CHINA

HIGHWAY DEVELOPMENT AND MANAGEMENT
ISSUES, OPTIONS AND STRATEGIES

October 18, 1994

Transport Operations Division
China and Mongolia Department
East Asia and Pacific Region

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CURRENCY EQUIVALENTS
(as of December 31, 1993)

Currency Name = Renminbi
Currency Unit = Yuan (Y) = 100 Fen
$1.00 = Y 5.7
$0.175 = Y 1.00

FISCAL YEAR

January 1 - December 31

WEIGHTS AND MEASURES

1 meter (m) = 3.28 feet (ft)
1 kilometer (km) = 0.62 mile (mi)
1 square meter (m²) = 10.76 square feet (ft²)
1 square kilometer (km²) = 0.4 square miles (mi²)
1 hectare (ha) = 0.01 (km²) = 2.47 acres (ac) = 15 mu
1 mu = 666.7 m² = 0.0667 ha
1 kilogram (kg) = 2.2046 pounds (baize)
1 metric ton (ton) = 2,204 pounds (lbs)
ton-km = ton-kilometer (0.621 ton-mile)

ABBREVIATIONS AND ACRONYMS

1FYP - First Five-Year Plan
4FYP - Fourth Five-Year Plan (1971-75)
5FYP - Fifth Five-Year Plan (1976-80)
6FYP - Sixth Five-Year Plan (1981-85)
7FYP - Seventh Five-Year Plan (1986-90)
8FYP - Eighth Five-Year Plan (1991-95)
9FYP - Ninth Five-Year Plan (1996-2000)
ADB - Asian Development Bank
BOT - build-operate-transfer
CIF - cost, insurance, and freight
EA - Environmental Assessment
EAP - Environmental Assessment Plan
EDI - Economic Development Institute
EIRR - economic internal rate of return
FYP - five-year plan
### ABBREVIATIONS AND ACRONYMS (cont’d)

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>GATT</td>
<td>General Agreement on Tariffs and Trade</td>
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<tr>
<td>GDP</td>
<td>gross domestic product</td>
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<tr>
<td>GNP</td>
<td>gross national product</td>
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<td>GOC</td>
<td>Government of China</td>
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<tr>
<td>GOVAI</td>
<td>gross output value of agricultural and industrial output</td>
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<td>HDM</td>
<td>Highway Design and Maintenance Model</td>
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<tr>
<td>HPDI</td>
<td>Highway Planning and Design Institute</td>
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<td>ICB</td>
<td>international competitive bidding</td>
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<td>IHS</td>
<td>Interstate Highway System</td>
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<td>IOT</td>
<td>Investment Orientation Tax</td>
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<td>LCB</td>
<td>local competitive bidding</td>
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<tr>
<td>MOC</td>
<td>Ministry of Communications</td>
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<td>MOF</td>
<td>Ministry of Finance</td>
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<td>MOFTEC</td>
<td>Ministry of Foreign Trade and Economic Cooperation</td>
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<td>MOR</td>
<td>Ministry of Railways</td>
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<td>NHS</td>
<td>National Highway System</td>
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<td>NTHS</td>
<td>National Trunk Highway System</td>
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<td>NPV</td>
<td>net present value</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<td>OECF</td>
<td>Overseas Economic Cooperation Fund</td>
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<tr>
<td>PCD</td>
<td>provincial communications department</td>
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<tr>
<td>PMS</td>
<td>Pavement Management System</td>
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<td>PRC</td>
<td>The People’s Republic of China</td>
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<td>PSB</td>
<td>Public Security Bureau</td>
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<td>PTD</td>
<td>provincial transport department</td>
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<tr>
<td>RDB</td>
<td>Road Data Bank</td>
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<td>RMF</td>
<td>road maintenance fee</td>
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<tr>
<td>SAR</td>
<td>Staff Appraisal Report</td>
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<td>SEZ</td>
<td>special economic zone</td>
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<tr>
<td>SPC</td>
<td>State Planning Commission</td>
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<tr>
<td>TCI</td>
<td>total capital investment</td>
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<td>VPF</td>
<td>vehicle purchase fee</td>
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<tr>
<td>YEZTS</td>
<td>Yangtze Economic Zone Transport Study</td>
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MAP

IBRD No. 24766 China: Major Highway Development Program—National Trunk Highway System
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EXECUTIVE SUMMARY

i. The main purpose of this report is to discuss areas in which the Bank can support China in implementing policy improvements that will allow the Government of China (GOC) to carry out more efficiently its programs to maintain and substantially expand its highway system and to manage the system better. Such improvements would permit highway investments, including those financed by the Bank, to be used more efficiently and equitably.

ii. Background. Since the late 1970s, China has experienced a high rate of economic growth, which has increased the demand for transport, along with requirements for better service. The capacities of all transport networks are strained, such that major network links need to be expanded to reduce transport bottlenecks and to accommodate the surging growth of the economy. Most roads are of poor quality, are antiquated in design, and are inadequate in capacity. Increasing the capacities of the networks in turn demands large increases in investment and related financing. China has a history of low investment in transport and needs to catch up on this investment backlog, but is constrained by a shortage of funding.

iii. Modernization of the highway system brings with it attendant requirements necessary for improving road planning, construction, and management. Several constraints hamper fulfillment of the new requirements and the corresponding development of China's transport system. The roles of the central and provincial levels of government are changing, with a trend for continued decentralization. In the highway sector, the central authorities need to assess their role to allow them to lead the drive to modernize and expand the system within the context of a smaller public administration. The highway management engineering capabilities of local governments are also strained and warrant being upgraded to meet the needs of developing, maintaining and operating a modern highway network. Related improvements are needed to strengthen economic and engineering analysis and construction methods. Design standards also need to be improved for better highway safety and to optimize life-cycle costs.

iv. Challenges for the Future. In order for China to accommodate the increasing demands in the future as it grows and evolves into a market economy, the GOC needs to overcome the difficulty it faces just in meeting the present demands on the highway transport system. China needs to find ways to diminish or remove these constraints, and GOC has already begun implementing some remedial actions along with its reforms of the last decade. Solving present problems, however, and the increasing pressures on the system pose a formidable challenge.

v. The Highway System: Antiquated, Congested, and Underfinanced. The highway network in China ranks among the smallest in the world relative to either population or geographic area, and 30 percent of China's villages have no access to roads suitable for motor vehicles. In addition, most of the roads in the network are too small and too weak structurally to carry current traffic. Most of the roads need upgrading in
vi. **The numbers of trucks, buses, cars, motorcycles, and tractors on the roads are increasing steadily and rapidly, despite the severe constraints posed by inadequate road standards, small coverage of the system, and high traffic congestion. Over the next 5-10 years, highway traffic—freight grew at 15.3 percent per year, and passengers at 12.9 percent per year during 1982-91—is likely to continue to grow at a fast pace in response to the rapid growth of the market economies, changes in economic structure favoring faster door-to-door road service, rapid expansion of manufacturing and rural industries, and more long-distance, increased interprovincial trade and people's travel needs. The high incidence of slow-moving traffic, mainly tractors and nonmotorized vehicles, is a key peculiarity of China's road system. Such slow-moving traffic contributes the most to road congestion and traffic accidents. The high population of nonmotorized and other slow-moving traffic in China suggests the benefits of building facilities (such as access-controlled expressways) that separate traffic, both for the safety of these vehicles and to improve speeds for the rest of the traffic.**

vii. **Highway Demand.** In recent years, although transport flows have grown at high rates almost everywhere in China, the fastest growth has been in the coastal provinces. This is likely to continue, but significant changes will occur in the composition and spatial location of commodity flows throughout China. In future years, several strategic factors are likely to influence the level, location, and composition of transport demand growth: (a) continued growth of foreign trade, (b) changes in the location of industry, (c) sustained demand for long-distance haul of bulk commodities, (d) increased cross-border trade with Central European republics, (e) development of containerization, and (f) fast rising passenger travel. Overall, transport demand for all modes will steadily rise, and the highways will continue to increase their share.

viii. **Highway Sector Objectives.** In the medium term, the main objective of the central and provincial highway authorities will be to ensure that the highway system helps integrate China's national economy and facilitates mobility of goods and people. Attainment of this objective should correspond to the comparative economic and technological advantages of highways vis-à-vis other modes of transport and to available financial resources.

ix. **To achieve this objective, the relevant central and provincial authorities would need to:**

   (a) give high priority to developing the National Trunk Highway System (NTHS), a network of modern interprovincial highways;

   (b) develop provincial and rural roads that will feed into the NTHS; and
(c) continue reforming policies and regulations in order to provide adequate financing for the highway system, to ensure efficient utilization of the funds and to encourage rational utilization of the transport vehicle fleet and provision of road transport services.

Development of the NTHS is a necessity to respond to the increasing value assigned to travel speeds and safety, the growing demand for long-distance transport, and the high role of accidents on conventional roads resulting from the high proportion of tractors and bicycles.

x. Development Plans for the 1990s. The Ministry of Communications (MOC) plans for investment in highway construction to reach about Y 110 billion during the 8FYP (1991-95). This amount would be applied toward building 60,000 km of new highways. Although provincial roads throughout China—including trunk as well as county and rural roads—will comprise the bulk of the mileage to be added, the priority will be given to developing a system of expressways that will be part of the NTHS, a high-quality system of interprovincial roads. The NTHS consists of 12 national trunk routes and, when completed, would be 30,000 km long and would connect 95 cities. By the end of 9FYP (1996-2000) in 2000, total investments in highway construction would be required in the order of Y 290 billion, to meet the targets for total road network length for that year: 1.25 million km, including 3,000 km of expressways.

xi. The Ministry of Communications plans to allocate enough funds to finance about one third of total investment expected in the development of the NTHS. The remainder will be financed primarily with the provinces’ own funds, as well as domestic and foreign loans.

xii. Simultaneous construction of rail facilities and modern roads is more likely to occur in the high economic growth areas, mainly in the coastal regions and in heavy trafficked corridors such as Beijing-Shanghai-Guangzhou. Given the expected high growth rates in freight demand in these regions, the high proportion of railway lines operating at capacity, and the congestion on the roads, there is little risk overall that network development of either the highway or the railways within existing financial ceilings will end up providing transport capacity prematurely. However, risks of investments in the wrong place or with inadequate design standards need to be minimized by rigorous economic analysis of investments.

xiii. The current five-year plan allocates a higher share of investment to transport than previous plans. Under this plan, China’s investment for transport would be about 2 percent of GDP. This would be at the low end compared with that of other countries in similar stages of economic development, where the percentage ranged between 2 and 4 percent. The government is considering increasing the original transport allocation of the 8FYP in line with recent upward revisions of forecast economic growth rates from 6 percent to 8-9 percent annually. If the revised proposal is adopted, the percentage would increase to close to 2.5 percent, which would be more in line with the range prevailing in other countries relevant to China.
xiv. **Key Issues.** Developing and managing a modernized and expanded highway system in China are hampered by several constraints. Some of the constraints directly affect the availability and utilization of resources; others affect the use of physical facilities of the highway system, as well as the services provided. Most constraints have a strong institutional component, and several involve standards and rules of various kinds. These constraints are grouped into the following categories: (a) center-provincial roles and the NTHS, (b) finance, (c) investment planning, (d) management and technology, and (e) road transport services.

xv. **Center-Provincial Roles and the Development and Management of the NTHS.** The significant changes in China's economic policies and administrative relationships between the various levels of government and enterprises, and the overriding priority to develop the NTHS have prompted government authorities to reassess the relative role of the center vis-à-vis the provinces in highway development and management. This reassessment effectively started in 1986 when the MOC was provided with new funding earmarked for development of the NTHS, which strengthened the role of the center. In many sectors, such a decreased role of the center has translated into the sharpening of the center's role from micromanagement to policy guidance and macromanagement, as is the case of MOC's role in the management of the ports.

xvi. The substantial change in MOC's financial resources and related institutional strengthening aimed to give it leadership in the development of the NTHS have, however, largely preserved the provinces' autonomy in planning, financing, building, and maintaining their highway networks. China's peculiar conditions, the economywide trends for administrative decentralization, and the urgent need to modernize its highway system pose the special challenge of establishing the most efficient role for the central authorities in regard to developing and managing the highway system.

xvii. There are two aspects to how roles evolve during the 1990s. On the one hand, China is planning new, smaller roles for the central government in all spheres of the economy, and the provinces have developed good administrative capacity and highway engineering capabilities for the existing highway network. On the other hand, the government has ambitious plans for highway development and modernization, and the provincial capabilities are adapted to roads with antiquated design and used mostly by light vehicles.

xviii. Trends in China's public administration signal that the provinces will continue to retain their primary responsibilities of planning, financing, constructing, and maintaining the highway network, and the MOC will continue overseeing the sector and coordinating development of the NTHS. This approach is sound. However, the government must take the leadership in the planning of the NTHS and would need to play a stronger role in several areas where policy adjustments and institutional changes are essential: highway finance, economic and engineering analysis, construction, procurement, supervision, and training. Specifically, the government could provide technical assistance to the provinces; organize and monitor pilot schemes in provinces and counties, to test new policies, standards, or procedures and disseminate the results; develop and guide
professional highway organizations in drawing up highway standards and offering training programs; and implement a system of performance indices to assess the efficiency of provincial organizations in building, operating, and managing their highway systems. The Bank recommends strengthening the MOC capability in sector planning, strengthening the collection and analysis of data (for investment planning and performance monitoring), and providing policy assistance in carrying out selected transport sector policy and planning studies.

xix. Finance. The present highway finance system faces two challenges, which apply at the central as well as the provincial government levels:

(a) The Need to Rationalize Road-User Charges and Restructure Finance. Based on taxes which are essentially unrelated to highway use—taxes on vehicle purchases, on vehicles' carrying capacity and on transportation companies' revenues—the present road user charge system is "economically inefficient" and does not promote a rational use of highway infrastructure and vehicles. China needs to restructure user charges and highway finance through the introduction of fuel taxes earmarked for highway construction, supplemented by taxes based on axle weights and targeted at heavy vehicles that cause the most pavement damage. At a current price of gasoline in China of about $1.00 per gallon, compared with a price 2 to 4 times higher in OECD countries, the potential for a fuel tax in China is good.

(b) The Need to Diversify Finance. Following worldwide trends, China has started to look for new ways to mobilize financing for highways. Toll roads are expanding rapidly, and after going through "infancy" problems, are now becoming a better established and more rational form of finance. Domestic borrowing and bonds have been used only in a limited way, and the government is looking to widen their use; changes taking place in the capital markets are substantially enhancing the feasibility of these options. Private financing has been done for several years on a limited basis mainly in the fast-growing coastal provinces, and should now expand rapidly following a GOC directive in August 1992 providing private investors incentives to finance transport infrastructure.

xx. Investment Planning. As a result of the economic reforms over the last decade, China’s planning process has been radically altered as investment and production decisions are increasingly left to the market. The current 8FYP reflects these changes and focuses more on setting the economic framework than on setting targets. Plan priorities of 8FYP indicate that while transport will receive higher allocations than in the past, total sectoral investments would still not remove all the bottlenecks in this century.

xxi. The relaxation of planning controls requires an improvement of investment analysis and evaluation of investments at all levels. MOC, in conjunction with the State Planning Commission, would need to strengthen their leadership in this area with a view to:
improving highway feasibility methodologies, appropriately differentiated to different kinds of road projects, which could include the introduction of the Bank's Highway Design Model to the provinces;

(b) introducing the revised methodologies in the provinces through a program that would include technical assistance and training;

(c) establishing a method for screening highway projects proposed by individual provinces;

(d) disseminating, on a selective basis, the techniques for comprehensive transport planning developed through (Bank-sponsored) studies in Guangdong and the Yangtze special economic zone;

(e) ensuring that highway investments are analyzed in an intermodal framework; and

(f) strengthening MOC's own capacity for highway planning and economic evaluation.

Management and Technology for Maintenance and Construction. Until now, highway maintenance has generally been organized and carried out well, thanks to consistent, routine maintenance operations organized and implemented by the provincial governments. However, underlying factors threaten a major regression in the quality of highway maintenance. The present structural capacity of the road pavements is generally marginal for the current traffic, and is fast becoming inadequate to meet the needs of the high growth of traffic and of vehicular loadings. This poses three interrelated issues. First, there will be a substantial increase in the needs of financial resources to tackle the growing demands for pavement maintenance at a time when funding for maintenance has, in relative terms, been declining. Second, with limited resources, the provinces will need to be able to carefully identify where and for what maintenance activities such resources will yield the highest returns, which will require the introduction of modern maintenance planning and information systems. Third, the way highway maintenance is carried out will need to be reassessed to ensure that implementation methods are as efficient as possible.

At the same time, the cost and quality of constructing the NTHS depend on the capacity of the highway construction industry. Most construction enterprises are heavily subsidized and poorly equipped, and do not meet the requirements for building efficiently and with excellence the modern highway system that China plans to develop. There is a need to restructure and modernize the industry, to improve the enabling environment, mainly to allow construction contracts to be based on market rather than government-fixed prices, and to provide special encouragement to the more autonomous, commercially oriented enterprises.

Development of Road Transport Services. Despite substantial deregulation and liberalization in recent years, the road freight services industry in China is still plagued
by serious problems. Among these are inefficient management of trucking enterprises; antiquated trucking fleets prone to frequent breakdowns and which are mismatched with the needs of shippers; the resultant higher operating costs, especially fuel and maintenance costs; and lack of a customer orientation among service providers. In addition, the old-technology, underpowered vehicles cause traffic congestion and pollute the air, further warranting their renewal. Similar problems affect road passenger services. The development of road passenger services is also of critical importance in meeting China's growing transport needs. The problem of insufficient passenger capacity can best be solved by utilizing all modes of transport and developing a rational, integrated network structure. Unless conditions are changed, with increased commercialization, the benefits of improving China's highway systems will be substantially negated by inefficient, high-cost transport services.

xxv. Further restructuring and marketization of the road freight services industry as a whole is necessary to complement China's ongoing program of road investments. Private and collectively owned transport operators are developing fast, but there are still a number of constraints—such as inadequate access to finance, lack of commercial legislation—that the government would need to resolve. The role of state-owned transport enterprises is declining, but they will continue to be important in the foreseeable future and it will be required to further increase their financial accountability and enhance their commercial orientation.

xxvi. Role of Bank Assistance. The Bank Group has supported the initiatives of the GOC in the transport sector through projects, sector studies, technical assistance, and training. The highway subsector has received to date $1,289 million in Bank Group financing under 10 projects. These projects, most of which are for a specific province, provide for the construction of high-quality national and provincial roads totaling about 1,760 km, and the expansion and improvement of some 6,430 km of rural roads and major bridges. When completed, some of these roads will help to provide vital missing links in the national highway network; others will help to ease severe congestion in parts of the network or provide access to remote areas. The projects are also designed to provide foreign technical assistance and training of Chinese personnel in areas such as supervision and quality control of road construction, design, and planning. The highway projects constitute the Bank's first major involvement in civil works in China, and they have successfully introduced competitive bidding for the procurement of works, despite the difficulties of dealing each time with a different province and implementing agency. Finally, the projects support studies on key issues of highway development such as road safety, pavement management, user charges, and methods of financing the expansion, improvement, and rehabilitation of the road network.

xxvii. Of the 10 Bank-financed highway projects, only the first highway project has been completed. The project, which was designed to construct and improve sections of the national and provincial/county road networks, achieved its objectives and demonstrated the benefits accruing from improved accessibility to communities deprived of adequate transport infrastructure in economically less developed regions. Economic activity in the area of influence of the project roads surged, and income levels increased noticeably. The
Bank's involvement facilitated the acceptance of competition in the contracting for road works, even for smaller civil works contracts, in preference to force account operations, and demonstrated the merits of supervision of construction by specially assigned units.

xxviii. **Proposed Bank Strategy.** The proposed Bank's strategy for future highway lending is to continue to support institutional development and sectoral reforms aimed at modernizing the highway system and its management. This support will continue both at the central and provincial government levels. During the next three to five years, the investment components of highway projects will continue to focus on high priority links of the National Trunk Highway System, and to support the development of the provincial road networks.

xxix. The proposed Bank strategy also envisages continuing close collaboration with the MOC, and assisting it, through economic and sector studies and through lending operations, in adapting to the evolving needs of the Chinese economy. The proposed institutional strengthening program for MOC and a planned exercise to improve prioritization and feasibility methodologies for highway investment are key elements of the strategy. Specifically, the proposed Bank's highway lending strategy comprises the following elements: (a) sectoral reforms and institutional components and (b) investment components.

xxx. In addition, the Bank should be prepared to consider new operations that would help further marketize China's highway sector, for example by providing finance for trucks or other transport equipment that might be leased or sold to collective or private operators or by providing guarantees to private loans directed to road investments.

xxxi. Since the Bank is interested in helping China develop its transport sector further, and in view of the Bank's broad experience in formulating and implementing sound policy for development, the Bank should continue to help China, not just with its funding needs, but also with making policy adjustments that will allow the country to catch up more quickly and effectively with the great demands stemming from burgeoning economic growth.
1. BACKGROUND

A. REFORMS

1.1 China’s economic transformation and development since the opening of its economy in the late 1970s have resulted in a 9.5 percent average annual rate of economic growth, which has had a sweeping impact throughout the economy, including the transport sector. Since the opening of its economy in 1979, China has experienced rapid growth in freight and passenger traffic, consistent with rapid expansion of the economy (Tables 1 and 2).

1.2 The economic reforms are also changing the role of the central government vis-à-vis provincial and local authorities. The transformation from a command economy to one with a key market role is transferring more decision-making power, particularly on resource allocation, to the lower levels of government, dictating a reassessment of the scope and focus of central government’s functions. This will have important implications for the development and management of China’s transport system, including its highways.

1.3 One important outcome of China’s economic reform has been the marketization of the economy, with market control of the economy gradually replacing production decisions. The marketization of the economy and the changes in the composition of output have greatly affected transport demand, costs of inputs, quality of service demanded, and organization of the sector.

