction on all major busy trunk lines, dedicated passenger service lines, and dedicated coal transportation line etc., to realize the upgrades and renewals of the traction mode.
 - (9) To improve the railway construction technology, introduce the integrated and intelligent survey and design, actively adopt advanced construction techniques and equipment, and to master the construction technology for constructing Qinghai-Tibet Railway.
- By the end of the Tenth Five-year Plan period, the major technical equipment on the Chinese railways will come close to the international level by the end of the 20th century.

2.1 The Objectives of the 2015 Long-term Programs

By 2015, improving railway industries with high tech will make a great progress. Railway informatization will basically come true. The high-speed technology will be mastered totally, and dedicated passenger service technology will be extended. Rapid transport network for both

passenger and freight traffic will cover the whole country, and the improved train operation safety system will be set up. Modern railway technology system with China's characteristics, which meets the sustainable development demand, will take shape.

3. Key Tasks for the Railway Scientific and Technical Development

The key tasks in the Tenth Five-year Plan and 2015 Long-term Programs of the Railway Scientific and Technological Development can be classified into 3 aspects.

3.1 Developing High tech, and Realizing Great Technical Advances

3.1.1 Overall application of information technology, and accelerate the railway informatization with full efforts

The key tasks in the aspect of information technology during the Tenth Five-year Plan period are:

(1) Study railway informatization system structure and digital railway technology, integrate systems to introduce the sharing of information resources. Stipulate relevant standard, specifications and management rules, and establish a basic platform for railway informatization development and application;

(2) Improve railway transportation management information system, focus on the study of the comprehensive applications of data base with 3-level raw information and system installed with 4-level raw information, the network safety and system structure adjustment. Develop and install the management information system mainly including waybills, train dispatching and train number information to real-time trace trains, cars, locomotives, containers and commodities. Accelerate the study on DMIS by taking the train-dispatching control as the main body and realize "transparent" traffic control. Set up comprehension maintenance management system the for railway information system;

(3) Study the optimization and upgrades of the national-wide passenger ticket booking and reservation system, and study the reliability and safety of the network operation as well as the management information system of luggage & postal traffic;

(4) Develop the railway finance management system of railway transport costing and revenue clearing adequate to the reform of railway business management system, study transportation enterprise marketing strategies and public information inquiry service system;

(5) Study the security authentication technology of electronic digital data exchanges and railway logistics information system, and promoted railway electronic business;

(6) Study the relevant technology of the modernization of railway office system, set up government web sites and office network system at all railway levels, and develop the supporting system for business management decision-making;

(7) Study key technology of railway intelligent transportation system, develop the applications of micro-electric and information technology in the field of production process control, and study the integration technology of product and the engineering design and manufacturing technology.

(8) Study the railway informatization telecommunication network demand, its security protection and mode of application, develop the relevant technologies of information collection, processing and transmission.

During the Tenth Five-year Plan period, railway transportation management information system will be established to realize internet management at marshalling yards, major stations and freight traffic stations in order to realize real-time tracing of trains, cars, commodities and containers. Set up passenger traffic management information system mainly in passenger traffic control, passenger flow control, ticketing system and luggage & parcel management system and set up traffic control management information system on all the major busy trunk lines. Establish the railway cost accounting and revenue clearing system to realize the informatization of finance management and network links of the railway office system for the purpose of progressively setting up the railway intelligent transport system. Basically establish the information system of railway comprehension operation management.

By 2015, on the basis of wide application of all information systems, the railway informatization will be further improved. Focusing on the development of the comprehensive passenger service system,

establish the freight traffic service system with the functions of real-time information processing, set up intelligent decision-making system, and develop the office automation system with new functions of forecast, and decision making etc. Building up national wide comprehensive electronic business system and digital railway. The railway informatization will be basically introduced.

3.1.2 Establishing the Safety Monitoring Network to Form a Safety Equipment Protection System

During the Tenth Five-year Plan period, the key tasks in the aspect of transport safety are:

- (1) Study and improve the safety technologies of self monitoring, self-diagnosis and self-control of the moving equipment and research on moving equipment with the technology of monitoring the fixed facilities e.g. track and catenary etc. Research on the information exchange system between the moving and track-side equipment and the relevant technology;
- (2) Research on the development of supervision technology and supervision equipment to the running performance of locomotives and rolling stocks and on the loading state of commodities, form a track-side network to monitor rolling stocks and the loading condition;
- (3) Research on and manufacture multi-purpose safety inspection car of running speed at 200km/h measuring the track condition, track and rail dynamics, inspect the telecommunication and signals, and carry out pantograph and catenary as well as environment image inspection;
- (4) Research on fast speed rail flaw detection car of speed at 80km/h;
- (5) Develop the technology on the forecast, prevention and rectification of the hideous disasters, e.g. mud flow, flood and landslide. Research on the condition inspection, monitoring and rehabilitation technology on the hidden structures, e.g. tunnels, bridges, culverts and track formation. Developing the research on endurance technology of bridge and tunnels;
- (6) Research on the automatic protection and automatic control devices on trains of different speeds. Improve signal safety protection system;
- (7) Study the technology and equipment for accident rescue, rapid repair, accelerate the modernization of rescue measures;
- (8) Study the relevant technology of safe transportation of dangerous goods.

During the Tenth Five-year Plan period, taking the monitoring system for train running performance on Shanghai - Nanjing line as a pilot program, the train running safety monitoring network will be preliminarily formed up on the major busy trunk lines of Jinghu, Jingguang, Jingjiu (including Guangshen line), Longhai and Zhegan (including Huhang) lines. Promote the wide application of all kinds of safety comprehensive inspection car and fast-speed rail detection car. Realize the dynamic inspection on fixed facilities such as tracks and catenary etc., realize the supervision from the train borne equipment. Introduce on-line automatic inspection, remote fault diagnosis, fault forecast and alarming signaling system at the centralized interlocking station. Enhance the inspection on the performance of wagon and loading condition, establish train operation accident analysis system and fast rescue and restoring system.

By 2015, a proper safety supervision network of "train to track-side", "Track-side to train" "train to train" and "track-side to track-side" shall be established. By adopting the engineering technology and theory of man-machine-environment to form a safety loop system of machine-control domination, man-control priority and man-machine control interface. Set up the train operation safety system to cover different grade railway lines in the whole railway system.

3.1.3 Developing High-speed Technology and Constructing High-speed Railway Lines.

The key tasks in the aspect of high-tech during the Tenth Five-year Plan period are:

- (1) Research on the track structure technology on high-speed railway lines, technology of rehabilitation of track formation in difficult section and the technologies of after-work settlement control, high-speed turnouts and traction power supply technology, technology of high-speed railway inspection, maintenance repair, and the technology for the design and construction of immersed tube tunnel and long-span bridge. Carry out the comprehensive experiment of high-speed railway;
- (2) Research on the dynamics of high-speed trains, high-speed bogies, vibration and noise reduction technology, AC traction-transmission technology, braking technology, high-speed current pantographing technology, aero-dynamic features, technology of light-weight design and technology

of car-body material and structure for air tightness design and technology of high-speed and train borne network control system;

(3) Research on the development of the integration of train dispatching control, automatic train control, safety supervision control and comprehensive information management on the intelligent control system over the whole train operation process;

(4) Research on the self-diagnosis of technical equipment in train operation, natural disaster pre-warning system, intruder supervision system, comprehensive safety supervision system including accident site quick response system and the accident rescue system;

(5) Research on the high-speed train transport organization and management approach, research on the automatic preparation and review of high-speed train working diagram. Research on the high efficient operational management system, the optimized organization solution of the high-speed and the existing lines. Research on the organization measures which can tap the full potential of the high-speed and the existing lines to generate comprehensive benefit;

(6) Research on the major technical and economic issues of the application of the high-speed maglev train on the long trunk line. Research on the design parameters for the magnetic lines, guide-way design and the manufacturing technology, key technology of the maglev train, power supply technology and train group control technology and transportation organization solution.

During the Tenth Five-year Plan period, a comprehensive experiment on high-speed railway shall be completed, 270km/h high-speed train shall be designed and manufactured and the industrialization shall be realized, the high-speed sample train of 300km/h shall be further developed. At the same time Jinghu railway line shall be under construction.

By the year 2015, high-speed railway system technology shall be totally mastered with the ability of manufacturing complete high-speed railway technical facilities.