1.4 Agriculture and industry were initially the sectors leading economic reforms. Although starting later, the government has also carried out important reforms in the transport sector, including substantial tariff increases and reduction of subsidies in all modes, opening of transport market to individual and township enterprises in waterways and highways, increased financial autonomy and introduction of competition in ports and civil aviation services and in the construction of infrastructure (Box 1.1).

B. STRAINS ON TRANSPORT SYSTEM

1.5 The following factors have placed enormous and increasing strains on China’s transport system: (a) sustained high economic growth rates of agriculture and industry, (b) radical changes in the composition of economic output, (c) gradual but sustained changes in the location of economic activities as location decisions become increasingly based on cost rather than on political decisions, and (d) the growing attention given to removing administrative and physical barriers to spur interprovincial trade. Existing transport infrastructure is currently being used to saturation levels, creating high logistics costs for producers and consumers; railway lines used to capacity have increased from 7 percent of the network in 1985 to 37 percent in 1989. The resulting gap between
Box 1.1: Recent Policy and Management Reforms in Transport

Reforms in the transport sector of the last decade have reflected the objectives of overall reforms in China and made quick progress at increasing economic efficiency, by reducing intervention from the central government at all levels, reducing the government's subsidies to state-owned enterprises, and opening the economy by allowing further participation of private and collective enterprises. Railway and port reforms have aimed at increasing the autonomy and accountability of management. Economic and administrative reforms have also affected the management of the highway. Although the reforms were started only recently, they have made tremendous headway in strengthening MOC's investment resources; opening financing of transport infrastructure to the private sector; improving the analysis and evaluation of investments; instituting competition in road construction; opening road transport market to private and collective operators; and utilizing appropriate technology in expressway design.

The Ministry of Communications (MOC) has gradually strengthened its role in areas where involvement from the central government is necessary. In 1986 the government introduced a nationwide vehicle purchase fee (VPF) to provide MOC the first substantial and steady source of funding for developing the National Trunk Highway System (NTHS). MOC contributes 30-50 percent of construction costs, with the coastal, wealthier provinces receiving a smaller share and the poorest provinces receiving a larger share. At the same time, the MOC established road design standards and, in collaboration with the SPC and the Ministry of Finance (MOF), made the use of engineering and economic feasibility studies compulsory for the provinces to obtain MOC share financing.

In August 1992, MOC formally opened transport infrastructure (including ports) to financing on a larger scale, to allow private capital to finance and manage toll expressways. Leasing of land along highways is also being attempted to raise additional money for highway construction. Limited involvement of foreign companies in the road transport business is also being encouraged.

Competitive bidding in China began with World Bank projects in the early 1980s, and is now more widely used, particularly in the highway sector for bidding in civil works. This has changed China's traditional policy of building roads with government construction forces. Bidding for highway projects has been extended throughout China, initially for high-class roads under external financing, thereafter for locally financed roads. Some provinces have begun reducing their support for state-owned construction companies, and are encouraging development of financially autonomous construction companies.

Since 1984 private, collective, and town and village enterprises have been allowed to enter the intercity transport business in both road and river transport. In addition, relaxation of trucking regulations, principally in the most developed regions, has allowed own-account trucks to haul cargo for other factories and cooperatives, thus promoting competition with state-owned transport companies.

Transport supply and demand is manifested in the existence of transport bottlenecks, the administrative rationing of limited transport capacity, and poor quality of services.

1.6 After a slowdown in growth in 1989/90, high economic growth resumed and, since 1991, has correspondingly brought about a surge in transport demand and new strains on the capacity of the transport system.
1.7 Although the railways' share of traffic has declined over the last decades as the share of road traffic has grown, rail transport still dominates freight and long-distance passenger traffic in China (Figure 1.1). The lack of modern, high-speed highways coupled with an old fleet of buses and trucks and inadequate development of road transport services are the main factors hindering road transport.

Figure 1.1: Trends for Traffic by Mode

C. Investment

1.8 Transport investment levels have not kept pace with demand. The consequence of the chronic underinvestment in transport has been that China today has a very small transport network, which has resulted in transport bottlenecks that severely
constrain economic growth. Neglected by central economic planners and handicapped by inadequate provincial resources, transport suffered from chronic underinvestment for a long time. Investments were essentially focused on the needs for moving large quantities of essential minerals (particularly coal), heavy machinery, grain, and military equipment long distances. Such needs preeminently favored the development of railways, but even here resources were inadequate.

Figure 1.2: INTERNATIONAL COMPARISON OF LAND TRANSPORT NETWORKS

Unsatisfied rail transport demand in 1989 was estimated at 200 million tons and up to 30 percent of total passenger demand, causing economic losses of about 1 percent of GDP, as reported in the study, China's Railway Strategy, World Bank, February 1993.
Over the last 40 years, the length of the railway network more than doubled, and the highway system expanded ninefold because of provincial efforts and funding. However, the extension of the network was mostly for county and intraprovincial roads, which were built mostly to low standards, with obsolete technologies and with small budgets. Despite the expansion of the rail and road networks, the situation has worsened over the last years. Railway links operating at capacity rose from 7 percent of the network in 1985 to 37 percent in 1989. China's transport network is still one of the sparsest in the world when compared to the area and population it serves (Figure 1.2).

Although China kept a high investment rate over the last decade, investment in transport—and particularly its highway infrastructure—continued to be neglected, as it had been in earlier periods. During 1980-89, overall investment in transport infrastructure represented only about 1.3 percent of GNP, compared with 2-3 percent for countries such as the Republic of Korea, India, and Brazil (Tables 3a and 3b). The overlook of China's transport needs under the "old" system stems in part from central planners' disinterest with support sectors, which do not count in China's traditional measure of economic activity, focused on agriculture and industry. Roads and road transport, not easily subject to central controls, received even less resources. (See Table 4 for a breakdown of past investments in China among various modes of transport.)

The government plans to reduce the transport investment backlog. This will require major investments in roads and railways, sometimes in parallel links. Ensuring that investments to expand transport capacity will not be redundant or made in the "wrong" transport mode is less difficult in China than in most other countries because of China's past and projected fast increase in transport demand throughout the country, its chronic underinvestment in transport, and the large number of bottlenecked links in the railway system. This situation, however, should not exempt the capital-intensive highway and railway projects from rigorous investment analysis.

### D. CHALLENGES FOR THE FUTURE

In the years ahead, a challenge for the government will be to meet the needs of the emerging economy to expand and modernize the transport infrastructure. Meeting the challenge will require redefinition of the roles of the various government levels in the developing and managing the infrastructure, improving investment and financing methods, modernizing technology, and setting the conditions for the development of efficient and competitive road transport services.

The movement toward a market economy will increase demand for market-responsive transport services, which will favor a shift to road transport, but will still leave a growing market for the relatively low-cost rail transport system.

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2/ China's Railway Strategy.
2. THE HIGHWAY SYSTEM: ANTIQUATED, CONGESTED, AND UNDERFINANCED

2.1 This chapter briefly describes the status of China's highway system. The issues posed, along with possible ways to address them, are discussed in Chapter 4.

A. NETWORK AND FLEET

Highway Network

2.2 The highway network in China totaled about 1.028 million km in 1990. Relative to either population or geographic area, the network ranked among the smallest in the world, with about 30 percent of China's villages having no access to roads suitable for motor vehicles. In addition, the road network consists mainly of aging roads with neither the geometric capacity nor the structural strength to carry current traffic.

2.3 For purposes of design and technical specifications, the network is classified by the Ministry of Communications (MOC) as expressway, and class 1, 2, 3, and 4 for various traffic capacities in different terrain (Table 5). For administrative purposes, roads are classified as national, provincial, county, village, and special-purpose. Table 2.1 gives lengths of each category of road in 1990. (Table 6 shows breakdown by province.)

<table>
<thead>
<tr>
<th>Administrative classification</th>
<th>Length (km)</th>
<th>%</th>
<th>Technical classification</th>
<th>Length (km)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>National</td>
<td>107,390</td>
<td>10.5</td>
<td>Expressway</td>
<td>522</td>
<td>0.05</td>
</tr>
<tr>
<td>Provincial</td>
<td>166,060</td>
<td>16.2</td>
<td>Class 1</td>
<td>2,600</td>
<td>0.26</td>
</tr>
<tr>
<td>County</td>
<td>340,770</td>
<td>33.0</td>
<td>Class 2</td>
<td>43,200</td>
<td>4.20</td>
</tr>
<tr>
<td>Village</td>
<td>370,200</td>
<td>36.0</td>
<td>Class 3</td>
<td>170,000</td>
<td>16.54</td>
</tr>
<tr>
<td>Special-purpose</td>
<td>43,800</td>
<td>4.3</td>
<td>Class 4</td>
<td>520,000</td>
<td>50.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nonclassified</td>
<td>291,000</td>
<td>28.37</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,028,000</strong></td>
<td>100.0</td>
<td><strong>Total</strong></td>
<td><strong>1,028,000</strong></td>
<td>100.0</td>
</tr>
</tbody>
</table>

2.4 About 84 percent of the road network (covering 863,000 km) is surfaced using a variety of pavement structures and materials. Of this percentage, only about
24 percent is paved with cement concrete or bituminous mixed materials. Thirty-one percent have crushed stone or graded gravel surfaces, and 29 percent are primarily covered with stabilized soil composed of local materials. Although pavements are generally well maintained, they are showing increasing levels of roughness and deterioration because the new economic activities have generated traffic volumes and axle loads above what the existing facilities can accommodate, and many of the pavements here reached the end of their design life. Overloading of trucks, particularly tractors, is a serious problem, which accelerates deterioration of the pavement.

2.5 Most of China's road network needs upgrading in addition to the normal maintenance and rehabilitation. Despite major strides in road building during the last decade, as much as 70 percent of the paved road system remains inadequate for meeting the needs of modern road transportation. A World Bank policy study (1988) on road deterioration in developing countries classified China among the countries with an extensive and obsolete network in need of modernization to meet the rapid growth in road transport. Upgrading and rehabilitating pavements remain a heavy task for the next decade.

Vehicle Fleet

2.6 In 1990, the vehicle fleet in China totaled 5.5 million trucks, buses, and cars, with trucks comprising over 71 percent. Growth in the truck and bus fleets has been fairly steady at an average annual rate of 12.4 percent over the last 12 years, with particularly strong growth in small passenger vehicles (Table 7). Most trucks are of 4-ton capacity with outmoded designs, have low fuel efficiency, and are mostly gasoline powered. The older vehicles were manufactured domestically until in the early 1980s, when a large number of modern vehicles were imported and joint ventures with foreign manufacturers started to produce trucks. The vehicle fleet in China is forecast to reach 9-10 million by 1995 and 14-16 million by the year 2000, with an annual average rate of increase of about 11 percent.

2.7 The tractor and motorcycle fleets, at 4.6 million and 4.2 million, respectively, rival the size of the truck and bus fleet. Growth in tractor and motorcycle fleets has increased sharply, with motorcycles showing the strongest growth of all vehicle types.

2.8 The privately owned fleet of motor vehicles (cars, buses, and trucks) is increasing at an astronomical rate in China. In 1985, there were only 19,342 privately owned passenger vehicles (cars and buses). By 1990 this number had increased by an overall 477 percent, and by 1991—only one year later—privately owned passenger vehicles had increased by another 172 percent. Similarly, there were 264,839 privately owned trucks in 1985. By 1990, this number had increased by an overall 140 percent.

1/ Road Deterioration in Developing Countries—Causes and Remedies.
2.9 The three provinces with the largest fleets of privately owned vehicles in 1990 were Guangdong (13.4 percent of the total), Hebei (11 percent of the total), and Henan (10 percent of the total). In Guangdong Province, which has registered the fastest economic growth in China, the percentage of privately owned vehicles relative to population is almost three times as big as the average province. Conversely, the smallest number of privately owned vehicles are in Tibet (0.6 percent of the total), Tianjin (0.6 percent of the total), and Shanghai (0.5 percent of the total).

B. Traffic

Traffic Growth

2.10 Spurred by sustained economic growth and economic reform, the demand for road transport has been rising fast. Between 1982 and 1992, road freight grew at an average annual growth rate of 14.7 percent (Table 1), and passenger traffic grew 297 percent, with an average growth rate of 12.9 percent (Table 2). During the same period, the road network expanded from 942,395 km to 1,028,300 km, an increase of 9.1 percent.

2.11 The increase in road freight and passenger transport is reflected in the growth in traffic on the road networks. In the national road network, the annual rate of traffic growth of motor vehicles averaged at 8.3 percent during 7FYP (1986-90). An investigation conducted by MOC, which compared the existing traffic volume with the designed capacity of the roads, provided a broad indication of highway capacity needs. The results suggested that an additional 1,000 km of expressways, 3,700 km of class 1 roads, and 10,600 km of class 2 roads were needed to accommodate the existing traffic level in 1990 on the national road network.

2.12 The steep growth in road traffic shows the strong demand for highway service, since the surge in traffic took place despite severe constraints posed by inadequate road standards, small coverage of the system, high congestion, and poorly developed trucking services. Over the next 5-10 years, highway traffic is likely to continue to grow at a fast pace in response to the rapid growth of the market economies, to changes in economic structure favoring faster door-to-door road service, to rapid expansion of manufacturing and rural industries, and to more long-distance, increased interprovincial trade and people's travel needs. Road freight traffic forecast is discussed in Chapter 3.

Traffic Congestion and Composition

2.13 The rapid increase in traffic over the past decade has been reflected in overall congestion in the network, particularly on the main roads. The average traffic congestion

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2/ Provincial figures are from 1991, and total figures are from 1990. Assuming there was little difference in the total figures between 1990 and 1991, provincial percentages were calculated based on figures from both years.

congestion factor (the ratio of existing traffic volume to the designed capacity) of the national road network was estimated by MOC to be 1.12 in 1991, up from 1.09 in 1990 and 1.05 in 1985. The average traffic speed of the national road network has marginally increased over the years: 42 km per hour in 1991 and 41 km per hour in 1990, compared with 38 km per hour in 1985.

2.14 The high incidence of slow-moving traffic, mainly tractors and nonmotorized vehicles, is a key peculiarity of China’s road system. Such slow-moving traffic contributes the most to road congestion and traffic accidents. An important component of this traffic is underpowered trucks and buses, which are the predominant vehicles on China’s roads. The large proportion of nonmotorized traffic [25 percent of that traffic on the national highways (see Table 2.2) and a higher percentage on provincial, county and village roads] substantially compound the problem.

<table>
<thead>
<tr>
<th>Year</th>
<th>Motor vehicles</th>
<th>Tractors</th>
<th>Man- or animal-powered vehicles</th>
<th>Bicycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>70.4</td>
<td>12.5</td>
<td>9.3</td>
<td>7.8</td>
</tr>
<tr>
<td>1990</td>
<td>74.6</td>
<td>10.7</td>
<td>7.0</td>
<td>7.7</td>
</tr>
<tr>
<td>1991</td>
<td>76.2</td>
<td>10.1</td>
<td>6.0</td>
<td>7.7</td>
</tr>
</tbody>
</table>

2.15 The high proportion of nonmotorized and other slow-moving traffic in China suggests the benefits of building facilities (such as access-controlled expressways) that separate traffic, both for the safety of these vehicles and to improve flow for the rest of the traffic.

C. ADMINISTRATION, PLANNING, AND MAINTENANCE

Highway Administration

2.16 Road administration in China is considered to be largely decentralized. While this assists responsiveness to local needs, it has created problems in ensuring national priorities and in keeping common standards in the construction and maintenance of infrastructure.

2.17 At the central government level, the road sector in China is the responsibility of MOC. However, the provincial communications departments (PCDs) are responsible for most of the provincial highway management functions. MOC provides general policy guidance and support to the PCDs through its nationwide policies and regulations, by specifying design, and construction and maintenance standards and specifications. Annex
1 provides an overview of MOC functions, organization, and future needs. Charts 1 and 2 depict the organization of MOC and a typical provincial transport department.

2.18 PCDs, through their city, prefecture, and county level units, take full responsibility for the planning and administration of the road sector in the provinces, including physical construction and maintenance of the road network and transport operations. Road safety, on the other hand, is the responsibility of the Public Security Bureaus at the local government level.

2.19 The road sector is generally well staffed with trained technical personnel at the different levels of the system, particularly at the central and provincial levels. Education and training systems are established in each province under the PCDs, which provide regular fixed-term training of technical workers or operators and various technicians for most of the activities in the sector, as well as on-the-job training. However, schools are normally poorly equipped, and facilities need upgrading.

Planning

2.20 MOC, as the responsible sectoral central agency, carries out three types of plans in conjunction with the provincial authorities:

(a) the long-term strategic plan, which focuses on strategic development perspectives over a span of 10 to 20 years;

(b) the five-year plan (FYP), which identifies highway investment projects proposed for implementation during the plan period; and

(c) the annual plan, which specifies a yearly construction program for the projects approved under the FYP. MOC's FYP of the National Trunk Highway System (NTHS) is subject to the approval of the State Council, after consultation with the State Planning Commission.

2.21 The planning of the NTHS is carried out centrally by MOC, while the planning of provincial highways and roads of lesser importance is the responsibility of the PCDs. National highways or other major projects require approval by MOC, but the remaining infrastructure is planned under the guidelines of MOC which are normally revised about every five years. The PCDs prepare the provincial five-year road development plans to reflect national and provincial development policy guidelines and objectives of the plan period. The highway administration units at the prefecture and

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county levels have some autonomy in planning small road investments, such as county and village roads, subject to approval by the PCDs.

2.22 At the national level, the State Planning Commission (SPC), is responsible for overseeing the planning and evaluation of infrastructure in all sectors of the economy. The SPC also decides on the allocation of government investment in the different modes of transport. The Provincial Planning Commission has similar responsibilities in each province.

Maintenance

2.23 Highways and bridges are maintained by the highway departments of the concerned cities and counties. Maintenance is well organized and is carried out mainly through labor-intensive operations. About 85 percent of the national and provincial roads and 75 percent of the county and village roads are being adequately maintained. However, the aging road system and the outmoded maintenance technology have seriously constrained good maintenance practices. The riding quality of the pavement surface is predominantly poor, despite periodic maintenance.

2.24 Despite the efforts at providing adequate maintenance, roads are deteriorating as a result of inadequate geometric and structural design for the current traffic load patterns. The current conditions of the road network reflect a history of modest to low investments, comparatively light traffic loadings, and a consistent routine maintenance regime of low-technology, labor-intensive practices.

2.25 Expenditures for maintenance increased substantially in terms of absolute figures in the past decade, but as a percentage of total expenditures for highway purposes, they decreased sharply. This is reflected in the use of revenues from the Road Maintenance Fee (RMF), the main source of financing for highway maintenance (Table 2.3).

2.26 The current surge in construction and upgrading of roads is bound to stretch the road maintenance system, since relatively fewer financial and human resources will be available for this activity in the future. This would require adoption of new technologies, institutional improvements, and development of skills. A start has been made toward establishing an advanced road maintenance system. Two building blocks—Road Data Bank (RDB) and Pavement Management System (PMS)—which have been developed (PMS) or are being developed (RDB) by MOC, will be implemented in all provinces in stages. Although the system is in the early stages of implementation, it is expected to be the key tool for projecting and programming future maintenance needs.
Table 2.3: Collection and Use of the Highway Maintenance Fee, 1981-90
(Y billion)

<table>
<thead>
<tr>
<th></th>
<th>6FYP (1981-85)</th>
<th>7FYP (1986-90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>24.6</td>
<td>59.5</td>
</tr>
<tr>
<td>Total expenditures</td>
<td>24.7</td>
<td>59.4</td>
</tr>
<tr>
<td>Routine maintenance</td>
<td>11.8</td>
<td>15.7</td>
</tr>
<tr>
<td>Periodic maintenance</td>
<td>3.7</td>
<td>7.7</td>
</tr>
<tr>
<td>Upgrading</td>
<td>5.6</td>
<td>17.0</td>
</tr>
<tr>
<td>Construction</td>
<td>0.4</td>
<td>4.1</td>
</tr>
<tr>
<td>Other</td>
<td>3.2</td>
<td>14.9</td>
</tr>
<tr>
<td>Maintenance as percentage of total expenditures</td>
<td>63%</td>
<td>39%</td>
</tr>
</tbody>
</table>

Source: MOC.

D. Highway Finance

User Charges

2.27 China’s practice has been to recover costs and provide most of the highway financing needs from earmarked user charges, with relatively little coming from provincial or central government budgets or from borrowings. The two main earmarked user charges are, at the provincial level, a Road Maintenance Fee (RMF), and, at the national level, a Vehicle Purchase Fee (VPF).

2.28 The RMF, collected and administered by the PCDs, is the central element of China’s road funding system. It was introduced in 1950 and is practically identical in all provinces. It is levied as follows:

(a) **Tax on Transportation Companies’ Revenues.** Freight and passenger transport companies that hire out their vehicles pay 15 percent of their gross revenues.

(b) **Tax on Ownership.** Companies or individuals who use vehicles for their own private use pay a monthly fee based on the rated payload of each of their vehicles. The fee is between Y 105 and Y 130 per ton per month, with a typical value of Y 110 per ton per month. The fee for tractors is 40 percent that of a truck with the same rated payload. Exemptions (covering some 6 percent of vehicles—administration and military vehicles),
discounts, and leakages in tax collection reduce average revenues by about 30 percent. The fee rate can be varied by the provinces within limits set by the central government.

2.29 The VPF was introduced in 1985 and is administered by MOC. Fees are levied as follows:

(a) 10 percent of the selling price for domestic vehicles;

(b) 15 percent of the delivered price (cost, insurance, and freight (CIF), and customs and local charges) for imported vehicles; and

(b) exemptions that include a 50 percent reduction for replacing old vehicles.

2.30 Other user charges, which are not earmarked for road construction, also include four other fees: (a) the vehicle use fee, (b) the transport administration fee, (c) the license plate fee, and (d) the annual vehicle examination and certification fee. The revenues from these fees are small and in some cases barely cover the costs to administer them.