3.1.4 Developing the Railway Environment Protection Technology to Cope with the Demand of Sustainable Development

During the Tenth Five-year plan period, major tasks in the aspect of environment protection technology are:

(1) Vigorously research on the comprehensive technology of railway noise and vibration control, develop the technology of reducing vibration and noise of trains, bridge and track structure, noise barrier utilization and track noise absorption technology;

(2) Research on the technology of passenger train vacuum toilet and the track-side waste collection system and passenger train waste disposal, research on the classification and disposal of the passenger train solid waste and start pilot construction program and research on the technology of the diesel locomotive exhaust emission control;

(3) Research on the technology of the electromagnetic emission protection and the technologies of power factor compensation and harmonic wave control;

(4) Develop the study on the system of evaluation on environmental effect caused by railway construction works, approach and standards for the evaluation on the water loss and earth erosion caused by railway engineering works as well as the prevention and control solutions;

(5) Launch the study of solutions for the emergent control of environmental pollution caused by dangerous goods traffic accident.

During the Tenth Five-year Plan period, a demonstration line satisfying the requirements of evaluation on environment pollution control shall be completed, railway shall become an environmental friendly transportation mode in the new century.

By 2015, the railways transport shall be basically with beautiful environment and with advanced technology to cope with the sustainable development.

3.2 Strengthening the Technical Innovation to Promote the Upgrades of the Railway Industries

During the Tenth Five-year Plan period, breakthrough of research on technologies shall be achieved and application of advanced technology shall be promoted to realize the industrialization. The technical development projects to provide technical upgrading services to the railway conventional industries can be classified into 6 fields.

3.2.1 Improving Fast Passenger Service Technology and Establishing Fast Passenger Service Network

In the Tenth Five-year Plan period, key tasks of the fast passenger service technology are:

- (1) Research on and prepare the raising speed plan and the technical requirements of raising speed on the existing lines in the railway Tenth Five-year Plan period;
 - (2) Research on the safety and reliability of the technical equipment for further raising the passenger traffic system of 160km/h;
 - (3) Research on the electric and diesel multiple units and tilting trains to meet the demand of further increasing speeds;
 - (4) Research on the technical equipment of taking the cab signal as dominating signal in the increased speed section;
 - (5) Research on the technologies of state evaluation, fault diagnosis and strengthening of roadbed, track, bridge and tunnel in the higher speed section;
 - (6) Research on the permanent way equipment adapted to the Chinese railway characteristics and develop the study in shortening the occupation for the maintenance of double track line and the study of track maintenance work done by comprehensive machinery in the scheduled "window" time.
- During the Tenth Five-year Plan period, the route length of speed raising line will be further prolonged. It shall be taken into consideration in the new line construction. The technology of fast passenger service at the maximum speed of 160km/h shall be promoted on the existing busy trunk lines. The complete system of higher speed technical equipment including fixed equipment, moving equipment, operation and maintenance management with the characteristics of the Chinese Railways shall be established. By 2005, a fast passenger service network taking Beijing, Shanghai and Guangzhou as centers and connecting all the major cities in China shall be preliminary established. The total route length shall be 14,000km - 16,000km to realize the passenger train organization of "departure at morning and arrival at evening" at the traveling distance around 500km, "departure at evening and arrival at morning" at the distance between 1200-1500km and "arrival within one day" at the distance between 2000km-2500km.

3.2.2 Researching on and Manufacturing the Complete Equipment of Trains of over 160km /h. Completing the Construction of Beijing-Shenyang Fast Railway Passenger Service Corridor.

The key tasks of researching on the complete technology of trains at over 160km/h in the Tenth Five-year Plan period are:

- 1) Research on and manufacture AC electrical multiple unit and AC passenger traffic electric locomotive at 200km/h;
- 2) Research on and manufacture the key and complete equipment of safety monitoring and comprehensive automation of the traction sub-station, and catenary and suspension system and main equipment;
- 3) Research and develop comprehensive traffic control system, local computerized interlocking system, the auxiliary technology and equipment;
- 4) Research on train control system based on non-insulated digital coding track circuits and taking locomotive cab signals as operational token, research on the integration of traffic control and interlocking as well as the auxiliary equipment;
- 5) Research on the technology of non-ballast track structure, the laying equipment and the complete equipment for laying seamless rail for more than one sections in one work process and the key technology;
- 6) Research on the complete equipment and key technology for bridge manufacturing and erection. Research on the equipment for roadbed quality monitoring and inspecting;
- 7) Carry out the comprehensive running test for Beijing-Shenyang fast railway passenger service corridor.