2.31 Fuel taxes are levied, but these accrue to general revenues and are not allocated to highway funding. Fuel taxes currently amount to 43 percent of the base price of gasoline and 13 percent of the base price of diesel fuels. Fuel prices at the pump, including taxes, are significantly higher than international CIF market prices, even for the fuels sold under planned allocations. However, retail prices of gasoline in China are about one third of those in most OECD countries.

Toll Roads

2.32 Tolls are fast emerging and being adopted throughout China as a way of recovering costs and funding roads, particularly for modern access-controlled expressways. Currently an estimated 1,500 km of toll roads cover more than 15 road sections. A number of toll roads, with a length of about 3,000 km covering some 20 sections, are under construction; some of them will be completed by 1995. Almost all the newly constructed interprovincial expressway roads are being planned as toll roads. Toll levels are set by the concerned province. Toll rates in China ($0.04 per km) are higher than in industrialized countries (where they range from a low $0.01 and $0.03 per km in the United States to $0.06 per km in some European countries). Toll rates in other developing countries are generally higher, sometimes reaching $0.10 per km. Toll setting in China is being revised in light of past experience; a series of studies in Bank-financed projects currently under way in Zhejiang, Henan, and Guangdong provinces will assist in this revision.
User Charges Share

2.33 In 1990, the share contribution by the various road user charges was as follows:

- RMF 53%
- VPF 8%
- Fuel and other product taxes 31%
- Vehicle use fee 3%
- Transport administration fee 5%

Total 100%

Since only a part of these user charges are earmarked for road finance, the above percentages reflect what users pay but not the relative contribution of each charge to highway finance; this is discussed in the next section.

Funding Highway Expenditures

2.34 Funding highway expenditures are based on the earmarked fees listed above, including tolls and other financing sources. This is illustrated by the composition of highway financing in 1990. The VPF revenues are divided between MOC, who gets 75 percent, and the SPC, who gets the balance and uses it for its highway construction program managed through the State Communications Investment Corporation (SCIC). In 1990, MOC received Y 1.7 billion from VPF revenues. Its main destination is helping finance construction of the National Trunk Highway System. MOC shares normally ranges between 30 percent and 50 percent of construction cost, with the higher share of financing for the poorer, hinterland provinces and a lower share for the richer, coastal provinces. MOC also provides subsidiary contributions for constructing or rehabilitating rural roads located in poverty-stricken areas. In specific cases such as Tibet Province, MOC has contributed 100 percent toward the costs of the national road network.

2.35 The total revenue of RMF in 1990 was Y 16.9 billion and, after various transfers to the central government, left Y 12.7 billion as net revenues for road purposes. The central government share of RMF comprise 15 percent, which goes to the Energy and Communication Fund (MOF), and 10 percent, which goes to the Budget Adjustment Fund (SPC).

2.36 Other sources of funding for roads are the following:

(a) **Government Grants.** These are generally very small. Most central government grants are to provide roads for defense purposes and to provide access for poverty areas, amounting to Y 0.2-0.3 billion per year for the whole country.
(b) **Foreign Borrowing.** China has successfully expanded its foreign borrowings in the road sector during the last 10 years, mainly from the World Bank, the Asian Development Bank (ADB), and the Overseas Economic Cooperation Fund (OECF) of Japan. Up to now, a total of $1.6 billion has been committed, with about $1.1 billion from the World Bank, about $0.1 billion from the ADB, and $0.2 billion from the Overseas Economic Cooperation Fund (OECF). Over the last years, it has borrowed an average of $200 million annually.

(c) **Tolls.** Toll revenues are helping to repay loans, but they generate a relatively small amount at present.

(d) **Domestic Loans and Bonds.** Loans for the transport infrastructure can be obtained from a number of banks, though the People's Construction Bank is the principal lender. Currently most of domestic borrowing is for construction loans (bridge financing) only. Some municipalities have started to issue infrastructure bonds, normally with short maturities of up to three years, part of which are used for road construction. Overall, domestic loans and bonds finance less than 5 percent of all highway investments.

(e) **Private Investment.** Guangdong Province has been experimenting with private investment for the construction of highways and bridges for a number of years. (Annex 2 provides a summary of private sector involvement in China's highway sector to date.) Recent reforms have opened the transport infrastructure, notably ports and highways, to participation by private financing. In the highways, this will encourage private capital for financing the construction of toll expressways, and for managing their operations.

While these sources comprise a small proportion of total funding at the moment, diversification of highway financing sources is appropriate and may be especially useful for developing the higher-quality roads. Figure 2.1 illustrates highway revenues and expenditures at the provincial level.

2.37 While China's earmarked road user charges are helping finance construction and management of the highway system at a relatively adequate level, at current rates they would not generate the resources necessary to meet the growing funding requirements for both maintenance and construction. The total revenues of VPF are projected to reach Y 4.4 billion in 1995 and Y 8.2 billion in 2000. RMF is projected to generate, at current fee rates, a total of about Y 26.9 billion in 1995 and Y 38.4 billion in 2000. According to MOC estimates made in 1991 before the government raised its forecast GDP growth rate, if existing sources for funding both national and provincial roads are not improved, the projected financing for year 2000 would be about 30 percent less than what is needed to develop the highway system in line with projected growth in highway demand. Revised MOC estimates based on an expanded investment program (para. 4.36) raised the revenue shortfall to 50 percent of the needs.
The two MOC estimates of funding shortfall, one under GDP growth assumptions and related investment needs contained in the original 8FYP and the other reflecting upward revisions of GDP, are broadly consistent. Substantial additional data and analysis would be required to make a more reliable forecast of the gap between expenditures and revenues. However, projected large increases in investments and fast-growing requirements for highway maintenance as traffic grows, as heavier vehicles are used, and as the road network is expanded signal that expenditures will grow faster than revenues. A recent study assessing the situation in Guangdong Province supports this finding. The study contains a range of forecasts of highway expenditures and revenues. For the year 2000, the shortfall estimate varies from 42 percent to 61 percent of total highway investment and maintenance requirements. In all three forecasts, while investments are expected to increase by 26 percent between 1992 and 2000, maintenance and reconstruction expenditures are forecast to grow between 59 percent and 230 percent during the same period.

E. Transport Services and Tariffs

Road Transport Services

There are mainly four groups of road transport operators in China:

(a) State-owned public carriers owned and managed by local communications departments. Individual organizations have large fleets of up to several hundred vehicles.

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(b) Collectively owned public carriers, which are locally oriented and smaller in scale.

(c) Privately owned public carriers that operate only small fleets.

(d) Own-account operators that can be state, collectively, or privately owned and which vary greatly in size. These are allowed to offer spare capacity for hire.

Table 2.4 provides the breakdown of vehicle fleet and freight for various types of road transport enterprises. (Table 8 shows breakdown by province.)

<table>
<thead>
<tr>
<th>Type of operator</th>
<th>Vehicle fleet (number of units)</th>
<th>Freight volume (100 million ton-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>State-owned</td>
<td>(-)/a</td>
<td>226.5</td>
</tr>
<tr>
<td>Collectively owned</td>
<td>312,985/a</td>
<td>125.7</td>
</tr>
<tr>
<td>Privately owned</td>
<td>816,173</td>
<td>758.0</td>
</tr>
<tr>
<td>Own-account</td>
<td>4,384,842</td>
<td>2,240.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,514,000</strong></td>
<td><strong>3,350.2</strong></td>
</tr>
</tbody>
</table>

/\a The figure of 312,985 units covers both state and collectively owned vehicles.


2.40 The state-owned specialist freight and passenger transport companies, organized and managed at the provincial, city, and county levels, played a central role in road transportation before the economic reforms in the early 1980s. Since then their market share has steadily declined as a result of competition from collective and private transport firms entering the market with greater pricing freedom and operating flexibility. This has led to cheaper and higher-quality services, and a rapid increase in own-account operations. As a whole, the road user industry in China is underdeveloped and suffers from inefficient organizational structure and outdated equipment. While the infrastructure has been steadily improving from the big effort of new construction and upgrading, there is an urgent need to rationalize the road industry, to reduce costs and improve quality of services to allow the final users to reap the benefits of highway construction.
Tariffs

2.41 Tariffs for highway transport are set by local price bureaus on the basis of national guidelines and can thus vary between provinces. On May 1, 1991, new regulations and guidelines on tariff setting for highway passengers and freight came into effect after being issued by MOC with the approval of the State Price Bureau. These regulations stipulate general principles for tariff-setting, but they leave provinces and operators more freedom to decide tariffs for specific services.

2.42 The tariff guidelines comprise several variables, including commodity, size of vehicle, and size of load. State and collective enterprises are required to observe the set tariffs, although there is flexibility to adjust rates locally. Own-account operators may use their vehicles for third-party transport, but they are expected to abide by the tariff that applies to public carriers. Road freight tariffs are broadly four to six times higher than those of rail or waterway, the precise differential depending on haul distance and commodity type. For passengers, the tariffs are closer between the two modes, the bus being slightly cheaper than rail for distances below 100 km (Table 9).

2.43 The freight differentials are mainly the result of truckers using overly small trucks and the result of an inadequate trucking industry organization, which lacks reliable commercial trucking services and forces industrial companies to rely on their own truck fleets. In both freight and passenger transport, however, the tariff differential should gradually decrease, notably for the shorter distances, as improvements to the roads and in the efficiency of the trucking industry reduce the costs of road transport.

2.44 Tariff comparisons should be looked at with caution, particularly in the case of freight where shippers' transport decisions are based on total logistics costs rather than on transport linehaul tariffs alone, and where major differences between these two concepts may exist, depending on the commodity, value of time, competitive conditions, and other factors.
3. HIGHWAY DEMAND, OBJECTIVES, AND DEVELOPMENT PLANS

A. PERSPECTIVES FOR ROAD TRANSPORT DEMAND

3.1 Worldwide experience points to transport demand elasticities relative to GNP greater than one, at least in the early stages of economic development. In China, this may not apply for freight, given development plans that foresee large increases in efficiency in energy production and consumption. Since coal makes up about 40 percent of all rail transport, and some 23 percent of total freight movements in all modes, improvements in energy efficiency will tend to limit increases in freight demand. Based on anticipated GNP growth rates of 8-10 percent per year over the next 5-10 years, freight is expected to grow at rates of 6-8 percent per year, and passenger transport at some 12 percent per year.

3.2 In recent years, although transport flows have grown at high rates almost everywhere in China, the fastest growth has been in the coastal provinces. This is likely to continue, but significant changes will occur in the composition and spatial location of commodity flows. (Tables 11 and 12 give details of road freight traffic and road-rail freight comparison.) In future years, several strategic factors are likely to influence the level, location, and composition of transport demand growth: (a) foreign trade, (b) location of industry, (c) long-distance haul of bulk commodities, (d) increased cross-border trade, and (e) development of containerization. At the same time, passenger travel will grow fast. Overall, these factors will result in a gradual increase in the road transport share of total transport movements, but will still lead to steady increases in demand for railway transport for the movement of mainly long-distance haul of bulk commodities.

3.3 The share of foreign trade in China’s GDP, which grew from 10 percent in 1970 to 31 percent in 1991, will be a key factor, particularly as the share continues to grow. In addition, the composition of trade will also continue to evolve: traditional exports of foods, raw materials, and petroleum have declined progressively over the last decade, as has manufacturing, notably electrical and electronic equipment and clothing and footwear. A substantial proportion of this production takes place in the Special Economic Zones (SEZs) mostly in the coastal areas. However, such activity has lately spread outside the zones. Continued geographic spreading of economic activity will generate more diversified commodity flows into and from an increasing number of origins and destinations. Demand will thus increase for faster and more customized transport services. Imports, also growing fast, are also changing in composition, particularly favoring capital goods that now account for 43 percent of total imports, compared with 19 percent at the start of the reforms. These imports will provide mostly the equipment and machinery for the new and expanded export industries, and will thus reinforce the transport demand pattern generated by the exports.
3.4 In the medium term, patterns of industry location will change substantially. Initially in the SEZs, but increasingly in the rest of the country, the more traditional industry is likely to move gradually from the cities to suburbs and countryside, and vacate valuable urban space for higher value-added industries. This trend is likely to increase significantly short- and medium-distance freight movements between the cities and the new industrial areas, as well as to further diversify origin and destination points of inputs and outputs.

3.5 The large-volume, long-distance flows of bulk commodities, such as coal (from inland provinces in the coal base of Shanxi, Shaanxi, and Inner Mongolia to eastern and southern China), timber, fertilizers, and grains, will continue to grow. While the growth rate will be lower than that of the GDP because of increasing energy efficiency and rationalization in bulk movements, notably of grains, their growth will be strong at some 4-6 percent per year. Hauling these cargos will continue to require massive increases in transport capacity mainly from the railways, although coastal shipping and inland waterways will play a role notably for north-south flows and inland pickup and distribution of grain movements.

3.6 The new geopolitical and economic setting of the eastern central European republics, and the inland extension of China's SEZs will favor increased cross-border trade between the republics and China's border provinces. While the volume of trade will initially be comparatively small, it will likely grow quickly and require the expansion of transport facilities, mainly road networks and services.

3.7 Containerization is developing fast. Increasingly, break-bulk and other general cargo will be moved in containers, notably the higher-value commodities moving in and out of the SEZs. Where the railway track has spare capacity, containers will more likely be transported at lower costs by rail than by road, particularly for medium hauls of about 500 km and above.

3.8 Passenger travel would be expected to grow significantly throughout China as a result of the increases in disposable income, reduction in administrative barriers to personal mobility, and rising business travel induced by the growing interprovincial trade. Travel originating in and around the SEZs is likely to register the largest gains in line with the high growth in per capita income, and this travel would be expected to rise at the highest growth rates.

Projections of Road Transport Demand

3.9 On the basis of the above factors, and the upward revision in China's economic growth projections, current government forecast is that highway transport turnover for freight and passenger traffic will grow at an annual rate of 11.7 percent and 13.5 percent, respectively, during the next five years. Since highway transport turnover has been growing at about double the rate for total transport turnover, this forecast appears reasonable and is consistent with the projections for overall transport growth mentioned earlier (para. 3.1).
3.10 A decrease in the gap between railway and road tariffs would become an important factor in road transport’s potential for competing with, and diverting traffic from, the railways. Historically, railway tariffs have been substantially lower than road transport tariffs. A series of recent tariff adjustments for railway services has reduced the gap, but it remains large. Table 9 illustrates the rate differences between some selected commodities (for a 100-km haul distance) and for passenger travel.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Rail (yuan per ton)</th>
<th>Road (yuan per ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>6.6</td>
<td>26.0</td>
</tr>
<tr>
<td>Bulk minerals</td>
<td>6.4</td>
<td>26.0</td>
</tr>
<tr>
<td>Semibulk</td>
<td>6.5</td>
<td>29.0</td>
</tr>
<tr>
<td>Container (per 20-ft box)</td>
<td>226.2</td>
<td>636.0</td>
</tr>
<tr>
<td>Passenger (for 100-km trip)</td>
<td>5.1/a</td>
<td>5.1</td>
</tr>
</tbody>
</table>

/a Tariff for "hard-seat" class.

Source: Yangtze Economic Zone Transport Study.

3.11 As shown by the above figures, road transport tariffs for general cargo are about four times higher than the railway tariffs (for a 100-km haul). The differential diminishes or even changes sign for shorter distances (since the rail tariff includes a substantial penalty for short distances), but increases with longer hauls. Thus, for short hauls of 67 km on average, road transport is cheaper, and coal comprises some 25 percent of all road freight in this haul range. The tariff differential does diminish when transshipment costs and travel times are considered, and the road becomes more competitive for higher-valued commodities whose production and destination points are not along the railway line.

3.12 Key factors that kept railway operating costs and tariffs low include (a) price subsidies to some of the railways’ operating inputs, such as petroleum and electricity; (b) credit and capital subsidies, and (c) inadequate provision for depreciation expenses. Over the last five years, most of these distortions have been eliminated or substantially reduced, and have led to multiple tariff increases during the period. Today, rail freight prices are estimated to be within 95 to 115 percent of their average economic long-run marginal costs on a systemwide basis. Distortions still remain for individual commodities and services.
3.13 Road transport has a high cost structure, reflected in high tariffs. The causes are a combination of technical and organizational factors, including (a) small and antiquated transport vehicles (trucks and buses) with high operating costs; (b) low average load factors and low annual distances traveled; (c) poor roads; and (d) extremely short hauls for most road freight. The relatively recent opening of trucking to private and collective operators, and the increasing liberalization in routes and commodities controls, coupled with the improvement of the road network, should, over time, bring operating costs down.

3.14 The big difference between rail and road freight tariffs for most commodities for medium and long distances, together with the congested infrastructure of both these modes, has resulted in little competition between these modes. The exception is the short hauls. The average road haul distance is only 46 km (Table 12). The construction of new expressways and the increasing efficiency and reductions in trucking costs will gradually expand the range of distance, at least in some routes and for some commodities, where roads will become competitive with rail. However, most of the railways' traffic consists of bulk commodities moving at distances of over 500 km; for this traffic, the railway is likely to retain its comparative cost advantage over the long term.

3.15 Over time, technology and productivity improvements should bring down the costs and prices of all transport modes. Road transport, farthest today from the technological frontier, should benefit the most. This will reduce the gap in costs with the railway. Tariffs will need to evolve to reflect cost changes, and should also help manage demand in the transport services suffering capacity shortages and congestion.

B. HIGHWAY SECTOR OBJECTIVES

3.16 In the medium term, the main objective of the central and provincial highway authorities will be to ensure that the highway system makes an important contribution to the integration of China's national economy and to a more efficient and better quality of service for the mobility of goods and people. Such a contribution should be compatible with the highways' economic and technological comparative advantages vis-à-vis other modes of transport and with available financial resources.

3.17 To achieve this objective, the relevant authorities would need to:

(a) give preferential attention to identifying, financing, and constructing sections of the National Trunk Highway System in accordance with economic priorities;

(b) develop plans for and construct provincial and rural roads that will feed into the National Trunk Highway System; and

(c) continue reforming policies and regulations with a view to fostering adequate financing for the highway system's development and management
and encouraging the efficient utilization of the transport vehicle fleet, compatible with environmental and safety goals.

C. Development Plans for the 1990s

3.18 The 6FYP and 7FYP (1981-90) substantially improved and expanded China's highway system, although these changes were insufficient to make up for several decades of underinvestment. The Y 25.9 billion spent on constructing new highways and rehabilitating existing highways served to build 140,000 km of new roads, resulting in an increase of 16 percent for China's road network.

3.19 The capital investment program of 8FYP allocated Y 110 billion to build 60,000 km of new highways, including 500 km of expressways and 3,600 km of other high-class highways. The 8FYP targets for all sectors were adjusted following an upward revision, in late 1992, of the government's economic growth forecast to between 8 and 9 percent. A revised "indicative proposal" prepared by MOC shows that investment in highway construction would be expected to reach about Y 160 billion during the next five years, or about Y 32 billion annually. This amount would be applied to carry out the revised highway development plan, which includes 92,000 km of new highways to be built. While provincial roads throughout China, including trunk as well as county and rural roads, will comprise the bulk of the mileage to be added, the plan gives priority to the development of a system of expressways that will be part of the incipient National Trunk Highway System (NTHS), a high-quality system of interprovincial roads. The NTHS consists of 12 national trunk routes and, when completed, would be 30,000 km long and would connect 95 cities. By the end of 9FYP in 2000 (9FYP's investments in highway construction are planned at Y 290 billion), the total length of highways in China is expected to increase to about 1.25 million km, including 3,000 km of expressways.

3.20 The Ministry of Communications plans to allocate some Y 54 billion to 8FYP's highway construction program, which would represent 34 percent of the total investment expected under the revised program, while the remainder will be financed primarily with the provinces's own funds, as well as domestic and foreign loans.

3.21 China's development plans through 2000 also envisage substantial investment in railways. The Ministry of Railways' investment plans aim to reduce the number of bottlenecked links primarily by increasing the capacity of existing lines. To this end, some 75 percent of the proposed investments will go to building double tracks and/or electrifying existing lines, to rehabilitating and maintaining track, and to providing new locomotives and rolling stock. The remaining 25 percent is planned for new line construction, mainly for a new line running from Beijing to Hong Kong between the heavily congested Beijing-Guangzhou and Beijing-Shanghai corridors, and for short line sections on east-west corridors intended to relieve congestion caused by the high-volume coal movements from the coal base in the east to the major industrial centers on the east coast. With such plans,
as noted in the recent Railway Strategy Paper, bottlenecks on the main lines would be reduced minimally from 37 percent of the lines in 1989 to 34 percent of the lines by the year 2000. At the same time, the railway network will remain small and will not provide access to many populated areas, particularly as industrial zones move to previously rural areas not served by the railway.

3.22 As a result of the proposed expansion of rail facilities and construction of modern roads, in selected transport corridors some spare capacity may be created over time that may trigger competition for the shorter distance, higher value commodities. Such simultaneous construction in the two modes is more likely to occur in the high economic growth areas, mainly in the coastal regions and in heavily trafficked corridors such as Beijing-Shanghai-Guangzhou. However, with the high rates in the growth of freight demand expected to take place in these regions, and the fact that rail and road transport tariffs are close to current economic costs, there is little scope for sustaining any spare capacity in the transport system for further rail tariff increases to divert significant amount of freight to the road. Thus, provided that the investment proposals are carefully analyzed, there is little risk overall that network development of either the highway or the railways within existing financial ceilings will end up providing unnecessary transport capacity.

3.23 The road and rail investments proposed under the 8FYP, together with investments in other modes, would make transport investments reach close to 2 percent of GDP, which would be a 50 percent increase compared to the 1.3 percent during the 1980 decade. If MOC's revised proposal is adopted, the percentage would increase to close to 2.5 percent, which would be more in line with the range prevailing in other countries relevant to China. However, financial, engineering and implementation constraints make it unlikely that road investments may be substantially increased beyond the plan over the next three years, until such constraints may be relaxed.