Obtain the complete technology for construction and rehabilitation of the tracks for train running at over 160km/h and complete the construction of the Beijing-Shenyang fast railway passenger service corridor. Conduct comprehensive test on the construction of Qinshen dedicated passenger service line in the Tenth Five-year Plan period. The experimental speed shall be over 250km/h to accumulate experience and provide technology for the construction of other dedicated passenger service and high-speed railway corridors.

3.2.3 Researching on Rapid Freight Transportation Technology to Establish a Rapid Freight Transportation System

The key tasks of developing rapid freight transportation technology in the Tenth Five Year Plan Period are:

- 1) Develop and improve the technology of manufacturing of 120km/h freight locomotive and wagons. Research on a new type of freight wagon to meet the demand of high value-added cargoes and research on the technology of running mixed trains of both passenger and freight traffic;
- 2) Research on the relevant technology of multi-mode container transportation. Develop and research on special wagons and traffic organization as well as special handling equipment for container transportation;
- 3) Develop new type of refrigerator wagon, research on traffic organization and management system for fast transportation of cargo refrigeration;
- 4) Research on the whole freight traffic process control management system and the train formation plan for through and fast freight trains;
- 5) Research on freight traffic organization for unit train and the requirement of loading and offloading equipment and the related upgrading solutions for the marshalling yard and related stations;
- 6) Research on the technical requirements for fast freight train loading and fastening, and the technical requirements for safe crossing of fast freight trains;
- 7) Complete the modification of Model Rotating 8A bogie, adopt high wearable braking blocks to enable freight trains running at 90km/h and to increase the line passing capacity.

The tasks during the Tenth Five -year Plan period are to further improve the organization work of running "trains of five scheduled items", "container block trains" and "rapid freight trains". Efforts shall be made to run fast freight trains between the 30 major and medium cities in the railway network in the manner of running inter-city passenger trains and to establish the rapid freight transportation system on the three main trunk lines.

3.2.4 Developing Heavy Haul Transportation Technology, and Improving the Heavy-haul Transportation System

The key tasks for developing the heavy-haul transportation system in the Tenth Five-year Plan period are:

- 1) Improving the technology for manufacturing wagons of 25ton axle load with low dynamics;
- 2) Improving the complete technology of running 5,000ton heavy haul freight trains and the special heavy haul trains for dedicated coal transportation;
- 3) Research on the structure of track and bridge suitable for 25ton axle-load transportation. Improving the technology of bridge fatigue evaluation and bridge consolidation. Research on the live-load standards for bridge dynamic load design, review the live-load chart for bridge designing;
- 4) Research on manufacturing of 25ton axle-load double-stack container transportation wagons. Research on the establishment of double stack container transportation routes.

During the Tenth Five-year Plan Period, 25ton axle-load low dynamic wagons and double stack container wagons shall be manufactured and heavy haul trains of over 5000 tons shall be running on the coal transportation main lines.

Running of over 5000 tons heavy haul freight trains on the busy trunk lines of Beijing-Shanghai, Beijing-Guangzhou, Beijing-Kowloon, Beijing-Harbin, Shijiazhuang-Dezhou, Zhengzhou-Xuzhou to form the heavy-haul transportation system covering the whole railway network to cope with the speed raising of the passenger trains.

3.2.5 Researching on the Technologies of Construction and Operational Management of Qinghai-Tibet Railway and Start the Construction of the Qinghai-Tibet Railway

The key tasks of Qinghai-Tibet Railway Construction during the Tenth Five-year Plan Period are:

- 1) Research on the design approach, principle and standard of Qinghai-Tibet Railway to be constructed in the plateau permafrost area;
- 2) Research on the new structures of tracks, bridges and tunnels, new construction materials and the related construction technology and machinery for the construction of Qinghai-Tibet Railway;
- 3) Research on the locomotives and rolling stocks to be used in permafrost area on plateau as well as telecommunication and signaling technology and equipment;

- 4) Research on the technology and equipment for Qinghai-Tibet Railway inspection and maintenance work;
 - 5) Research on the operational cost, traffic organization and operational management system of the Qinghai-Tibet Railway;
 - 6) Research on the technology and measures for environmental protection during the construction and operational period of Qinghai-Tibet Railway;
 - 7) Research on the technology of survey, design and construction of railway in the difficult geology sections haunted by natural disasters in the traverse fault mountain areas.
- Reliable technology and equipment shall be provided in the Tenth Five-year Plan Period for the construction of the Qinghai-Tibet Railway with high level, high quality and High standard.