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4. KEY ISSUES IN THE HIGHWAY SECTOR

4.1 Developing and managing a modernized and expanded highway system in China are hampered by a number of constraints. This chapter reviews these and indicates options and recommendations for tackling them. It discusses the difficulties resulting from these constraints in meeting China's needs in the highway sector. Some of the constraints directly affect the availability of resources; others affect the allocation of financial resources and use of physical facilities of the highway system, as well as the services provided. Most constraints have a strong institutional component, and several involve standards and rules of various kinds.

4.2 These constraints are grouped into the following categories:

(a) center-provincial roles and the development and management of the National Trunk Highway System (NTHS),

(b) finance,

(c) investment planning,

(d) management and technology for maintenance and construction, and

(e) development of road transport services.

Given the overriding importance in China's plans for developing the NTHS, the discussion of center-provincial roles examines this question separately.

A. CENTER-PROVINCIAL ROLES AND THE DEVELOPMENT AND MANAGEMENT OF THE NATIONAL TRUNK HIGHWAY SYSTEM

Center-Provincial Roles in Highway Management

4.3 The significant changes in China's economic policies, administrative relationships among the various levels of government and enterprises, and the overriding priority to develop the National Trunk Highway System (NTHS) have prompted government authorities to reassess the relative role of the center vis-à-vis the provinces in highway development and management. This reassessment effectively started in 1986 when the MOC was provided with new funding earmarked for development of the NTHS, which strengthened the role of the center.
4.4 At the same time, the general trend in China's administration and center-local relations has been toward a decrease in the role of the center. This is exemplified by the gradual reduction in the central government's revenues as a share of GNP, and in the increased share of extrabudgetary resources, which provincial governments and local administrations are using to finance expenditures. In many sectors, such a decreased role of the center has translated into the sharpening of the center's role from micromanagement to policy guidance and macromanagement, as is the case with MOC's role in the management of the ports, as discussed in Chapter 1.

4.5 Several other countries similarly are pursuing policies aimed at decentralizing functions throughout the government, including the management of highways. Such countries are moving away from traditionally strong central public works ministries and central planning agencies, whose role in allocating the financial resources available for road construction and maintenance has hindered accountability and efficiency in the planning, financing, construction, and maintenance of highway networks.

4.6 China has for many years practiced devolution of responsibility for local roads to lower levels of government, in part as a result of the central government's long-standing neglect of the highway system. As a result, the provinces were forced to develop highway management organizations capable of operating with minimal or no financial or technical support from national authorities.

4.7 In China, following the provision to MOC of earmarked funding, the center's role in key areas of national interest has been strengthened, particularly to develop the NTHS. However, the provinces' autonomy in financing, building, and maintaining their highway networks has been preserved. China's peculiar conditions, the economywide trends for administrative decentralization, and the urgent need to modernize its highway system pose the special challenge of establishing the most efficient role for the central authorities in regard to developing and managing the highway system.

4.8 The experience of relevant countries could help China in addressing this question. Relevant international experience of other countries shows a broad range, from minuscule to large, in the role of federal government in highway development and management, and also shows that the central government may exert a large influence by indirect means. Such experience also shows the evolving roles of the center and periphery as the road systems develop and as other conditions change. It would be important for China to study closely these experiences; some examples are provided in Box 4.1.

Role Options for MOC and Related Central Agencies

4.9 In the last decade, a new center-provincial relationship has emerged in highway management, along with a highly ambitious national highway program. The provinces retain their primary responsibilities of planning, financing, constructing, and maintaining the highway network, and MOC oversees the sector and coordinates development of the NTHS.
Box 4.1: The Center's Role in Highway Development and Management—International Experience

The experience of the United States, as a big country with a large population, and as a leader in highway development, is especially relevant to China. Federal financial support in the United States was started in 1916 (Rural Post Roads Act) when federal grants were authorized to pay for half the costs of constructing rural roads used to deliver the mail. At that time, about one tenth of roads in the United States were paved, and about 4 million automobiles were registered—about 1 for every 30 people. The current road situation in China is not much different. Over time, as the states in the United States introduced user charges for highways, the federal role shifted to developing and providing the bulk of the financing solely for the Interstate Highway System (IHS). In the 1970s when the IHS was nearly complete, the role of the federal government was refocused. First, laws were passed covering vehicle standards, traffic operations, and highway design, which firmly established the federal interest in safe highway operation. Second, federal programs were broadened to cover major highway maintenance of the IHS.

In other countries, the federal government plays both larger and smaller roles. In Japan, for example, the national highway expressway system is financed by an autonomous corporation of the central government (Japan Highway Public Corporation), which funds investments through bonds guaranteed by the government and other sources, and recovers part of such costs from tolls. The corporation also has a strong say in the management of the system, since it appoints the provincial managers of the system. In India, the government has recently created the National Highway Authority, which has broad responsibility and which is expected to be more competent than the many state highway departments. However, there is a debate whether such authority would have a more effective role if it limited itself to developing and managing the modern expressways only.

How should the roles evolve during the 1990s? This question has two aspects. On the one hand, China is preparing to establish new, smaller roles for the central government in all spheres of the economy, and the provinces have developed good administrative capacity and highway engineering capabilities for the existing highway network. On the other hand, the government has ambitious plans for highway development and modernization, and the provincial capabilities are adapted to roads with antiquated design and used mostly by light vehicles. In this situation, what role should the central transport authorities and related central agencies play in the highway sector that (a) is consistent with a small (or smaller) central government and (b) maximizes the impact it can achieve in meeting government highway sector objectives with limited staff and financial resources? MOC has unique responsibilities regarding the NTHS where it cannot be substituted by provincial governments (see paras. 4.16-4.19). The following areas (discussed in more detailed further in this chapter) appear to be prime candidates for priority attention by the central authorities:

(a) **Highway Finance.** Designing an efficient road financing system; contributing finance to ensure that the development objectives and network integrity of the NTHS are met; providing funds to allow more equity in the form of redistributive schemes among jurisdictions, particularly to favor the poor areas.
(b) **Safety.** Providing guidelines for design standards to be used by the provincial communications departments; encouraging and guiding safety campaigns, education, and law enforcement by the provincial public security bureaus.

(c) **Economic and Engineering Analysis.** Assisting provinces in strengthening the use of market-oriented economic and modern engineering analysis in road planning and design.

(d) **Construction, Procurement, and Supervision.** Guiding improvements in construction technologies and techniques; preparing uniform documentation for procurement and supervision of major road works is essential.

(e) **Training.** Strengthening capacities in the center and the provinces (through training both locally and abroad) for modern highway planning, design, and construction.

4.11 The role of the central government in these areas may vary from an operational one in the case of financing, which involves collecting and distributing funds, to preparing guidelines in areas such as economic analysis and design standards, and to monitoring performance in the construction, operation, and maintenance of the national and provincial networks. In addition to its direct staff functions, the central government could exercise leadership through a variety of means, such as the following:

(a) providing technical assistance to the provinces;

(b) organizing and monitoring pilot schemes at the provincial or county level, in conjunction with provincial communications departments, to test new policies, standards, or procedures and disseminating the results of such schemes;

(c) playing a catalytic role in developing and guiding professional highway organizations, which could help draw highway standards, training programs, etc.; and

(d) developing and implementing a system of performance indices to assess the efficiency of provincial organizations in the construction, operation, and management of their highway systems.

4.12 The creation in 1991 of the MOC-sponsored China Highway Transport Association, an organization grouping professional transport operators, is a good example of ways MOC can further concentrate on major policy directions and macromanagement, and delegate its controlling and operational roles to industry organizations.

4.13 The government in 1991 introduced an Investment Orientation Tax (IOT) to influence the direction and volume of investments. The IOT, which is zero for
construction costs of the roads themselves, but ranges from 5 to 30 percent for ancillary facilities (e.g., administrative buildings) thus is a useful instrument to support efficient use of capital.1/

4.14 The challenge of the next decade is to carry out massive road construction and maintenance and rehabilitation of the road network. Yet the institutional capacities of highway authorities, both at the central and provincial governments is weak. If MOC and the provinces gear up to train their staff and upgrade their institutions, they can avoid the costly mistakes in planning, design, and construction that can easily take place.

4.15 The World Bank has been supporting institutional development in all its highway projects, primarily at the provincial level. Although the need to also strengthen MOC's evolving role as the central highway agency has been recognized for some time, addressing this has not been possible, since Bank highway loans are made to the respective provinces. Recently, Bank and MOC staff have prepared an Institutional Development Program for MOC, and understanding has been reached with GOC that this program would be financed under the China Reform and Institutional Support Project. The main objectives of the MOC Institutional Development Program are to strengthen the MOC capability in sector planning; to strengthen the collection and analysis of data, both for investment planning functions and for performance monitoring; and to provide consulting assistance in carrying out selected transport sector policy and planning studies.

Planning, Developing, and Operating the National Trunk Highway System

4.16 Planning for and constructing the NTHS is China's overriding priority in the highway sector. There are good reasons for building the NTHS. China's fast and sustained economic development is rapidly changing economic and social values. Such changes include a higher utility of time, and of travel safety and comfort. At the same time, the high proportion of slow traffic in most roads, combined with poor road design, results in low vehicle speeds that average less than 30 kilometers per hour and cause a high rate of accidents. Further, there is pent-up demand for long-distance transport, as signaled by the fast-growing demand for aviation services; containerized, door-to-door demand, requiring fast transport services, is also showing a steep increase. The proposed NTHS, conceived as a modern network of access-controlled expressways, properly interconnected, is the appropriate technological and economic response to meet these challenges.

4.17 The central government—notably the Ministry of Communications, the State Planning Commission, and the Ministry of Finance—has a unique responsibility in defining the NTHS, establishing criteria for project selection and design standards, and establishing priority requirements for allocating central government resources. The MOC has defined 12 key corridors for initial development of the NTHS (Annex 3 and IBRD Map 24766) and has identified, based on population, production, and other socioeconomic criteria, the main cities or other points through which such routes would pass. Four of these corridors, two

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north-south (Route 107, Beijing-Zhuhai, 2,310 km, and the coastal highway (Tongjiang-San Ya, 5,700 km) and two east-west (Route 310 Lianyungang-Hoerguosi, 3,980 km and Shanghai-Chendu, 2,970 km), would be given priority for construction through the year 2000.

4.18 The main purpose of the proposed NTHS is to expedite the movement of goods and people. Much of such travel and trade will be interprovincial. Until recently, many barriers to interprovincial transport existed, for imports and exports of individual commodities, cross-border transit by freight vehicles, and to personal mobility. Over the last few years, China has been removing many of these barriers. However, some obstacles still remain to transport and trade between provinces, for example, discriminatory toll charges for out-of-province vehicles and restrictions on selected interprovincial commodity exports. Individuals traveling by private car are subject to systematic provincial border controls, which resembles the controls for foreign travel and which defeat the purposes of building modern expressways. Relevant central government agencies, including those concerned with domestic trade and mobility of people, would need to work together with transport authorities to relax such barriers and ensure that NTHS investments achieve the fullest benefits.

4.19 Determining investment priorities for NTHS links would require to reach consensus with the provinces, in light of the provinces' own assessment of priorities, on the detailed construction schedules and financial arrangements. Only central authorities can interpret national objectives and have access to data required to plan the NTHS network. It is, however, inevitable that conflicts of priorities will arise from time to time between MOC and the provincial governments. MOC's principles in resolving these conflicts should include assuring the connectivity of the NTHS, that new road sections can be used upon completion.

4.20 One important question will be to determine design standards, taking into account both the need to avoid premature investments, and the fast growth of traffic in China, which may saturate highway capacities earlier than expected.

4.21 For any section along the planned corridors, assessments of construction timing and optional designs will be required, including the potential for staging construction. The most critical decisions appear to be the initial capacity, i.e., number of lanes, degree of access controls, and appropriate design standards; this would include options for the earthworks, bridges, intersection-section schedule if a staged program is recommended, and the design life of the pavements. Both decisions are likely to have important implications for allocating and optimizing resources available for developing the NTHS.

4.22 On the former, one key question is when to build access-controlled expressways to only two lanes in the initial phase. This, in turn, involves considering (a) the need to construct structures, especially underpasses, to appropriate width to allow further expansion; (b) the need to reserve right-of-way for the ultimate development, including space for interchanges. Two-lane expressways have been tested successfully in
a number of countries, for example, Sweden and Finland. China is also building some new expressways staged with this initial design, and is conducting tests under Chinese traffic conditions. The economics of the design show that when traffic volumes are likely to grow rapidly to reach the design capacity of a two-lane expressway in a short period (four to six years), the interim solution of two lanes may turn out to be more costly in the long term. This is a dilemma which the Chinese designers will have to face and analyze specifically for each section of the NTHS, although it is clear that the staged construction approach will generally be more suitable in the inland provinces where traffic levels and growth rates are comparatively lower.

4.23 On the pavement issue, the question is the appropriate design life. Should the pavement be designed for a 20-year life, as is the practice in the United States and other countries, or for a 40-year life span, as is the current practice in most European countries? In the case of China, this issue is twofold: (a) China's practice is to construct pavements for a 15-year span, or even less, as shown by highways in Guangdong Province where the fast growth in traffic has required pavement reconstruction after as little as 8 years. Empirical evidence shows this has cost China dearly, since the lower initial construction costs account for much higher maintenance and rehabilitation costs later, as well as higher vehicle operating costs. (b) How strong should the pavement be? The European approach, which implicitly assigns a higher value to future cost savings in rehabilitation and maintenance costs, including traffic disruptions, is for a stronger surface initially. Since heavy trucks cause most of the pavement damage, an approach that reduces maintenance and rehabilitation costs would result in lower user charges for trucks, and lower road transport tariffs. China ought to seriously assess the merits of this approach in the design and construction of the NTHS, taking budget constraints into consideration.

4.24 Planning for the NTHS should also consider the connecting road accesses and related provincial road networks. At present, central government planning (and financial contribution) appears to be strictly limited to the NTHS system itself. Inadequate connecting roads and feeder networks could seriously negate a substantial part of the benefits expected from the investment in NTHS links.

4.25 Government planners may be tempted to resort to comprehensive planning modeling to select and evaluate links for the system. Generally, this would not appear to be necessary, at least in the initial stages of the development, since most of the current road network is simple and does not offer multiple alternative routes, for which comprehensive models are most useful. Rather, planners should carefully select the methodologies for planning and evaluating the individual sections of the NTHS, such that they can differentiate the complexities in some corridors, where more sophisticated modeling techniques are warranted, from the simpler cases, where relatively simple feasibility studies would suffice. All major highway investments should, however, be analyzed in an intermodal context, taking into account existing and future capacities in other transport modes. (See the section, Investment Planning, in this chapter, for more detail.) Since specific investment proposals are initiated and evaluated by the provincial communications departments, MOC would need to ensure that the provinces are able to conduct the studies with the level of analysis that would be required. Such studies could
include a simple set of technical and traffic indicators to facilitate review by provincial and central authorities.

4.26 In addition to the lanes and pavements aspect, central authorities need to ensure that NTHS sections will be operated under similar traffic engineering principles in aspects such as speed limits and traffic control devices (signs, markings, and signals), although flexibility should be retained to adapt to varying topography, climate, distances, and other factors that may affect highway operational norms. Tolling principles and methods would also need to be coordinated centrally. The government would also need to ensure that NTHS roads are maintained at an adequate level. While some coordination exists for these functions at present, there appears to be a need for substantial strengthening of MOC's role and for closer collaboration between MOC and the provincial transport departments. Recent agreements between Henan and Hebei provinces for coordinating development and operations of the expressway that will link both provinces—Route 310, China's most important north-south corridor—reached in the context of a Bank-aided national highway project, exemplify the type of coordination required. Improving interprovincial coordination, in turn, is likely to require some institutional restructuring in addition to extensive training of central government and provincial staff.

4.27 The National Trunk Highway System, because it will have the most modern expressways with high traffic levels, will also be a prime candidate for introducing corporatized management and private financing. Already most provincial governments have set separate highway authorities to plan and manage their sections of the system, and such authorities could set the scene for developing a corporate approach.

Rural Transport

4.28 Historically, the MOC has received a budgetary allocation, though small, to support rural roads. This MOC function is important, since more than 50 percent of China's population is rural. Roads are the only mode of transport that can help these populations reach markets and services. Nonmotorized vehicles are the main form of transport today, but organized freight and passenger rural services are developing. China has done well in the past on rural road development because of a decentralized highway planning and construction system, and the availability of a large well-organized labor force at local levels. However, building roads to many villages is hindered, since many rural roads cannot support larger commercial vehicles. Development plans in most provinces include improvement of rural roads, although the criteria for selecting projects are often unclear, and funds are limited. Also, "free" or cheap labor will increasingly be difficult to find. Central government funding and assistance is limited to the few areas designated as poverty pockets by the central government. In the future, fewer financial resources will be available for rural road programs as national and provincial roads take greater priority in the budget.

4.29 Rural poverty declined from 260 million people in 1978 to about 90 million in 1984 because of rapid growth in rural real incomes of an average of 15 percent per year. However, between 1984 and 1990, real income growth was minimal, and about
10.4-12.3 percent of the rural population remained under the poverty line. China's worst remaining rural poverty is concentrated in remote and mountainous areas where the arable land is poorer, and where transport, power, and other rural infrastructure are inadequate. The lack of road access to these areas raises the costs of transport so much that only high value-to-weight products will be profitable to market. For transporting low value-to-weight commodities, such as coal, outside local markets, either high-grade roads or railroads are needed. At the same time, some imports crucial to production, such as chemical fertilizers, are more likely to be demanded in small quantities, for which highway transport would be more suitable.2/

4.30 Despite the importance of rural transport, there is little data on which to base development policies, particularly regarding appropriate technologies, road design and maintenance standards, execution and financing of road maintenance, and the future role of nonmotorized vehicles. MOC will need to assist provincial governments in formulating plans for developing rural transport. Such assistance should start by taking stock of present conditions and analyzing and formulating policy options.

B. Finance

4.31 As noted earlier, China has an established and reasonably well-functioning highway finance system. However, new road construction over the last 5-10 years and the resources required for building the National Trunk Highway System are radically increasing the level of funding needed. In addition, maintenance needs of the existing roads are rising. Further, present funding sources rely substantially on a set of earmarked taxes, which were designed more for simplicity of collection rather than for economic efficiency. The present highway finance system faces the following three issues:

(a) the need to rationalize road user charges,
(b) the need to mobilize additional resources and diversify funding sources, and
(c) the need to restructure finance.

The Need to Rationalize Road User Charges

4.32 The two main practices for collecting road user charges in China, the RMF and VPF (Table 13) are inefficient ways of charging users, since they do not reflect actual highway usage. The RMF, as is applied to transportation companies, bears only a weak relationship to highway user costs: vehicles with different sizes and weights using and damaging the roads in substantially different ways may generate the same revenues and therefore pay the same fee. The relationship is even weaker in the case of noncommercial truckers, where the RMF tax is based on vehicle capacity. Further, taxes on transport companies over the standard corporate tax only distort transport prices, raising the prices

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and therefore discouraging the use of professional trucking services. This may be a factor
in the strong growth in recent years in own-account trucking, to the detriment of the
trucking industry, which leads to inefficient utilization of the truck fleet. This tax also
further increases road transport costs and reduces the competitiveness of this mode relative
to the railways, thus contributing to the saturation of railway lines.

4.33 The RMF, when applied to noncommercial vehicles and the VPF, are
essentially taxes on vehicle ownership. Fees are charged on the type and weight of the
vehicles—whether fixed monthly charges in the case of the RMF or a one-time charge as
in the case of VPF—of how much the vehicles are used. There are also
concerns about the sustainability of the VPF, the main source of MOC funds, in light of
China’s plans to join GATT since it imposes discriminatory fees on foreign vehicles.

4.34 The current system of user charges also fails to get adequate cost recovery
from the heavier vehicles. While most of the trucks in China’s fleet are currently of
medium size (4-6 tons net), many trucks travel greatly overloaded, exerting axle forces
well above the design loads of the pavements. In the coming years, heavier trucks will
certainly become an increasingly larger proportion of the new truck fleet, so that
recovering costs from such vehicles will be increasingly important. A practice used in
other countries to deal with this problem is to charge annual fees based on truck
capacity and axle loads that reflect the exponential relationship between axle loads and
damage to pavements.

4.35 So far, road traffic patterns in China show substantially fewer hourly
variations than in other countries. This is likely to change, leading to road congestion at
peak hours. Since the length of toll highways will increase significantly in the coming
years, China highway authorities should consider introducing, over time and as congestion
develops, differentiated peak and off-peak toll rates.

The Need to Mobilize Additional Resources and Diversify Funding Sources

4.36 The present highway finance system will be unable to meet the projected
demands for needed road construction, rehabilitation, and maintenance. Preliminary
projections made by MOC in its "indicative proposal," based on current financial sources
show that, by the year 2000, there will be funding for only about 50 percent of projected
expenditures.

4.37 The central and provincial governments are considering ways of raising
additional funds, as well as making better use of the resources generated by the earmarked
user charges. MOC is considering converting part of its financial contribution from grants
to loans to the provinces. This would stretch MOC resources, but would risk further
reducing MOC's leverage and hindering MOC's ability to achieve key national objectives
relating to development and operation of the National Trunk Highway System.

4.38 China has started trying new highway finance sources, and is introducing
financing methods practiced in industrialized countries (Box 4.2). Assessing the results
Box 4.2: INTERNATIONAL EXPERIENCE IN THE FINANCING OF MAJOR HIGHWAYS

There are substantial differences in the financing practices of tolled expressways and other major highways among industrialized countries. In one extreme, the United Kingdom finances all highway expenditures from the government budget, and neither tolls nor earmarked taxes are used. On the other extreme, most highway financing in the United States comes from earmarked federal and state taxes (mainly fuel); the construction of toll roads is generally financed by municipal bonds, which are repaid from toll revenue collection. These revenues also provide the necessary funding to cover the highway's operating and maintenance expenditures. In Japan, the Public Highway Corporation, which is responsible for building and managing the national toll expressway system, funds its investments and operations from a variety of sources: about one third of the funds are generated by toll revenues. Most of the remaining two thirds is financed by a government treasury fund, which includes government-issued and government-guaranteed bonds, including privately placed, domestic bonds, private borrowing, and foreign bonds. The government makes a small contribution in the form of grants and subsidies, which amounts to about 2 percent of the corporation's budget.

Korea is at the forefront of diversified highway financing among developing countries, notably with regard to the importance of tolls. The Korean Highway Corporation generates over 50 percent of its funding from toll revenues. Most of the remainder of the funding is made up of government capital contribution and government subsidies.


of such trials and exploring ways to mobilize additional resources should be an important priority for China's policymakers. Several ways of mobilizing additional resources include the following:

(a) The National Trunk Highway System is being envisaged as a toll road system, which will repay the loan-financed construction costs, and maintenance costs from the tolls collected. Foreign and domestic borrowing are encouraged for this program. The World Bank, the ADB, and OECF (Japan) are likely to be primary sources for this program. Annex 4 presents an overview of China's toll road experience and the issues being faced. In essence, many of China's early toll roads posed significant problems because toll rates were high, and because tolls discouraged traffic and decreased the benefits from the new road investment. More careful studies of toll rates and higher traffic levels have reduced the problem, but there remains the need for detailed toll analysis for future roads and for monitoring the economic and financial performance of toll roads.

(b) To date, domestic borrowing and bonds have mainly been used as a source of funding for construction financing, but their use is limited. Domestic loans were a key source of funds in construction of the new link road to the Capital Airport in Beijing. Recently municipalities have started raising
funds through bonds for infrastructure development, but these bonds, mostly of short maturities of up to three years, are inadequate for long-lasting infrastructure investments. Although China’s high rate of domestic savings points to good potential for developing a bond market, and financing road construction through municipal-type bonds would have an appeal, China’s current financial markets are not adequate for long-term bonds; however, the situation is changing rapidly, secondary markets are emerging, and long-term bond financing may be a viable option within three to five years.

Private financing applied to China’s highway system dates back to late 1970s when a Hong Kong company undertook to construct the Guangzhou-Hong Kong-Macao superhighway (Annex 2). The experience to date of this and a number of other private ventures has been mixed, and in most cases prolonged negotiations and administrative procedures have resulted in delays in projects. In August 1992, GOC issued new policies encouraging private investments in the transport sector, which are expected to result in a better environment for the private sector involvement in highway finance.

4.39 Private financing of roads is generally done through the build-operate-transfer (BOT) approach. BOT projects based on toll revenues require a number of safeguards to ensure a “level playing field” for both the government and private investor, and to ensure that the BOT operation is financially and technically sustainable. Such safeguards are generally well known, although their application is not simple. More recent agreements in China for BOTs include land concessions along the proposed new roads. This approach is relatively new worldwide (some experience exists for subways and light rail, but these involve mostly land use in stations). While road-land concessions are generally more attractive to investors than those based purely on toll revenues, they may generate serious economic distortions, such as a potential for significant monopolistic land rents and cross-subsidies between road users and nonroad users. Such problems could be minimized by subjecting BOT operations involving land concessions to competitive bidding based on carefully designed tender conditions.

The Need to Restructure Finance

4.40 The need to restructure the road finance system, including the user charge structure, is well recognized in China. While such need is being seen essentially to meet financial requirements, the need also exists on efficiency grounds. Overall, China’s road users are not being subsidized, since receipts from user charges exceed maintenance and construction expenditures. At the same time, since most vehicles on the roads are medium-sized trucks, which contribute the bulk of user revenues, there are fewer cross-subsidies among users in China, and much fewer than in other countries, where the large, heavy vehicles normally underpay. Since the number of heavy vehicles is likely to grow fast in China, the relatively contribution of various users is likely to change, and become more similar to countries with a higher degree of motorization. On the other hand, as already noted, the main source of user charges, the Road Maintenance Fee, does not reflect
usage of highway capacity and pavement damage. Thus, efficiency as well as resource mobilization reasons point to the need for restructuring the user charge structure.

4.41 A new highway cost-recovery and finance system would need to comprise a multi-part structure of charges to reflect different costs imposed on the roads by different users, as well as the roads' fixed costs. As in other countries with modern highway finance systems, most of China's highway funding should come from an "earmarked fuel tax." This is being debated in China, and there are proposals for initiating an experimental fuel tax surcharge. Fuel taxes are recognized in many industrialized countries as the most efficient way of charging highway users, and are generally used as the main source for recovering costs and financing highway expenditures. Road pricing technology that will allow vehicles to be charged so as to account for road space and road damage is still experimental and is not likely to be suitable for China in the immediate future. Receipts from fuel taxes vary with road use and, while imperfect, fuel taxes are the most efficient way to charge users among the various instruments available. The long-term needs for a high level of funding for highway development, as well as China's long-standing experience with earmarking, would make the proposal suitable to Chinese conditions. Such an earmarked tax could provide funds to both the central and provincial governments; this tax could be collected at provincial levels, and transfers made to the central government. Earmarking is essential to ensuring that a road user charge becomes a steady source of finance, at the levels required, thus also helping improve efficiency in the planning and execution of highway investments. At the same time, by linking payments with benefits, earmarking enhances cost recovery; beneficiaries will be more willing to pay since they know the funds will be allocated to activities that directly benefit them. The main drawbacks of earmarking are that they introduce inflexibility in government budgets and that a risk exists that in some years, earmarked revenues may exceed expenditure needs for the activity. To address these concerns, an earmarked tax should be subject to the standard caveats: independent controls and monitoring are required to ensure that the funds are invested in high-return projects and that expenditures are done through transparent procurement processes; at the same time, periodic assessments should be made of the amounts collected by the earmarked tax and the funding needs to ensure that, as conditions change, the earmarked funds do not exceed economically justified levels of highway expenditures. The creation of a fund fed by the earmarked receipts would allow formalization of the caveats into operating rules for the use of the moneys.

4.42 Ideally, a new earmarked fuel tax should be set at a level that would allow the government to scrap the existing RMF, and to generate the resources needed for both construction and maintenance, considering other current and prospective sources of funding, such as tolls and private financing. This tax should be supplemented by an annual tax levied on heavy vehicles, or better, on a weight-distance tax, which reflects more closely heavy vehicle usage. The government is considering scrapping the VPF; this could be replaced by an annual license fee, which would serve to pay roads' fixed maintenance costs (those costs independent from road use). An issue with the fuel tax is that it would also fall on nontransport users of fuel (gasoline and diesel). However, other countries have faced a similar problem, and a number of options are available to address it.
4.43 Although determining the level for the proposed earmarked fuel tax would require a detailed analysis, the potential for this type of tax in China would clearly be good. The price of gasoline in China, at little over $1.00 per gallon in the open market, is about comparable to the price in the United States, which is one of the lowest in the industrialized world. Because of higher fuel taxes, gasoline prices in Europe and Japan are two to four times higher. A fuel tax would likely have only a small effect on inflation; to minimize such impact, the tax could be introduced gradually. For China, a high gasoline tax level would help raise revenues for highway finance and also charge users for traffic congestion and air pollution. Both are important in China, given the current high level in both externalities. A high gasoline tax would also have an impact on supporting the use of public transit in cities and on discouraging a too high rate of motorization.

C. INVESTMENT PLANNING

4.44 As a result of the economic reforms over the last decade, China's planning process has been radically altered as investment and production decisions are increasingly left to the market. The current Eighth FYP (8FYP) (1991-95) reflects these changes and focuses more on setting the economic framework than on setting targets. At the same time, an important part of the plan continues to be for the government to retain control, as happens in most countries, over public goods and those facilities with characteristics of natural monopolies. This covers economic infrastructure, including roads, railway, and other transport modes. In the case of China, the government's role in planning the transport infrastructure is further justified by the widespread capacity bottlenecks in the system.

4.45 Plan priorities of 8FYP indicate that while transport will receive higher allocations than in the past, total sectoral investments would still not reach levels adequate to meet future transport needs of the growing economy. Even doubling the proportion of GDP allocated for transport investments would not remove all the bottlenecks in this century.

4.46 The first, macro-level problem with highway planning is the institutional fragmentation of the transport sector. The five transport modes are under the direction and administration of the Ministry of Railways, the Ministry of Communications (for roads, ports and waterways), the Civil Aviation Authority, and the Ministry of Foreign Trade and Economic Cooperation (MOFTEC) (for shipping). While the State Planning Commission has special coordinating responsibilities in fragmented sectors such as transport, it cannot substitute for a modern ministry of transport, which has become almost standard practice in most countries. It is true that, as noted elsewhere, the potential for misinvestment in transport in China is currently comparatively small, given the extent of transport bottlenecks and the fast growth of traffic. However, between misinvestment and investment optimization, there is a large distance. In China, better transport coordination could help get investment decisions closer to the optimal level. At the same time, better sectoral coordination could further rationalize the use of the capacities by ensuring that transport pricing policies and guidelines are done in an intermodal context and, when necessary, through administrative measures.
In the future, transport planning should be strengthened, and a specific analysis framework at the national level is needed for all the modes, so that critical data for planning decisions are identified in a comprehensive, multimodal context rather than strictly within each mode, as is now the case. This would apply specifically to the identification and evaluation of NTHS links and would need to be taken into account in MOC's planning methodology for the NTHS (Annex 3). The World Bank has been supporting comprehensive transport planning through a number of transport studies, notably the Guangdong Comprehensive Transport Planning Study and the Yangtze Economic Zone Transport Study (YEZTS). The provinces involved should use the experience from these studies to strengthen their organization and methods for highway planning, and MOC could help disseminate the know-how gained from these studies to other provinces.

In the meantime, there is also a real limitation for more focused, single-mode evaluation of highway projects proposed under the current plan. Under the guidance of MOC, significant improvements have been made in introducing economic criteria for evaluation of highway investments. Most provinces have adopted the methodologies for conducting highway feasibility studies developed by MOC, and are applying them to provincial and even rural roads. However, the quality of road investment studies varies enormously from province to province or even from project to project.

A review of recent highway feasibility studies submitted to the World Bank for projects in Guangdong, Zhejiang, Hebei, and Henan provinces showed the areas where improvements would be required in the preparation of such studies. Improvements would be needed for the studies to (a) analyze improvements to the existing roads and to alternative road alignments and locations, in addition to the proposed new highway investment; (b) include alternate road designs, by homogeneous road section; (c) improve statistics on traffic, particularly keeping records of traffic speeds and conducting well-designed, origin-destination sample surveys; (d) improve traffic forecasting by relying less on historical projections and relating the forecasts to projections of economic growth and other relevant economic and demographic indicators; (e) improve the measurement of current road capacity, relating it to actual conditions rather than to theoretical design standards; (f) improve construction cost estimates by relying more on costs of recent projects and actual analyses of unit construction costs and less on standard construction cost indices; and (g) improve measurement of benefits, especially reduction in vehicle operating costs and value of time saved. Annex 5 provides an overview of investment planning and feasibility methodology in China.

As part of the improvement in the selection of highway projects both for financing by the central government and by external lenders, there is also a need to develop a set of simple and easy-to-apply analytical tools to screen highway investments, and then rank or prioritize those that pass the screening exercise. These systems could be made specific to the national, provincial, or local levels and to the type of roads

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expressways, other main roads, secondary roads, tertiary roads, etc.). China should also progress beyond the testing stage and make more systematic use of the Highway Design Model, the highway planning and evaluation software developed by the Bank for screening and evaluating improvements to existing road networks, which is now common in many countries and which is used routinely by transport consultants.

4.51 The economic evaluation techniques to be applied to candidate projects should also be adapted to the needs. This applies principally to projects submitted for central government financing. Until China's road system becomes more of an interconnected network, evaluation and selection of individual road projects, rather than systemwide planning approaches, would be the appropriate way to allocate resources. For example, several sections of the 12 key corridors in initial development of the NTHS are obvious choices, since they serve the most important population and production centers, and since current routes are highly congested. Well-conducted feasibility studies—and exceptionally, transportation modeling in the case of individual corridors where network effects may be important and alternate routes exist (in corridors such as Beijing-Shanghai)—should be the right means for analyzing the proposed investments. The same general principles should apply to local road projects submitted for provincial government financing.

4.52 In summary, a number of actions would improve investment planning and evaluation of investments. MOC, in conjunction with SPC, would need to take the lead in preparing and implementing such actions, which should include the following:

(a) undertaking a program that would review and improve highway feasibility methodologies, appropriately differentiated to different kinds of road projects, which could include the introduction of the Highway Design Model to the provinces;

(b) devising a strategy for introducing the revised methodologies in the provinces through a program that would include technical assistance and training;

(c) establishing a method for screening highway projects proposed by individual provinces;

(d) disseminating, on a selective basis to provinces that may require it, the technique for comprehensive transport planning developed through the studies in Guangdong and the Yangtze economic zone; and

(e) strengthening MOC's own capacity for highway planning and economic evaluation.
D. MANAGEMENT AND TECHNOLOGY FOR MAINTENANCE AND CONSTRUCTION

Maintenance Management

4.53 Until now, highway maintenance has generally been organized and carried out well, thanks to consistent, routine maintenance operations organized and implemented by the provincial governments. The main drawback has been poor riding quality of the road surface stemming from labor-intensive, low-technology practices. Yet, while excessively high vehicle operating costs and reduced speeds have resulted in economic losses, the overall situation has been satisfactory, particularly when compared with the situations of most countries in similar conditions.

4.54 However, underlying factors threaten a major regression in the quality of highway maintenance. The present structural capacity of the road pavements is generally marginal for the current traffic, and is fast becoming inadequate to meet the needs of the high growth of traffic and of vehicular loadings. This poses three interrelated issues. First, there will be a substantial increase in the needs of financial resources to tackle the growing demands for pavement maintenance at a time when funding for maintenance has, in relative terms, been declining. Second, with limited resources, the provinces will need to be able to carefully identify where and for what maintenance activities such resources will yield the highest returns, which will require the introduction of modern maintenance planning and information systems. Third, the way highway maintenance is carried out will need to be reassessed to ensure that implementation methods are as efficient as possible.

Funding for Maintenance

4.55 During the Sixth FYP (6FYP) (1981-85), expenditures for highway maintenance nationally averaged about 65 percent of the revenue from the RMF, while about 25 percent was spent on road upgrading and new construction. More recently, expenditures for maintenance as a percentage in total revenue of highway maintenance fee have dropped to 53 percent in 1985 and to 39 percent in 1990 as a result of the need to fund the surge in highway development.

4.56 During this period, road traffic and truck loads increased rapidly and new roads added to the highway network, with an average increase of more than 17,000 km per year during 7FYP, thus increasing the overall maintenance requirements. Although increased expenditures for road upgrading and rehabilitation have to some extent substituted for maintenance requirements, there are clear signs of an increasing backlog of maintenance work in most of the provinces. Thus, continuation of the trend for increasing diversion of highway funding to road upgrading and new construction at the expense of maintenance is certain to lead to faster deterioration of the existing highway network.

4.57 MOC estimates that the funding gap for highway maintenance in 8FYP is about ¥ 10 billion, on the basis of projected increases in the RMF of 12 percent annually.
On a temporary basis, and until China’s system of road user charges and financing is revised, MOC and provincial highway departments should strive to retain for highway maintenance a reasonable share in the RMF earmarked for road maintenance and rehabilitation to ensure good condition of the existing road networks. According to preliminary estimates, a "reasonable share" for maintenance would be 60-65 percent of the total revenue of the highway maintenance fee.

**Maintenance Planning and Resource Allocation**

4.58 The basic management information and data needed to plan the maintenance, development, design, and construction of the highway network are not available in a readily accessible format in China. Although efforts have been made to maintain the network over the years, because of the lack of management information, most of these efforts have been focused on short-term targets under "mandatory planning" and therefore have had limited returns. Routine maintenance aimed at patching holes, and neglect of resurfacing, which is more capital intensive, but often with higher returns, is a classic example of this in China.

4.59 The prior requirements for planning and management include procedures for paving and monitoring roads, a road data base, decision analysis models for network program preparation, and pavement and structures evaluation methods for project design. During the past decade, China has made considerable progress in developing a data bank, pavement management system, and bridge management system, and implementation is starting in some provinces. However, these systems are complex, and their implementation is likely to go through a protracted period. MOC should pay particular attention to assisting the initial implementation efforts and ensuring that the methods being put in place are practical, not overly sophisticated, and can yield usable information. The current status of these systems is summarized in Annex 6.

**Efficiency of Implementation**

4.60 **Institutional Setup.** Provincial transport departments have a highly decentralized organizational structure for highway maintenance. Such a structure, supported by labor-intensive techniques, little mechanization, and community participation, has been highly effective for conditions prevailing in China’s highway system. The heavier traffic and loads, and the maintenance requirements of modern expressways will require rethinking the institutional approach. Already, many provinces are setting up separate, relatively autonomous agencies that are charged with the planning, construction, operation, and maintenance of toll-financed expressways. If properly set up and accompanied by suitable equipment and intensive staff training, this approach should prove a step in the right direction. Similar recognition of the needs for maintenance of other major provincial roads will be required, accompanied by some centralization of heavier, more equipment-intensive maintenance operations.

4.61 At the same time, the more advanced provinces should consider further modernization of road maintenance organization and implementation. A first step would
be to contract out periodic maintenance activities through a bidding process similar to that employed for new construction. Since equipment and techniques for pavement resurfacing and other periodic maintenance operations are similar for construction and maintenance, the domestic road construction industry, which is gaining experience in the construction of modern highways, would also be qualified to carry out these maintenance works.

4.62 **Outdated Construction and Maintenance Technology.** The current, prevailing labor-intensive techniques for construction and maintenance, which may still be considered appropriate for secondary roads and/or county roads, pose serious problems for developing and maintaining a modern national and provincial highway network.

4.63 The most critical area of construction and maintenance is the pavements, which deteriorate fast and reach unacceptably high levels of roughness soon after construction. The poor quality of the pavements stems from inadequate and inappropriate design and specifications, slack quality controls, obsolete construction and maintenance equipment, and poor quality of materials, notably bitumen and aggregates. For example, the technology of road drainage design and construction has long been overlooked in China, resulting in early damage of road pavements, as well as high costs for maintenance. At the same time, traditional materials design, including modification of natural soils and gravels, and bituminous materials, along with construction practices, are not fully adequate for the higher traffic loadings becoming prevalent on the highway networks.

4.64 Modernization of technology is needed in practically all areas of construction and maintenance, and is required for equipment, materials, and techniques. Improving quality in highway work and technology for construction and maintenance requires MOC and provincial highway departments to take a combination of actions, beginning with a commitment to quality, the provision of funding resources to modernize equipment fleets, the improvement in specifications, the training of government highway staff and contractors, and the setting up of independent quality controls for all types of works. A comprehensive review of the state of the art in materials processing technology for crushed stone, bituminous materials and cementitious materials would be a basis for enhancing current techniques. Special care should be taken by MOC over the development and improvement of its design specifications and construction manuals for road drainage systems, especially for high-class highways. Nationwide guidelines on quality assurance and quality control need to be developed by MOC for material processing and construction performance, as well as manuals for mechanized construction and maintenance activities, rather than labor-intensive operations, to promote the achievement of uniform and adequate quality.

4.65 **Addressing the highway maintenance issue before it reaches a critical level** would require MOC, working in conjunction with the Ministry of Finance and the provincial transport departments, to:

(a) set guidelines and establish appropriate mechanisms for ensuring adequate levels of funding for maintenance (this could best be done in the context of
an overall review of highway finance and road user charges, as noted in the section on Finance);

(b) assist in the implementation of improved maintenance planning and information systems methods in the provinces that are more advanced, ensuring that the process is initially of adequately small size and well focused, and establishing a suitable monitoring system; and

(c) conduct, on a sample basis, an assessment of the adequacy of the provincial highway maintenance organization to deal with changing network and traffic situation and identify possible ways for reorganizing and modernizing maintenance arrangements and for establishing maintenance by contract.

**Road Construction Industry**

4.66 The cost and quality at which the National Trunk Highway System and other major provincial roads will be built will depend basically on the efficiency of China's road construction industry. Currently, three quarters of the construction companies doing highway work (about 560 companies in total nationwide, including some railway and other companies that also build highways) are state-owned, heavily subsidized companies. The remainder are corporations set up as financially and managerially autonomous entities.

4.67 These financially autonomous corporations are China's best hope on which to found the development of a sound civil works construction industry. However, these corporations are hindered by unfair competition from an excessively high number of subsidized government-owned contractors who are able to meet the abnormally low prices expected by the public works departments, and by contracts which provide small margins for working capital and renewal of equipment. Access to work opportunities in other provinces is restricted by the poor condition of the road network, which makes transport and other mobilization costs high. Financial problems are compounded by four- to six-month delays in payments for the works, which requires the companies to borrow at high interest rates, as well as by frequent underestimation of the costs of the works on the part of the companies because of low official cost estimates. In addition, their equipment is old, with low productivity, and suffers frequent breakdowns.

4.68 The situation in Fujian Province, which has one of the more advanced road construction industries, illustrates these points. The construction enterprises primarily involved in provincial road works comprise 17 enterprises located throughout the province, and include two larger, three medium-sized, and 12 small construction enterprises. All these enterprises, though state-owned, are financially autonomous corporations and receive no budgetary support from the agencies to which they are administratively attached. Most of these enterprises make no profit, have acute cash-flow problems and are unable to invest in equipment renewal, let alone in expanding their fleet. In Fujian Province, since there are practically no large state-owned enterprises in the highway construction business, the autonomous corporations are not faced with unfair competition. They do work, however, below market prices, since Fujian follows a nationwide practice that bid prices must be
within a narrow bracket (about 5 percent) of official cost estimates. The corporations’ problems are compounded by lack of commercial credit. In addition to lacking major pieces of equipment, particularly for earthworks and paving, the companies have little laboratory and field testing equipment, which is essential for quality control. While staffing is relatively adequate, managers and staff have not been trained in the latest technology and ways to manage it.