3.2.6 Researching on the Technology of Urban Rail Transit System, and Providing Complete Equipment for the New Generation of Urban Rail Transit

The key tasks of the urban rail transit technology development during the Tenth Five-year Plan Period are:

- 1) Research on the technologies of urban rail transit, AC transmission technology, safety inspection equipment, and new bogie and computerized control analogue braking system. Develop a new generation of multiple unit train for urban rail transit and for short distance service;
- 2) Research on the technology of medium and slow speed maglev trains for urban rail transit;
- 3) Research on the technology of new track structure, signaling and control equipment for urban rail transit;
- 4) Research on the technology of environmental protection of reducing vibration and noise and comprehensive control measures for urban rail transit and regional railways;
- 5) Research on the technology of integrating the national railway, urban rail transit and regional railway systematically.

A complete set of advanced technical equipment of domestic-made trains, signaling and controlling equipment shall be provided during the Tenth Five-year Plan period.

3.3 Strengthening Research Work on Basic Theories and Providing Technical Support

Promote the development of basic theory research work, the testing approaches and the railway standardization, metrology and quality control, totally in six areas:

3.3.1 Strengthening Research Work on Basic Theories

The research work on wheel and rail relation, pantograph and catenary relation, train aerodynamics, train-track-bridge dynamics, electric and magnetic comparability, research on the theory of structure and equipment reliability and the theory on calculation of the transportation capacity shall be promoted in areas of high-speed, high safety and information technologies.

3.3.2 Enforcing the Construction of Testing Base

Attention shall be paid to the construction of the railway scientific and technological testing base in the period of the Tenth Five-year Plan period. Strengthen the information exchanges with National Transformer technological engineering Research Center, National traction power Laboratory, Transportation simulation and automation laboratories. Establish national railway intelligent transportation systematic engineering research center. Establish Ministerial laboratory loop line testing center aiming at being adopted into the national key laboratory construction scheme.

3.3.3 Further Improving Railway Standardization and Metrological System and Strengthening Technical Supervision and Quality Control Work

Establish and improve the technical supervision and quality control system on the principle of "focus on quality control by taking the standardization and metrology as a foundation". Vigorously adopt international standards and advanced standards abroad to establish a standardization and measurement system to accommodating the international standards and the development of the Chinese Railways. By the end of Tenth Five Year Plan period, the standardization shall cover more than 80% of the railway major and special products, the compulsory measuring tools and exclusive

and major railway measuring tools shall be inspected by 100%, and the qualification rate should be over 95%. The quality control work shall be strengthened by strict control of issuing the Production Permit and Special Production Permit and establishing and practicing the Quality Certificate Authentication System.

3.3.4 Vigorously Developing the Railway Soft Science Research Work

During the Tenth Five Year Plan period, attention shall be paid to the research on the major issues relating to the strategy of railway development, such as the implementation of separating the infrastructure from the operation, restructuring of the railway operational enterprises and the management system, improving the railway legislation system, railway traffic forecast and railway financing policy etc.

3.3.5 Vigorously Developing the Research Work on Energy Saving and Comprehensive Utilization of Resources

Encourage and support the technical innovation, promotion and industrialization of the new technology on energy saving and comprehensive utilization of resources. Vigorously promote the technology on the comprehensive energy saving and resource re-utilization, residual heat and energy utilization. Effort shall be made to reach 30% of the energy utilization rate. Research, develop, promote and practice the utilization of the new energy technology and gradually adjust the railway energy consumption structure. The main energy consumption equipment shall meet the national energy consuming standards by the end of the Tenth Five-year Plan period.