4.69 A strategy for improving the road construction industry should be two-pronged. It should (a) assist the financially autonomous corporations, mainly through improvements in the enabling environment and targeted measures to modernize their management and technology; and (b) restructure the traditional state-owned enterprises along the lines of the autonomous corporations. To advance the basis for developing a strategy, studies would be required to identify the nature and extent of economic environmental constraints on the construction industry, in particular the following:

(a) government policies, such as bid prices within official cost estimates, that greatly affect the contractors’ profitability, productivity, and efficiency;

(b) the impact of reform measures being introduced for the transformation of the state-owned industrial enterprises on the highway construction industry; and

(c) the impact of current price controls, the quota system, and materials supply system.

4.70 From initial diagnosis of the system, assisting the financially autonomous corporations would require the central and provincial governments to take measures directed to the following:

(a) liberalizing the restrictions that currently constrain contractors’ bid prices;

(b) making credit more readily available for renewal of technology and for working capital to allow such companies to catch up with modern technology;

(c) creating leasing companies for the provision of modern equipment;

(d) obtaining managerial assistance from well-experienced foreign companies or encouraging joint ventures between local and foreign companies; and

(e) improving know-how in equipment and methods by training managerial staff and technical personnel.
Environmental Assessment and Management Plans

4.71 While introduced only in recent years, China's practices in environmental assessments for highways are comparable to those of the most advanced industrialized countries. Environmental Assessment Plans (EAPs) and Action Plans are prepared routinely for all highway projects that involve new alignments or expansion of the right of way, and the guidelines for such assessments are strict.

4.72 However, there is need for improving, both upstream and downstream, the preparation of the environmental plans, particularly with a view to the following:

(a) Integrating the environmental assessment with project planning and design by advancing preparation of the environmental assessment to earlier stages of the project cycle. Thus, environmental considerations could effectively be incorporated in the selection of road alignments and in the analysis of alignment alternatives where, under current practice, such assessments are applied to the design solutions and are mainly used to determine measures to mitigate negative environmental effects during construction.

(b) Strengthening the implementation and management of the EAPs to ensure that the recommended measures are effectively taken and monitored thereafter during execution of road works and operations. This requires incorporating in the duties of contractor, supervisory entities and environmental agency specific responsibilities to implement and monitor the measures recommended in the EAPs.

4.73 The MOC intends to strengthen its environmental division, which will be instrumental in assisting the start-up of similar entities to be created in the provincial transport departments. This would provide the institutional setup needed for covering the whole range of functions required in the environmental area, and for considering and implementing recommendations, such as those suggested above.

4.74 Assessing the environmental aspects of motor vehicle pollution is better done in the context of urban transport, since air pollution is basically urban. However, the proposal for restructuring road user charges toward a high tax on vehicle fuels noted above would be consistent with an economically sound policy on urban air pollution.

Safety

4.75 China's highways have a high rate of accidents (Table 14) by almost any international standard. A study completed in 1987 under the Bank's First Highway Project found the accident rate to be 100 deaths per 10,000 vehicles. This high rate costs the Chinese economy close to $1.0 billion each year. The situation has worsened due to the higher traffic levels and traffic congestion. The causes are varied, chief among them being highway congestion, inadequate awareness of safety in highway design and traffic engineering, a high percentage of slow and nonmotorized traffic, poor driver habits, and
laxity in enforcing highway laws and regulations. The construction of expressways under
the NTHS will gradually reduce the accident rate as access-controlled highways, which
separate the slower traffic, become substantially safer. However, construction of the
NTHS will take some time, and improving safety over the rest of the road network will
remain important.

4.76 Responsibility for road policing, accident reporting, traffic engineering, and
statistics are vested in the Ministry of Public Security, while highway design is done by
the provincial highway departments. With a few exceptions, in most provinces there is
little formal or informal coordination between these two agencies, which constitutes one
of the main barriers to enhancing highway safety in China.

4.77 The existing division of responsibilities for highway safety among various
agencies is also customary in other countries, which have recognized the importance of
coordinating the work of such agencies. Thus, it has been common to create coordinating
agencies or committees expressly to deal with highway safety issues, sometimes at the
highest levels, as France did when it placed such functions initially in the prime minister’s
office. Currently, central and Eastern European countries are setting up such coordinating
committees, which include several agencies—notably ministries of finance, interior, and
transport—that are normally placed under the chairmanship of the ministry of transport.
Such committees overview the preparation of highway safety action plans, and monitor and
evaluate the implementation and results of such plans.

4.78 Several measures, which China’s central and provincial governments could
consider to improve highway safety, include establishing road safety committees or units,
aimed at improving coordination among the transport and public security agencies;
conducting safety audits with the purpose of identifying dangerous “black spots” where
accidents frequently occur; collecting, summarizing, and analyzing reliable accident data;
conducting training for safety-focused highway design and traffic engineering; organizing
campaigns for improving driver education and tightening law enforcement; and developing
comprehensive highway safety action plans.

4.79 However, important, enhancing safety is not cost-free. While the wide body
of international experience may help assess the benefits of different approaches, conditions
in China are singular and even vary among provinces. Thus, in order to ensure that
resources assigned to safety are allocated to those activities with the largest benefits,
candidate measures should be tested on a pilot basis and the results carefully monitored and
evaluated before such measures are recommended for widespread adoption.

4.80 Guangdong Province is following such an approach. Having the fastest-
growing provincial economy with the highest traffic growth rates, the number of road
accidents and fatalities is rising fast. From 1985 to 1991, accidents increased from 14,676
to 30,326 and fatalities from 1,984 to 4,429, representing average annual growth rates of
12.9 percent and 14.3 percent, respectively. While the institutional division of
responsibilities between the agencies noted above also affects this province, the provincial
transport authorities, with Bank assistance, are launching a Road Safety Pilot Program,
which will allow initiation of actions that are within the purview of the transport authorities. The program consists of training, equipment, and a demonstration project tied to the training, which would identify existing hazardous sites (black spots) where accidents occur frequently. Engineering improvements would be developed and implemented accordingly to eliminate the hazards. Based on the results of the program, transport authorities will assess the utility of establishing a special road safety unit that would regularly identify and develop improvements for accident black spots and initiate and implement safety audit procedures and other road safety activities.

Training and Manpower Development

4.81 The fast development required of China's highway system is being hampered by inadequate managerial and technical skills at all levels. The staff of MOC, provincial, prefectural, city, and county highway departments are, in general, professionally competent, but most have not been trained in modern techniques and technology. Although highway staff have benefitted from the training provided by MOC and provincial training institutes, the development and implementation of training programs for managers and senior professionals has been hindered by difficulties in designing appropriate programs and in selecting suitable trainers, and by the government's reluctance to use foreign loans to finance training. However, the backlog in highway technical and managerial skills is large, and academic programs in universities and provincial highway institutes—such as the strong engineering programs at Tongji University, the transport management programs at Xian Highways Institute, and the new graduate program in transport economics at Nankai University in Tianjin—would not be able to meet the needs in a timely fashion.

4.82 Training and manpower development is an integral part of modernizing China's highway system. As part of this effort, MOC and provincial highway departments should, first of all, forecast the optimal size and professional composition of their staff to be attained in the next decade, based on the current and prospective roles of these agencies in the highway sector. This should be followed by an analysis of existing staffing and personnel policies and of the current staff skills mix. The outcome of this exercise should be the preparation of a manpower development plan.

4.83 In MOC as well as in the provinces, the skills for traditional engineering fields, such as bridge design, are generally good and sound. Skill improvements are needed in the newer areas of highway management: economics analysis and planning; project management; design of modern expressways, including pavements; traffic engineering, toll road operation and management; highway safety; and environmental protection.

4.84 The World Bank has supported training and manpower development through its highway loans (see Annex 7). In addition, the ongoing CRISSP technical assistance program provides funding for the strengthening of a network of 14 transport training institutes, including several that focus on highway training, in a program that is being led by the Bank's Economic Development Institute (EDI).
E. DEVELOPMENT OF ROAD TRANSPORT SERVICES

4.85 Under the objectives of 8FYP, the integration of markets and expansion of interprovincial trade are to be emphasized. Road freight haulage is well suited to meet the needs of China's changing economy, especially rapidly expanding segments, such as wholesale and retail trades, light manufacturing, and construction. At the same time, commercial vehicles, mostly carrying freight, make up the largest proportion of traffic on China’s highways. How transport services are operated will have a substantial effect on the operations of the NTHS and other main roads.

4.86 Significant liberalization measures, coupled with the pace of economic reform, have brought dramatic changes to the road freight services industry. Beginning in 1983, entry barriers to private operators were removed, and price controls progressively relaxed. Further measures in 1992 replaced the existing fuel allocation system with a market mechanism.

4.87 Despite these improvements, road transport services remain underdeveloped relative to other modes of transport, particularly to meet the growing needs of freight and passenger traffic. Currently, the trucking market share in China is low, and represents only 25 percent of road and rail combined, a lower figure than in other countries at a comparable phase of economic development. Slow development of the trucking sector is partly due to the underdeveloped state of China’s highway network, as discussed in earlier sections of this paper.

4.88 Growth of road freight services and diversification of providers is well under way. During the last five years, China’s trucking fleet increased 65 percent, from 2.2 million to 3.7 million trucks. The volume of freight carried increased from 270 billion ton-km to 340 billion ton-km. Most of the increase in freight and passenger highway transport in recent years has been absorbed by collective and private transport operators, and by own-account operators.

4.89 For-hire road transport services, both freight and passenger, are provided by publicly owned companies affiliated with local (provincial or district) highway authorities, and by a smaller but growing number of cooperatives and private operators. They include state-owned enterprises (SOEs), collectively owned enterprises (COEs) and privately owned enterprises. In addition, there are "own account" operators—nontransport entities who operate truck fleets to carry their own cargo. The SOEs have steadily been losing ground to the other operators.

4.90 The failure of the for-hire industry to keep up has boosted the trend among industrial and commercial enterprises to move goods using their own trucking fleets. For example, a textile manufacturing company in Zhengzhou, Henan Province, which employs 7,000 (including some 700 engineers), and which brings most of the production inputs by

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4/ A Bank study of China's road freight services is currently under way.
rail, still keeps a fleet of 110 trucks (capacities ranging from 4-10.5 tons per truck), mostly for the distribution of finished products. Each truck travels on average 30,000 km per year, which is a low utilization by international standards. The company’s management feels that owning a truck fleet is essential, despite poor truck utilization and high investment and operating costs, because for-hire services are not reliable or not available when needed.

4.91 Road freight services offer the flexibility and reliability that is suited to expanding transport to more remote, inland areas. Unlike other modes of transport, trucking is not characterized by scale economies; rather, it is particularly suited to small, micro-enterprises. Service providers in this size category compete effectively with SOEs due to their flexibility, innovative drive, and interaction with customers. The success of private sector trucking companies has in fact been cited as a model for developing private enterprises in China’s transport sector.

4.92 The road freight services industry in China is characterized by several general problems. Among these are inefficient management of truck enterprises; inefficient and antiquated trucking fleets prone to frequent breakdowns and which are mismatched with the needs of shippers; the resultant higher operating costs, especially fuel and maintenance costs; and lack of a customer orientation among service providers. Similar problems affect road passenger services.

4.93 Unless conditions are changed, with increased commercialization, the benefits of improving China’s highway systems will be substantially negated by inefficient, high-cost transport services. One area of focus is the reduction of vehicle operating costs, which remain extremely high, stemming in part from technological factors (e.g., poor roads, outmoded vehicles), as well as from the still small number of commercially oriented transport companies.

4.94 Improved vehicle technology and operating practices are also necessary. Progress on these aspects could lead to a one-third reduction in maintenance costs and a 20 percent reduction in fuel consumption—a lowering to levels occurring in other countries. High priority needs to be given to reviewing the procedures and incentives for vehicle investments, as well as ensuring that full encouragement is given to the introduction of more modern designs. The current, old freight vehicle fleet is causing accidents, road congestion and excessive levels of air pollution. Their modernization is clearly an area that requires central government initiatives.

4.95 The mix of vehicles available is also inadequate to meet transport needs. Currently, 40 percent of total transport tasks are performed by trucks with only a 5-ton carrying capacity. The remainder is carried by trucks with an average carrying capacity of 10 tons. In other countries, 2 larger truck models are typically used—a 3-axle rigid truck with 16-ton capacity, and an articulated truck with a capacity 24 tons. Eventually, China will require a similar mix of vehicles. Domestically produced trucks are currently technologically inferior to those available overseas. However, GOC plans substantial development of the automotive industry. By the year 2000, a limited number of large
regional conglomerates are expected to be manufacturing high-quality, internationally competitive vehicles.

4.96 The restructuring of the road freight services industry as a whole is necessary to complement to China's ongoing program of road investments. Besides regulatory changes and the accelerated introduction of more modern vehicles, the government should also ensure that operational productivity is maintained at as high a level as possible. This should be particularly so for the large state transport enterprises, which will continue to play the major roles in many parts of the transport sector in the foreseeable future. For example, procurement and distribution decisions have not been based on economic criteria, such as carrier hauling capacity, price, service, or reliability.

4.97 Future passenger transport demand in China will be driven by population growth, rise in household incomes, the growth of economic activity, and changes in fare levels. From the perspective of development, economic growth and geographic location, population density, and tourist demand will be the strongest factors in the growth of demand.

4.98 The development of road passenger services is also of critical importance in meeting China's growing transport needs. The problem of insufficient passenger capacity can best be solved by utilizing all modes of transport and developing a rational, integrated network structure.

4.99 Railways will continue to be the main mode of transport for medium- and long-distance passenger transport. However, other transport modes, such as intercity bus travel and waterway transport, should be further developed, since short-distance trips could be better accommodated by road transport, which would free rail capacity for longer trips. Air transport needs to be further developed to meet the needs for long- and medium-distance travel demand.

4.100 The development of road passenger services requires attention in several areas. First, road capacity must be increased, particularly along high-density corridors. In addition, the road passenger transport suffers from the general problems with the quality of the road system and vehicle technology described earlier in this section. For example, constructing new expressways would reduce journey times for intercity bus travel and increase road transport's competitiveness. Road improvements in the main railway corridors would also facilitate moving short- and medium-distance passengers from the railways.

4.101 Improvement of vehicle technology and quality is equally important in the further development of road passenger services. Increased demand for higher-quality bus travel is already evident, for example, in the demand for air-conditioned buses.

4.102 Improving road transport will require the following:
(a) further deregulation and amelioration of the truck licensing system to promote competition while preserving safety, equalizing taxes and transport input prices to generate a "level playing field," and restructuring user charges to cover pavement damage and account for congestion and pollution externalities;

(b) continuing reform of the industrial structure by "hardening" the budget constraints of state-owned enterprises and by providing financial and other assistance for the development of private and collective enterprises, and gradual reduction of "own-account" trucking;

(c) modernization of technology and operating practices; and

(d) commercial legislation for the road freight and passenger business.
5. BASIS FOR A HIGHWAY DEVELOPMENT AND MANAGEMENT STRATEGY—ROLE OF BANK ASSISTANCE

A. NATIONAL AND PROVINCIAL GOVERNMENTS

5.1 A concerted effort among central economic and transport authorities at both the national and provincial government levels will be required to achieve China's objective of expanding, modernizing, and strengthening management of its highway system. Over the medium term, they would need to pay particular attention to the following areas:

(a) cost recovery and financing, (i) to introduce an earmarked fuel tax to provide a steady source of funds needed to construct the NTHS, to meet the increasing costs of maintenance and operations, and to encourage an efficient use of the highway system; and (ii) to introduce annual fees based on axle weights that will reflect the sharply rising damage from high axle loads on pavement;

(b) highway planning and investment strategies, to better identify short- and long-term highway development priorities and to assess road design standards based on economic analysis;

(c) role of MOC, to make it consistent with the rapid decentralization taking place in the management and financing of highway operations, and to strengthen its capacities to deal with its expanded role in the planning, finance, and operations of the NTHS;

(d) preparation of feasibility studies, to deepen use of modern analytical techniques, and based on data and relationships reflecting actual conditions on China's highways;

(e) operations of the road user services industry, both for freight and passengers to reduce costs and improve quality of services, through the promotion of competition, further development of private and collective transport enterprises, introduction of modern technology and management methods; and

(f) road construction industry, to improve the management and application of contract conditions, modernize equipment, further competition, develop private and autonomous construction companies and clarify relationships among clients, contractors, and supervisory bodies.
B. BANK GROUP STRATEGY

The Bank’s Experience

5.2 Through December 1993, the Bank Group had loaned about $4.1 billion to China under 28 projects for the transport sector, and there are a number of new transport sector projects under preparation.

5.3 The highway subsector has received $1,289 million in Bank Group financing under nine projects (Loan 2539-CHA/Credit 1594-CHA; Loan 2811-CHA/Credit 1792-CHA; Loan 2951-CHA/Credit 1917-CHA; Loan 2952-CHA; Credit 1984-CHA; Loan 3073-CHA/Credit 2025-CHA; Loan 3471-CHA; Loan 3530-CHA; Loan 3531-CHA; and Loan 3681-CHA). These projects provide for the construction of high-standard national highways totaling about 1,630 km, and the expansion and improvement of some 5,140 km of lower-class provincial and county roads and major bridges. When completed, some of these roads will help to provide vital missing links in the national highway network; others will help to ease severe congestion in parts of the network or provide access to remote areas. The projects are also designed to provide foreign technical assistance and training of Chinese personnel in areas such as supervision and quality control of road construction, design, and planning. Finally, the projects support studies on key issues of highway development such as road safety, pavement management, user charges, and methods of financing the expansion, improvement, and rehabilitation of the road network. The first Highway Project (Loan 2539-CHA/Credit 1594-CHA) is completed; a Project Completion Report was issued in May 1992.

Proposed Bank Strategy

5.4 The proposed Bank’s strategy for future highway lending is to continue to support institutional development and sectoral reforms aimed at modernizing the highway system and its management. This support will continue both at the central and provincial government levels. During the next three to five years, the investment components of highway projects will continue to focus on high priority links of the NTHS, and to support the development of the provincial road networks.

5.5 The proposed Bank strategy also envisages continuing close collaboration with the MOC, and assisting it, through economic and sector studies and through lending operations, in adapting to the evolving needs of the Chinese economy. The proposed institutional strengthening program for MOC (para. 4.14) and a planned exercise to improve prioritization and feasibility methodologies for highway investment are key elements of the strategy. Specifically, the proposed Bank’s highway lending strategy comprises the elements listed below.

Sectoral Reforms and Institutional Components

5.6 The Bank’s dialogue with central and provincial authorities, as well as the insights gained during supervision of the highway projects portfolio, have helped to
identify key issues in the highway sector and devise ways to address them systematically. While some institutional and sector issues will normally be addressed in every project, other issues requiring more detailed studies will be addressed selectively in individual provincial projects, with a view to formulating recommendations that may also serve other provinces.

(a) The following are to be included in all highway projects:

(i) sound planning, investment analysis and management of the highway network, including rehabilitation and maintenance;

(ii) compliance with environmental and resettlement requirements; and

(iii) promotion of road safety.

(b) The following are to be included selectively in individual provincial highway projects:

(i) identification of a structure for adequate road user charges and financing mechanisms, in order to mobilize the necessary resources for road development and equitably recover from users the costs of the highway system;

(ii) promotion of adequate road freight and passenger services, including encouragement to private, collective, and township enterprises to enter the business as part of the reform of the transport sector;

(iii) upgrading the capacity and effectiveness of the highway construction industry and creation of an enabling environment for the corporatization of provincial construction companies and opening opportunities for the development of collective and private contractors;

(iv) integration of road transport services with other modes, particularly in the field of containerization, and the establishment of modern, integrated multimodal services;

(v) planning and budgeting of highway expenditures, including monitoring and control of monetary and physical objectives, and efficiency of disbursement procedures;

(vi) organization and management of the highway corporations being set up to operate toll highways;

(vii) highway maintenance management, including finances, resource allocation, organization, and operations;
(viii) recent experience in China with private finance of roads and provide a framework for future private investment;

(ix) highway construction costs to analyze costing practices and assess actual prices and to stimulate commercially oriented bid prices; and

(x) other issues that may be of special interest in individual provinces.

Investment Components

5.7 The Bank will give priority attention to helping finance the following investment components:

(a) development of expressways of the NTHS in specific corridors of proven high demand and inadequate existing capacity. This will include:

(i) continued support to the high-traffic, high-growth provinces where road congestion is most acute;

(ii) increased assistance to the lesser developed provinces, for investments at standards appropriate for traffic levels and growth potential that are economically justified;

(b) improvement and expansion of the provincial and rural networks including attention to roads that will support increased cross-border trade between inland provinces and their western border countries;

(c) equipment mainly to modernize road maintenance operations and to ensure satisfactory operations of the access-controlled expressways;

5.8 In addition, the Bank would be prepared to consider new operations that would help further marketize China's highway sector, for example by providing finance for trucks or other transport equipment that might be leased or sold to collective or private operators or by providing guarantees in road investments which involve private financing.
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/a Excludes ocean-going transport.

Table 2: **Passenger Traffic by Mode**  
(billion passenger-km)

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<th>Year</th>
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<th>Civil Aviation</th>
<th>Total</th>
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**Growth rate % p.a.**

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<th>Civil Aviation</th>
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Table 3a: TRANSPORT INVESTMENT VS. ECONOMIC OUTPUT

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<th>Transport investment as % of GNP</th>
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/a Investment of FYPs includes Post and Telecommunications (about 4% of total).

Table 3b: INTERNATIONAL COMPARISON

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Source: Statistical Yearbook of China—1992 and 1993. Other data based on SAR of China Sixth Railway Project, Table 1.5, p. 88.
Table 4: INVESTMENT IN THE TRANSPORT SECTOR  
(INCLUDING POST AND TELECOMMUNICATIONS) \(^a\)  
(By Five-Year Plan Period)  
(Y billion)

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<td>16.0</td>
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\(^a\) Investment of FYPs, before 1980, includes Post and Telecommunications (about 4% of total).

Table 5: Highway Design Standards

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<td>Rolling</td>
<td>Mountainous</td>
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<td>Flat</td>
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<td>Passenger car equipment.</td>
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<td>Medium truck equipment</td>
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<tr>
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<td>10,000-25,000</td>
<td>4,500-7,000</td>
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### Table 6: Road Network by Province

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Table 7: **CIVILIAN MOTOR VEHICLES**  
(Thousands)

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**Annual growth rates**

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**Proportion of individually owned**

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*Source: China Statistical Yearbook—1993.*
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<th>Total trucks (1,000 tons)</th>
<th>Average hauling capacity per truck (ton/truck)</th>
<th>Transport entities (1,000)</th>
<th>Transport entities (1,000 tons)</th>
<th>Average hauling capacity per truck (ton/truck)</th>
<th>Privately owned trucks (1,000)</th>
<th>Privately owned trucks (1,000 tons)</th>
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<td>over 500 km: Y 9.50 + 0.029/km</td>
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<td>Operator interviews</td>
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<td>Y 2.58 + 0.045/km</td>
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<td>Y 10.92 + 0.032/km</td>
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<td><strong>Air (full economy)</strong></td>
<td>Y 0.00 + 0.39/km</td>
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/a Rail tariffs have marked "kink" at 500 km. For model application, the two linear regressions were replaced by the single expression given in the text.

/b Average rate taking account of buses of various class, size, and ownership, and the affect of local fees paid by bus operators.

/c Third class is 31 percent higher.

/d Classes 3A and 3B are 89 and 40 percent higher, respectively.

/e Discounted fares are, on average, about 72 percent of full economy fares, i.e., Y 0.28/passenger-km.

Source: Yangtze Economic Zone Transport Study.
Table 10: FREIGHT TRAFFIC CARRIED BY HIGHWAY SECTOR  
(excluding tractors and nonmotorized vehicles)

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Table 11: RAILWAY AND HIGHWAY FREIGHT TRAFFIC BY PROVINCE, 1992

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<th>Province</th>
<th>Population (mil.)</th>
<th>Agriculture output value (Y billion)</th>
<th>Light industry output value (Y billion)</th>
<th>Heavy industry output value (Y billion)</th>
<th>GNP Total value of retail sales (Y billion)</th>
<th>Tons-originated by trucks only (mil. ton)</th>
<th>Tons-Carried by trucks only (bil. ton-km)</th>
<th>Average distance (km)</th>
<th>Railway freight traffic (mil. ton)</th>
<th>Highway freight traffic (mil. ton)</th>
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<td>2.25</td>
<td>0.13</td>
<td>0.27</td>
<td>3.33</td>
<td>1.68</td>
<td>5.58</td>
<td>5.58</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>34.1</td>
<td>20.53</td>
<td>23.99</td>
<td>35.97</td>
<td>49.45</td>
<td>23.73</td>
<td>105.95</td>
<td>105.66</td>
<td>6.62</td>
<td>6.62</td>
</tr>
<tr>
<td>Gansu</td>
<td>23.1</td>
<td>12.27</td>
<td>9.93</td>
<td>26.78</td>
<td>30.19</td>
<td>14.42</td>
<td>96.66</td>
<td>80.43</td>
<td>6.04</td>
<td>5.86</td>
</tr>
<tr>
<td>Qinghai</td>
<td>4.6</td>
<td>2.73</td>
<td>1.97</td>
<td>4.85</td>
<td>8.43</td>
<td>3.76</td>
<td>25.30</td>
<td>20.07</td>
<td>1.91</td>
<td>1.83</td>
</tr>
<tr>
<td>Ningxia</td>
<td>4.9</td>
<td>2.84</td>
<td>2.23</td>
<td>6.71</td>
<td>7.86</td>
<td>3.80</td>
<td>24.17</td>
<td>18.94</td>
<td>1.37</td>
<td>1.29</td>
</tr>
<tr>
<td>Xinjiang</td>
<td>15.8</td>
<td>17.24</td>
<td>14.62</td>
<td>17.11</td>
<td>38.23</td>
<td>15.76</td>
<td>93.20</td>
<td>77.69</td>
<td>9.88</td>
<td>9.37</td>
</tr>
</tbody>
</table>

Table 12: Average Distance of Freight Traffic by Mode, 1981-92

(km)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Railway</th>
<th>Highway</th>
<th>Waterway</th>
<th>Pipeline</th>
<th>Civil aviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>232</td>
<td>530</td>
<td>21</td>
<td>1,241</td>
<td>457</td>
<td>1,809</td>
</tr>
<tr>
<td>1982</td>
<td>238</td>
<td>539</td>
<td>25</td>
<td>1,236</td>
<td>449</td>
<td>1,961</td>
</tr>
<tr>
<td>1983</td>
<td>244</td>
<td>559</td>
<td>19</td>
<td>1,285</td>
<td>459</td>
<td>1,983</td>
</tr>
<tr>
<td>1984</td>
<td>219</td>
<td>584</td>
<td>22</td>
<td>1,351</td>
<td>456</td>
<td>2,074</td>
</tr>
<tr>
<td>1985</td>
<td>243</td>
<td>636</td>
<td>31</td>
<td>1,216</td>
<td>442</td>
<td>2,128</td>
</tr>
<tr>
<td>1986</td>
<td>236</td>
<td>646</td>
<td>34</td>
<td>1,042</td>
<td>413</td>
<td>2,143</td>
</tr>
<tr>
<td>1987</td>
<td>234</td>
<td>673</td>
<td>37</td>
<td>1,174</td>
<td>413</td>
<td>2,183</td>
</tr>
<tr>
<td>1988</td>
<td>243</td>
<td>681</td>
<td>44</td>
<td>1,128</td>
<td>416</td>
<td>2,226</td>
</tr>
<tr>
<td>1989</td>
<td>258</td>
<td>686</td>
<td>46</td>
<td>1,281</td>
<td>402</td>
<td>2,226</td>
</tr>
<tr>
<td>1990</td>
<td>270</td>
<td>705</td>
<td>46</td>
<td>1,447</td>
<td>398</td>
<td>2,218</td>
</tr>
<tr>
<td>1991</td>
<td>284</td>
<td>718</td>
<td>46</td>
<td>1,554</td>
<td>399</td>
<td>2,234</td>
</tr>
<tr>
<td>1992</td>
<td>279</td>
<td>734</td>
<td>48</td>
<td>1,433</td>
<td>417</td>
<td>2,330</td>
</tr>
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</table>

Table 13: COMPOSITION OF ESTIMATED ROAD-USER CHARGES, 1990

<table>
<thead>
<tr>
<th></th>
<th>¥ billion</th>
<th>(% )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road maintenance fee</td>
<td>16.88</td>
<td>54.0%</td>
</tr>
<tr>
<td>Vehicle purchase fee</td>
<td>2.21</td>
<td>7.1%</td>
</tr>
<tr>
<td>Fuel fee</td>
<td>7.32</td>
<td>23.4%</td>
</tr>
<tr>
<td>Added tire</td>
<td>1.81</td>
<td>5.8%</td>
</tr>
<tr>
<td>Heavy lorry</td>
<td>0.97</td>
<td>3.1%</td>
</tr>
<tr>
<td>Spare parts</td>
<td>0.40</td>
<td>1.3%</td>
</tr>
<tr>
<td>Other product taxes</td>
<td>10.5</td>
<td>33.6%</td>
</tr>
<tr>
<td>Vehicle user</td>
<td>1.28</td>
<td>4.1%</td>
</tr>
<tr>
<td>Transport administration</td>
<td>0.38</td>
<td>1.2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31.25</strong></td>
<td><strong>100.0%</strong></td>
</tr>
<tr>
<td>Province</td>
<td>Population (mil.)</td>
<td>Total number of accidents</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,158.2</td>
<td>264,817</td>
</tr>
<tr>
<td>Beijing</td>
<td>10.9</td>
<td>8,257</td>
</tr>
<tr>
<td>Tianjin</td>
<td>9.1</td>
<td>4,715</td>
</tr>
<tr>
<td>Hebei</td>
<td>62.2</td>
<td>10,773</td>
</tr>
<tr>
<td>Shanxi</td>
<td>29.4</td>
<td>7,283</td>
</tr>
<tr>
<td>Inner Mongolia</td>
<td>21.8</td>
<td>2,687</td>
</tr>
<tr>
<td>Liaoning</td>
<td>39.9</td>
<td>17,758</td>
</tr>
<tr>
<td>Jilin</td>
<td>25.1</td>
<td>3,899</td>
</tr>
<tr>
<td>Heilongjiang</td>
<td>35.8</td>
<td>3,313</td>
</tr>
<tr>
<td>Shanghai</td>
<td>13.4</td>
<td>7,524</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>68.4</td>
<td>15,309</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>42.0</td>
<td>13,595</td>
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<tr>
<td>Anhui</td>
<td>57.6</td>
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<tr>
<td>Fujian</td>
<td>30.8</td>
<td>8,384</td>
</tr>
<tr>
<td>Jiangxi</td>
<td>38.7</td>
<td>5,884</td>
</tr>
<tr>
<td>Shandong</td>
<td>85.7</td>
<td>16,850</td>
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<tr>
<td>Henan</td>
<td>87.6</td>
<td>18,330</td>
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<tr>
<td>Hubei</td>
<td>55.1</td>
<td>7,204</td>
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<tr>
<td>Hunan</td>
<td>62.1</td>
<td>11,065</td>
</tr>
<tr>
<td>Guangdong</td>
<td>64.4</td>
<td>30,326</td>
</tr>
<tr>
<td>Guangxi</td>
<td>43.2</td>
<td>8,347</td>
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<tr>
<td>Hainan</td>
<td>6.7</td>
<td>2153</td>
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<tr>
<td>Sichuan</td>
<td>109.0</td>
<td>21,851</td>
</tr>
<tr>
<td>Guizhou</td>
<td>33.2</td>
<td>5,651</td>
</tr>
<tr>
<td>Yunnan</td>
<td>37.8</td>
<td>6,805</td>
</tr>
<tr>
<td>Tibet</td>
<td>2.3</td>
<td>619</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>33.6</td>
<td>8,573</td>
</tr>
<tr>
<td>Gansu</td>
<td>22.9</td>
<td>2,210</td>
</tr>
<tr>
<td>Qinghai</td>
<td>4.5</td>
<td>2,728</td>
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<tr>
<td>Ningxia</td>
<td>4.8</td>
<td>1,978</td>
</tr>
<tr>
<td>Xinjiang</td>
<td>15.6</td>
<td>5,280</td>
</tr>
</tbody>
</table>

Chart 1: Organization of the Ministry of Communications

THE STATE COUNCIL

THE MINISTER

Vice Minister

General Office

Personnel & Labor Department

Supervisory Bureau

Planning Department*

National Highway

Project Feasibility

Annual Investment

Statistical Summary

Vice Minister

Logistic Department

Engineering Department*

Specifications & Standards

Engineering Design

Project Implementation & Supervision

Maintenance & Administration

Finance & Accounting Department*

Management of VPF

Project Disbursements

Policy & Legislation Department

Transport Department

Foreign Affairs Department

Safety Department

Public Security Department

Auditing Bureau
Chart 2: ORGANIZATION OF THE ZHEJIANG PROVINCIAL HIGHWAY ADMINISTRATION

Zhejiang Provincial People's Government

Zhejiang Provincial Transport Department

Highway Administration Bureau

Municipal or Prefectural Transport Bureau

Municipal or Prefectural Highway Administration Department

Municipal or Prefectural Highway Transport Administration

Municipal or Prefectural Highway Check & Levy Department

County Transport Bureau

Provincial Road & Bridge Engineering Department

Technical School

Machine Shop

Concrete Plant

Provincial Engineering Team

Engineering Team Maintenance

County Highway Engineering Division

County Highway Transport Administrative Division

County Highway Check & Levy Division

Work Site (Group)

Engineering Unit

Maintenance Unit

Construction Unit

Source: Zhejiang Provincial Transport Department.
MINISTRY OF COMMUNICATIONS (MOC) FUNCTIONS, ORGANIZATION, AND FUTURE NEEDS

A. BACKGROUND

General

1. This report has been compiled on the basis of a series of meetings with selected Departments and Divisions of the MOC as well as discussions with the two Planning and Design Institutes in Beijing (Highway and Water Transportation). A site visit to the Beijing-Tianjin-Tanggu Expressway and a discussion with the Expressway United Corporation have also been included during the fact-finding visit (October 23—November 16, 1992).

B. ROLES AND RESPONSIBILITIES OF MOC

Present Responsibilities of MOC

2. The Ministry of Communications is responsible for part of the communication sector, the highways, ports and waterway subsectors. Important segments of the transport sector, Railways and Civil Aviation are organized in separate ministries. There are few direct contacts between these independent ministries. Two of the most important roles of a Ministry of Communication or Transport, the intermodal planning and the coordination between the modes are thus not done at the ministry level. The intermodal balance is instead decided by the State Planning Commission, a level between the ministries and the State Council (the Cabinet equivalent).

3. MOC responsibilities for investments seems to differ somewhat from subsector to subsector but are generally restricted to major projects or—in the case of highways—to the National Trunk Highway System (NHS). However, MOC provides only some 30 percent of the investment costs, the disbursements are done biannually in advance without reference to progress or performance and in case of a dispute, the Engineering Department must write to the Finance Department via the Minister. Formally, MOC could stop the disbursement of funds to a project that did not meet specified standards.

Staffing and Organization

4. The total number of employees in the sector as defined above is about 5,000,000. At the central level (in MOC itself) there are 828 employees, among which
377 engineers, 186 economists, 51 accountants, 9 lawyers and 205 other staff. The directly controlled units comprise administrative units, safety and supervision bureaus, rescue and salvage units, press and publishing house, freight forwarding enterprises, research institutes, planning and design institutes, some manufacturing industry (e.g., vehicles, plant and equipment), training colleges, construction companies and some import/export companies. The number of units under the direct control of MOC amounts to 130.

5. MOC is not organized along modal lines, i.e., there is no roads, waterways, ports, etc. department. Instead, the organization is functional (planning, engineering, transportation, financing, etc.) though the individual departments have been organized along modal lines. Several of the Divisions—one per Department—are involved in the planning of the modes within MOC, though the main work and the coordination is done by the Comprehensive Division in the Planning Department. During 1993, MOC has been considering various reorganization options with a view to adapting MOC to new market economy conditions, changes in intergovernmental fiscal relations and increased roles to be taken by the provincial governments.

6. While the intermodal organization is necessary in a ministry responsible for intermodal planning, this is not quite the case for MOC, as MOC presently is something in between a combined modal authority and a Ministry of Transport.

C. MAIN PURPOSES OF A STRENGTHENING PROGRAM FOR MOC

7. The strengthening program for the Ministry of Communications (MOC) forms part of the China Reform and Institute Support Program (CRISP) and should be seen as a logical extension of the IBRD support to provincial infrastructure projects. The subproject will be implemented by the Ministry of Communications, Department of Planning with a total project budget of $3.6 million plus Y 1.0 million.

8. The main purpose of strengthening MOC must be to enable consistent long-range planning to ensure that funds will be used wisely; that the different policy instruments (investments, pricing, regulations, promotion, etc.) support each other; and that each mode of transport is used in the most efficient way. Considering the huge amounts planned to be invested in all modes, any mistakes in the planning and later in the implementation could result in large cost implications. Of particular importance is to ensure that no systematical errors are made—1 percent lower return on, e.g., the roads program during the 8FYP would mean an annual loss to the society of some Y 1.2 billion. Potential losses due to poor quality control, resulting in shorter life of the investments could easily run into many tens of billions of yuan.

9. Although two important sectors, Railways and Civil Aviation do not fall under MOC, the planning at MOC must consider intermodal aspects and be a part in the overall intermodal planning. A good working knowledge of the methods is also a prerequisite for being able to influence the decisions taken by other ministries or at higher level (by SPC). In time a decision to merge above-mentioned ministries into a Ministry
of Transport may come and a more widespread knowledge of intermodal planning would then be an advantage.

10. A development of sector planning, policy formulation and management capacity of MOC must, however, include also a development of the planning methods for each individual mode, for which MOC has the responsibility.

11. Another important aspect of a strengthening program for MOC must be to look at how the plans are implemented and the funds used, i.e., on the design and construction methods and on the management methods applied. MOC and the Planning and Design Institutes appear to have adequate technical knowledge but that there are problems with quality control methods and possibly also with the use of the specifications in the provinces. Designs and specifications for expressways would be in need of a review aiming at a new standard based on previous experiences.

12. The different roles of Client, Engineer and Contractor and the accountability of each of them are poorly developed and not in line with a market-oriented policy. An increased in dependence of the institutes and the contractors is from this point of view desirable but so is an increased awareness of their roles not least when it comes to the quality control.

13. The MOC Planning and Design Institutes are already to some extent operating as consultants and part of their budgets are financed by other than MOC, which would facilitate a development of the institutes towards a more market-oriented and independent consultants.
PRIVATE INVOLVEMENT IN CHINA’S HIGHWAY SYSTEM

1. Private sector involvement in China’s highway system appears to have gone the furthest in Guangdong Province, but it has not been without its difficulties. Much of the impetus has come from the interest of Hong Kong investors in the expectation of financial returns, partly from toll revenues, but more significantly from exploiting associated land development rights. This has led to a rather politically led involvement, with deals negotiated directly with the Governor’s Office and the Planning Commission, and with less involvement by the Communications Department in charge of provincial highway development.

2. The lead was taken by Hopewell Holdings, which have been promoting the Guangzhou-Hong Kong-Macao “superhighway” since the late 1970s. The highway design forms the shape of the letter A, with Guangzhou at the apex, Hong Kong and Macao at the two feet, and with a cross link between the two main highways, which would involve a major new bridge across the Pearl River. Only the Hong Kong-Guangzhou link is under construction with Hopewell Holdings involvement, but they are now responsible for only the central section—Guangzhou Municipality and Shenzen special economic zone are building the north and south sections, respectively. The project has been characterized by many “final” announcements of agreement, only to find that negotiations were in fact continuing, with the difficulties hinging on the extent of revenue sharing and land development rights. As a result of the long delays, Guangdong Province has arranged financing of a major expansion of the existing highway from Guangzhou to Hong Kong, but not by Hopewell Holdings. Another Hong Kong consortium financed the Tiger Gate Ferry at the same site. The status of the approach roads to the bridge is unknown. Negotiations continue with Hopewell Holdings on the Guangzhou-Macao link of the superhighway, but Guangdong Province is planning parallel road improvements, perhaps because of the uncertainty of the Hopewell project. Several other bridges have been financed by different Hong Kong groups, all tolled and said to be financially successful.

3. Guangzhou Municipality has been successful in obtaining Hong Kong financing (New World Company) for sections of the expressway ring road. Further sections are said to be financed by Hopewell Holdings. It was also recently announced that a Hong Kong company would finance a new ring road for the city of Hangzhou in Zhejiang Province. All these ring road sections are planned as toll roads, and early indications in Guangzhou are that tolls will cover costs relatively easily.

4. The Guangdong Provincial Communications Department is now examining other ways of involving private financing, not only from Hong Kong, but also from
domestic sources. They have cited different models, including floating bonds, setting up share holding companies, which would invest in highway and bridge projects as they saw fit, and highway construction corporations for specific corridors to tap the financial resources within the corridor of the highway itself. However, none of these really constitutes privatization, although they do represent interesting ways of raising revenues.

5. Private funding of highway projects presents a number of potential pitfalls to be avoided:

(a) Privatization implies tolling to raise user revenues, which could cause conflicts of interest, especially in mixed privately and publicly funded projects:

(i) Private sponsors will be looking to maximize revenues, which might imply a higher level of tolls than appropriate, and will pay less attention to maintenance than is desirable.

(ii) The frequency of toll stations could hinder long-distance travel. Already in Guangdong, there are comments about the number of individual bridges, tolls, and road sections charging tolls, and the burden this places on companies to provide their truck drivers with sufficient cash to complete a journey.

(iii) Toll collection on a massive scale, and with relatively unsophisticated toll collection systems, could provoke petty corrupt practices—Guangdong official claim that they change the toll barrier staff every month to reduce this problem.

(b) The rather political nature of the privatization process reduces the influence of technical issues on the highway alignments and interchange locations, and on the programming of highway development, since these critical decisions will be driven by revenue maximization criteria rather than a highway development strategy based on traffic needs.

(c) Further on the last point, there is little evidence that private involvement is improving China contracting processes—there is little value added in bringing Western methods to China. For example, the Hong Kong-financed sections of the superhighway project is being constructed by local Chinese contractors using a series of small subcontractors in the same way that they normally do projects.

(d) The linkage between privatization agreements and land development rights has important implications for urban development, which might not produce the best results for the community.
(e) Huge financial benefits could flow to a relatively small number of astute developers and financiers. This, combined with the relatively low salaries paid to public officials who retain the decision making role, is a potent recipe for corruption.

6. Against these reservations on privately led highway development must be set perhaps equal reservations about the ability of planners of all types—economic, land use, and highway—to come up with plans which are any better. This is especially true in China where a genuine analytically based planning process scarcely exists, with few well-trained staff to administer it, and where the sheer weight of development requires decisions to be made at an unusually high pace. Guangdong currently estimates that its economy will grow at 12 percent per year for the next 20 years, which implies a tenfold growth in the economy in the period—an astonishing, but perhaps not unattainable, goal given China’s resources.

7. On balance, private financing of highway infrastructure should probably be encouraged, but China should seek to learn from other places where privately funded highways have been built—such as Japan, Italy, and the United States—in order to learn from their mistakes, and to mitigate the potentially adverse effects of private financing. With the pressure for economic growth in China, especially in the eastern provinces, offers of private financing will likely be impossible to resist, and such financing may play a valuable role.
Box A2.1: BUILD, OPERATE, AND TRANSFER—CHINESE STYLE

The Beijing Capital Airport Expressway

The Beijing Capital Airport Expressway Project is a six-lane access-controlled toll expressway with a length of 18 km and five major interchanges. The expressway, which opened to traffic in 1993, will be equipped with full-scale traffic engineering facilities, such as a traffic surveillance system, communication system, automatic toll-collection system, and emergency responding system. The project is designed by Beijing Municipal Engineering Design Institute with technical assistance from various institutes of the Ministry of Communications (MOC). The estimated cost of the project at design stage was about Y 530 million, or about Y 30 million per kilometer. Traffic in 1992 in the existing two-lane airport road was about 11,000 vehicles per day and future traffic of 40,000 vehicles per day is projected by the year 2000 in the corridor.