Study the technology of comprehensive utilization of waste by classification, reuse of sewage and water, the new technology of water purification and recycle shall reach the national or local standards.

3.3.6 Strengthening the Research and Construction of the Railway Science and Technology Information Network

During the Tenth-five Plan period, railway science and technology information work should be in the line of business and market oriented. The information service areas and channels shall be expanded based on the development and utilization of the railway science and technology information. Establish the required database and information service system and increase the information service quality by vigorously utilizing advanced network information technology. Provide necessary information for quick decision of the policy making and quick reaction of traffic operation by tracing the world science and technology development and improve the starting level of the national technology development.

Based on the above description, by the end of the Tenth Five Year Plan period, the main railway equipment shall come close to that of the international level at the end of the 20th century. The main targets are:

- 1) Complete the construction of the passenger railway corridor of over 160km/h between Beijing and Shenyang;
- 2) Master the technology of construction, and operation of the Qinghai-Tibet Railway and initiate the Qinghai-Tibet Railway construction project;
- 3) Master the technology of high-speed railway construction and operation and initiate the Beijing-Shanghai high-speed railway project;
- 4) Complete the construction of 14,000~16,000 km of fast speed passenger traffic railway network covering all the major cities in China;
- 5) Basically establish the rapid freight traffic railway network connecting the major and medium cities;
- 6) Basically establish the comprehensive railway operational management system;
- 7) Preliminary establish train running safety monitoring system on the busy trunk lines;
- 8) Complete the research on and manufacture the multiple unit train, tilting train of 270 km/h and advanced urban rail multiple unit train. Establish batch production capacity of electric and diesel locomotives of AC transmission;
- 9) Complete the research on and manufacture the comprehensive automatic system of train dispatching and train control system for the running speed of 200 km/h;

(10) The track maintenance work shall be done with heavy-duty track maintenance machinery on the busy trunk lines.

4. Supporting Conditions for New Technology Promotion

The development of the new railway technology innovations relies on the further reform of the system, the technology encouragement system so as to promote the progress of the railway technology and to upgrade the quality and economic benefit of the Chinese railways.

4.1 Consolidating the Railway Technology and Increasing the Technology Development Ability of Railway Enterprises

The railway enterprises should establish and improve the technology development system, and take the improvement of technology development and enterprises management as key measures to improve enterprise's market competitiveness and profit making. The strategy and plan of the technology development, the strengthening of the technology development and improvement of the enterprise management shall be worked out based on the market orientation.

4.2 Encouraging Integration of Multiple Researches and Industries, Promoting the Cooperation Between the Scientific Institutions and the Enterprises

Vigorously promote the cooperation between the railway enterprises, universities and scientific institutes to promote the utilization of the new technology in the industrial areas.

4.3 Speeding up the Construction of the Technology Development Base

After reform of the system, research institute shall optimize its internal structure and establish a modern corporation with a standard management system and corresponding management mechanism. Vigorously trace the international advanced technology in railway industry and improve its ability to develop and promote the new technologies in railway industry. Establish the base for the new technology development in the railway industry to raise the ability of continuous development of the Chinese railway.

4.4 Increasing the Investment in Science and Technology Through Multiple Channels

The railway shall be the main stream for the new technology development. The enterprises shall actively increase the investment in technology development. The transportation shall invest 0.3% of the transportation expense and 2% of the rehabilitation and renovation projects, the industrial enterprises shall invest 1.5% of the sales revenue, and the construction enterprises shall invest 0.45% of the project revenue as the budgeted expense for the technology research and development of the enterprise. Besides, the railway enterprises should strive for the central and local government support to the technology development of the railway enterprises, as well as utilization of the encouraging tax and financial supporting policies for technology development. The railway enterprises are encouraged to mobilize financing in the capital market, such as fund of venture, technology innovation fund for the development of the new railway technology investment.

4.5 Speeding up the Transformation of the Technology from Laboratory to Market, Strengthening the Management and Protection of the Intellectual Property

Improve the encouraging system of utilizing the new technology, improve the payment and compensation system of the research personnel, and guarantee the research personnel's interest in the process of transforming the technology into products so as to activate the enthusiasm of the research personnel.

4.6 Strengthening the Training and the Education of the Employees

Improve the management and training system and create an environment for the development of research personnel and cultivate high quality research personnel.