The BOT (build, operate, and transfer) concept is introduced in the project by MOC and Beijing Transport Department (BTD). A joint venture, namely Capital Airport Expressway Company, Ltd., was set up between MOC and BTD as a shareholding company, because each party agreed to invest Y 200 million to the project from its own funding resource as a "shareholder." The remainder of funds come from domestic and external loans, including funds from the Spanish government of $4.5 million for the traffic engineering system.

The Capital Airport Expressway Company is organized according to the regulations for shareholding companies issued by the State Council. The board of directors of the company comprises senior staff of MOC and BTD, who direct and supervise the management and activities of the company. The joint venture has the overall responsibility of arranging financing, implementing services and business related to the expressway operation, repaying loans or other debts by collecting tolls and other incomes, and further developing new expressways.

The final cost of the project may exceed the estimated budget by about Y 800 million due to current significant price increases for major construction materials. The project's cost overrun is a major issue, and ways for financing and managing it are being worked out.
CRITERIA FOR IDENTIFYING ROUTES OF THE NATIONAL TRUNK HIGHWAY SYSTEM 1/

A. BACKGROUND

Economy and Transport of Cities

1. Up to the end of 1988, China had 434 cities, with an urban population of 290 million, or 27.2 percent of the total population. The total value of industrial output of the cities (constant prices of 1980, the same thereafter) was Y 862.1 billion, or 71.1 percent of the national total. The total retail value was Y 382.2 billion, or 51.4 percent of the national total.

2. Up to end 1988, 269 cities had railway transport, 87 cities had air transport, and all 434 cities had road transport.

3. These data show that cities are the mainstay of China's social economy, as well as the major origination and destination points of China's transport. As such, cities should be selected to be the nodes for China’s National Trunk Highway System.

Development Trend of Cities

4. Urbanization is a necessary and inevitable stage for China's social and economic development. Government studies project that by the year 2000, there will be 691 cities, or an increase of 257. By 2020, there will be 1,000 cities, with an urban population of 700 million, or 50 percent of the national population (which is estimated at 1.38 billion). During the urbanization process, the existing major cities will continue to play the role as centers. A city system will gradually be formed, taking as core the central cities such as Beijing, Shanghai, Guangzhou, Wuhan, Chongqing, Tianjin, Shenyang, Dalian, Xian and Lanzhou. These central cities will be the link with provincial capital cities, provincial major cities, and other medium- and small-sized cities. Within the city system, there will be groups of cities along the sea coast, along the Yangtze River, or along the major transport trunk routes.

1/ The methodology described in this annex has been developed by MOC's Highway Planning and Design Institute.
5. The urbanization and formation of the city system will further reinforce the importance of cities in China's social and economic development. Hence, cities should also be chosen from the future perspective as nodes for the National Trunk Highway System.

B. SYSTEM NODE ANALYSIS AND SELECTION

Analysis of the Types

6. At the end of 1988, of the 434 cities, the largest was Shanghai, which had a population of 10 million and an industrial output value of Y 100 billion. The smallest was Wanding, with a population of 1,000 and an industrial output value of Y 10 million. The development scales of cities were uneven. In accordance with the functions and roles of the trunk routes and the development trend of China's cities, nodes are planned to be selected from the following four types of cities: (a) provincial capital cities, (b) provincial central cities, (c) transport pivotal cities, and (d) major port cities open to foreign trade.

7. **Provincial Capital Cities (including cities directly under the central government).** Provincial capital cities are politically and administratively important, and are centers for provinces' economy, culture, commerce, finance, and transport. They are the most important part of China's social and economic system. Hence, all 31 provincial capital cities (including Taipei) should become nodes for the National Trunk Highway System.

8. **Provincial Central Cities.** Apart from the provincial capital cities, many central economic cities have large populations and high industrial output values, and are developed commercially. Some examples include Qiqihar of Heilongjiang Province, Jilin of Jilin Province, Tangshan of Hebei Province, and Chongqing of Sichuan Province. These cities have a great influence on the provincial as well as national economy, and thus should be selected as system nodes.

9. Based on comparisons and analyses, the following formula has been used to judge the importance of cities. Three indicators were included: nonagricultural population (to reflect the city's activity function), industrial output value (to reflect the city's production function), and total retail value (to reflect the city's commercial function).

\[ E_i = \frac{P_i}{P} + \frac{G_i}{G} + \frac{S_i}{S} \]

- \( P_i \) nonagricultural population of the urban district of \( i \) city (10,000 persons)
- \( P \) average value of nonagricultural populations of all cities (10,000 persons)
- \( G_i \) industrial output value of the urban district of \( i \) city (Y 100 million)
- \( G \) average value of industrial output values of the urban districts of all cities (Y 100 million)
Si \text{ total retail value of the urban district of } i \text{ city (Y 100 million)}

S \text{ average value of total retail values of urban districts of all cities (Y 100 million)}

10. Cities with $E_i \geq 300$ will be selected as the National Trunk Road System nodes. Based on the 1987 statistics, there were 65 cities with $E_i \geq 300$: Chongqing, Fushun, Anshan, Qiqihar, Tangshan, Jilin, Baotou, Zibo, Handan, Yichun, Xuzhou, Wuxi, Datong, Benxi, Luoyang, Huainan, Jixi, Suzhou, Jinzhou, Fuxin, Daqing, Liuzhou, Mudanjiang, Shantou, Zhangjiakou, Shenzhen, Changzhou, Xiamen, Liaooyang, Dongguan, Wenzhou, Zhongshan, Weifang, Baoding, Hengyang, Foshan, Kaifeng, Bengbu, Zhuzhou, Wuhu, Yingkou, Huangshi, Xiangtan, Zhenjiang, Anyang, Jiamusi, Xinxiang, Pingdingshan, Xiangfan, Shiyan, Zaozhuang, Huzhou, Yangzhou, Dongying, Yichang, Zigong, Shaoqian, Guilin, Shashi, Yueyang, Yancheng, Xianyang, Jiaying, Xi'an.

11. Transport Pivotal Cities. This type of cities play an important, pivotal role in the national comprehensive transport network, and should be selected as National Trunk Highway System nodes.

12. Based on the 1987 data, 23 cities had an annual cargo dispatch volume of 20 million tons and passenger dispatch volume of 10 million person-times: Beijing, Tianjin, Tangshan, Zhanjiakou, Shenyang, Dalian, Anshan, Benxi, Liaooyang, Harbin, Daqing, Shanghai, Nanjing, Fuzhou, Jinan, Qingdao, Zhengzhou, Wuhan, Zhanjiang, Nanning, Chengdu, Chongqing, and Xi'an.

13. Major Port Cities Open to Foreign Trade. With the open policies, the economies of port cities have been developing rapidly, which has brought the inland and national economies along. Open port cities are playing an increasingly important role in China's society and economy, and are China's door to foreign exchange and international cooperation. Accordingly, the open port cities should also be National Trunk Highway System nodes.

(a) Coastal Port Cities. Such cities that in 1987 had cargo throughput of 9 million tons and passenger throughput of 2 million persons should be chosen as road system nodes. There were 10 of them: Dalian, Qinhuangdao, Yantai, Qingdao, Lianyangang, Ningbo, Zhanjiang, Guangzhou, Tianjin, and Shanghai.

(b) Port Cities along the Yangtze River. Such cities that in 1987 had cargo throughput of 10 million tons should be selected as road system nodes. They are Wuhan, Nanjing, and Nantong.

(c) Inland Port Cities. Such cities that had large import/export volume and great potentials should be picked as road system nodes. The inland port
ANNEX 3

Cities were Manzhouli, Tongjiang, Suifenhe, Hunchun, Da'an, Dandong, Huocheng (Yining), Wanding, Ruili, Shenzhen, and Zhuhai.

14. From the above three types of cities, 113 cities were selected to be National Trunk Highway System nodes.

Grouping Analysis

15. Based on the indicators that reflect the economic level of cities, the 434 cities were evaluated and divided into four categories—highly developed cities, medium developed cities, general cities, and undeveloped cities.

16. Eleven indicators were used: total retail value, urban district's industrial output value, nonagricultural population, urban district's total employment, urban district's total investment, total passenger transport volume, total cargo transport volume, total postal and telecommunications volume, total number of beds in hospitals, road cargo transport volume, and road passenger transport volume.

17. These indicators reflect a variety of information about the cities, but since indicators are interrelated, some of them are overlapping with each other and deviation could occur as a result. Also, too many indicators would make the analysis process more difficult. Therefore, the indicators were grouped as comprehensive, independent, noninterrelated, and new indicators, and these main elements were analyzed.

18. The cities were categorized, as follows:

(a) Especially Developed Cities. Beijing, Shanghai, Tianjin, Wuhan, Guangzhou, Shenyang, and Dalian. Total: 7.


(c) General Cities. Xingtai, Changzhi, Huhehot, Chifeng, Dandong, Fuxin, Haicheng, Liaoyuan, Shuangyashan, Jiamusi, Changshu, Shaoxing, Zhoushan, Wuhu, Anqing, Liulan, Chachu, Putian, Zhangzhou, Pingxiang, Weifang, Dezhou, Binzhou, Linyi, Pingdingshan, Xuchang, Zhumadian, Qinhuangdao, Baoding, Datong, Jincheng, Baotou, Changyang, Tonghua, Jili, Huaiyin, Jinhua, Ruilan, Bengbu, Suzhou, Jiujian, Shangrao, Ganzhou, Dongying, Liancheng, Heze, Anyang, Luoke, Shangqiu, Nongyang, Jiaozuo, Zhangjiakou, Yangquan, Yingkou, Panjin, Hunjiang,

(d) Undeveloped Cities. The remaining 261 are undeveloped cities.

19. The 113 cities in 4 categories selected as road system nodes included all especially developed cities (7), all medium developed cities (53) and about half the general cities. Undeveloped cities selected were Lhasa, the capital of Xizang, and a few port cities (Manzhouli, Tongjiang, Suifenhe, Hunchun, Da’an, Yining, Huocheng, Wanding, and Ruili).

Analysis of Urban Development

20. In the next 30 years, China’s urbanization will be further expedited, and the national political and economic patterns will change accordingly. The National Trunk Highway System must suit the conditions of the target year (2020).

21. By 2020, China’s population is projected to be 1.38 billion, and total industrial and agricultural output value will be ¥7,923.8 billion (1980 constant prices). By 2000, there will be 691 cities in China, of which 124 will have nonagricultural population of more than 500,000, or 66 more than 1988. These 124 cities are Beijing, Tianjin, Shijiazhuang, Tangshan, Handan, Zhangjiakou, Baoding, Qinhuangdao, Xingtai, Taiyuan, Datong, Yangquan, Changzhi, Huhehot, Baotou, Yakeshi, Shenyang, Dalian, Anshan, Fushun, Benxi, Dandong, Jinzhou, Fuxin, Yingkou, Liaoyang, Changchun, Jilin, Hunan, Harbin, Qiqihar, Yichun, Jixi, Daqing, Mudanjiang, Hegang, Jiamusi, Shuangyashan, Shanghai, Nanjing, Wuxi, Xuzhou, Suzhou, Changzhou, Nanjing, Lianyungang, Zhenjiang, Yangzhou, Huaiyin, Hangzhou, Ningbo, Wenzhou, Jiaxing, Hefei, Huainan, Bengbu, Wuhu, Malanshan, Huaibei, Fuzhou, Xiamen, Nanchang, Pingxiang, Jingdezhen, Jiujiang, Jinan, Qingdao, Zibo, Yantai, Weifang, Zaozhuang, Jining, Dongying, Zhengzhou, Luoyang, Kaifeng, Xinxian, Anyang, Pingdingshan, Wuhan, Huangshi, Shashi, Yichang, Xiangfan, Shiyang, Changsha, Hengyang, Xiangtan, Zhuzhou, Yueyang, Guangzhou, Shenzhen, Shaoguan, Shantou, Foshan, Zhanjiang, Zhongshan, Dongguan, Haikou, Nanning, Liuzhou, Guilin, Chengdu, Chongqing, Zigong, Dukou, Leshan, Yibin, Wanxian, Guiyang, Liupanshui, Zunyi, Kunming, Lhasa, Xi’an, Baoji, Xianyang, Lanzhou, Xining, Yinchuan, Urumuqi, Yancheng, Fuyu, and Santao.

22. The 113 cities selected as road system nodes included 103 of the above-mentioned 124 cities, or 83 percent. Node cities that will have an urban population of less than 500,000 are 11 port cities (Da’an, Hunchun, Tongjiang, Suifenhe, Wanding, Ruili, Yining, Huocheng, Manzhouli, Huzhou, and Zhuhai).
23. It is evident that the careful selection of the node cities is in accordance with China's future social and economic development patterns.

C. GUIDELINES FOR SYSTEM NODE DISTRIBUTION

24. Studies that have been conducted from various angles on the current and future situations of China's cities have concluded that the following principles should be complied with when selecting the node cities:

25. The National Trunk Highway System node distribution is designed to include (a) all provincial capital cities, provincial economic centers, transport pivotal cities, and port cities, and (b) cities with a nonagricultural population of 500,000 by 2020. Based on this principle, the preliminary selection is as follows: Beijing, Tianjin, Shijiazhuang, Taiyuan, Huhehot, Shenyang, Changchun, Harbin, Shanghai, Nanjing, Hangzhou, Hefei, Nanchang, Fuzhou, Jinan, Zhengzhou, Wuhan, Changsha, Guangzhou, Haikou, Nanning, Chengdu, Guiyang, Kunming, Xi'an, Lanzhou, Yinchuan, Xining, Urumuq, Lhasa, Chongqing, Fushun, Anshan, Qi Qihar, Tangshan, Jinan, Baotou, Zibo, Handan, Yichun, Xuzhou, Wuxi, Datong, Benxi, Luoyang, Huainan, Jixi, Suzhou, Jinzhou, Fuxin, Daqing, Liuzhou, Mudanjiang, Shantou, Zhangjiakou, Shenzhen, Changzhou, Xiamen, Liaoyang, Dongguan, Wenzhou, Zhongshan, Weifang, Baoding, Hengyang, Foshan, Kaifeng, Bengbu, Zhuzhou, Wuhu, Yingkou, Huangshi, Xiangtan, Zelenjiang, Anyang, Jiamusi, Xinxiang, Pingdingshan, Xiangfan, Shiyian, Zaozhuang, Huzhou, Yangbu, Dongying, Yichang, Ziqing, Shaoguan, Guilin, Shashi, Yueyang, Yancheng, Jiaxing, Xianyang, Dukou, Hegang, Dalian, Qinhuangdao, Yantai, Qingdao, Liangyungang, Ningbo, Zhanjiang, Nantong, Manzhouli, Tongjiang, Suifenhe, Hunchun, Da'an, Dandong, Yining (Huocheng), Wanding, Ruili, and Zuhui.

26. One point worth noting is that the above plan is only preliminary, and may be changed or reduced due to route directions or other reasons after the route distribution is planned.

D. CHARACTERISTICS OF THE NODE DISTRIBUTION

27. Road system nodes will gradually be dispersed and reduced in number from east to west, with 80 percent east of (and including) the four provinces of Shanxi, Henan, Hubei, and Hunan. This is in agreement with the reality of China's eastern part being more developed than the western part.

28. The node cities will form the following five "strips":

(a) Harbin - Changchun - Shenyang - Dalian

(b) Beijing/Tianjin - Jinan - Xuzhou - Nanjing - Shanghai - Hangzhou - Wenzhou - Fuzhou - Xiamen - Shantou - Shenzhen

(c) Beijing - Shijiazhuang - Zhengzhou - Wuhan - Changsha - Guangzhou
(d) Beijing - Shijiazhuang - Taiyuan - Xi’an - Changdu - Kunming

(e) Beijing - Huhehot - Yinchuan - Lanzhou - Xining

E. Evaluation Indicators for System Routes Layout

29. After the system nodes were determined, they were connected with lines and a complete network was formed.

30. In order to use the method of linear programming of operational research, the evaluation indicators should first of all be determined and target functions need to be established. The American and Japanese principle that “routes should seek to pass densely populated areas with concentrated industries and busy traffic” was taken as reference, and China’s reality was taken into consideration. National road trunk routes are the main framework of China’s road network, they should suit the passenger and cargo traffic density and distribution of productive forces, should be coordinated with other transport modes, and should be able to take up road transport among provinces and major cities, as well as part of long distance road transport. Correspondingly, nonagricultural population, industrial output value and traffic volume for areas along the route, and route mileage were chosen as the evaluation indicators.

F. Optimization of Route Selection

31. In order to optimize the route selection, on the basis of the system node distribution, all possible routes between the nodes with comparison value were arranged and analyzed, and 237 routes were proposed for optimization analysis.

Using Mileage as the Evaluation Indicator

32. The method of using mileage as the evaluation indicator was to make the scope as short as possible based on the premise that all 111 node cities (Wanding and Ruili as one node, and Zhuhai and Zhongshan as one node) are connected. One hundred ten routes were selected from the above 237 routes, all 111 nodes were linked, and the smallest \( \sum_{i=1}^{110} L_i \) of the total mileage was extracted, and the target function was: \( L_{\text{min}} = \sum_{i=1}^{110} L_i \)

33. The methodology was to put the 237 routes in sequence from small to large, and on the node distribution chart connect the nodes according to this order without repetition (if two nodes are linked through other nodes, then these two nodes do not need to be linked to each other). Through this, 110 routes were selected. They have connected all nodes, and have added up to the shortest mileage.

34. The selected routes are as follows:
35. The total mileage of this plan is 27,206 km, the shortest to connect all system nodes.

Using Nonagricultural Population as the Evaluation Indicator

36. The population density is one of the major factors of the demand for transport. The system nodes have included all cities with a nonagricultural population larger than 500,000 in 2020. Hence the connection of the nodes should seek to pass
densely populated areas in order for the road system to have the largest unit population. The target function is:

\[ D_{\text{max}} = \frac{\Sigma r_i}{\Sigma L_i} \]

37. The methodology was on the basis of the 1987 census data to calculate and obtain the population density of the nonagricultural populations of above-county administrative districts along the proposed 237 routes; and then to arrange them in sequence from large to small, and link them according to that sequence on the node distribution chart without repetition. In this way, 110 routes were selected.

38. The total mileage of this plan is 31,357 km, which covers a nonagricultural population of 140 million, with the density of 4,550 persons/km.

39. One point must to be noted: Due to the two constraining conditions that (a) all the 11 percent nodes must be linked, and (b) no repetitions, i.e., only 110 routes should be selected, this plan may not have the greatest value of population per mileage. If more road sections were to be added, the area population density of the road system may be increased. But calculation showed that when the trunk routes mileage was expanded, the population density of the entire road system area actually decreased.

Using the Industrial Output Value as the Evaluation Indicator

40. The demand of an area on transport is closely related to its social and economic development. Using the industrial output value as the evaluation indicator enables the National Trunk Highway System to have the highest industrial output value per unit. The target function is:

\[ D_{\text{max}} = \frac{\Sigma T_i}{\Sigma L_i} \]

41. The methodology was based on 1987 data to calculate the industrial output value of above-county administrative districts along all routes, obtain the industrial output value density of each route, and select the plan with the largest value density.

42. This plan covers 30,000 km, with an industrial output value of Y 779.1 billion, and density of Y 26 million/km.

Using Traffic Volume as the Evaluation Indicator

43. The methodology was based on the 1987 data on national roads and provincial roads to arrange the traffic volume of the proposed 237 routes in sequence from large to small, and obtain the largest traffic density.

44. This plan covers 34,000 km, with an average traffic volume of 2,606 vehicles per day.
45. Combining the above four plans, the routes can be divided into the following four types:

(a) Routes selected by all four plans:

- Harbin - Qiqihar - Manzhouli
- Harbin - Jiamusi - Tongjiang
- Beijing - Tianjin - Qinhuangdao - Jinzhou
- Wuhan - Changsha - Guangzhou - Foshan - Dongguan - Shenzhen
- Nanjing - Shanghai - Hangzhou - Wenzhou
- Foshan - Xiamen - Shantou
- Datong - Huhehot - Baotou
- Lanzhou - Xining - Urumuq - Huocheng
- Chengdu - Chongqing - Guiyang
- Luoyang - Zhengzhou - Kaifeng
- Anshan - Yingkou - Dalian
- Shenyang - Liaoyang

(b) Routes selected by three plans:

- Harbin - Changchun - Shenyang
- Harbin - Mudanjiang - Suifenhe
- Shenyang - Jinzhou
- Tianjin - Jinan
- Wuhan - Zhengzhou
- Wuhan - Xiangfan
- Xuzhou - Bengbu
- Guiyang - Kunming - Wanding
- Shijiazhuang - Handan
- Shenyang - Anshan

(c) Routes selected by two plans:

- Shantou - Shenzhen
- Taiyuan - Xi'an - Chengdu
- Shiyan - Xiangfan

(d) Routes selected by only one plan:

- Xi'an - Loyang
- Changchun - Da'an
- Shashi - Xiangfan
- Foshan - Zhanjiang
- Chengdu - Zigong
- Nanjing - Huzhou
- Kaifeng - Xuzhou - Lianyungang
Lianyungang - Nanjing

(e) Using Multiple Targets

46. Four plans, as shown above, have been obtained through single target planning based on mileage, population, industrial output value, and traffic volume. These plans were in agreement with each other in general, but differences existed over a few routes. Integrating the four into one comprehensive plan was not easy, especially for those routes chosen by only one or two plans.

47. The layout of the National Trunk Highway System required the system to cover areas with dense population, high industrial output value, and large traffic volumes. On the other hand, the total mileage was also required to be around 30,000 km. As a result, multitarget planning was conducted, using the weighted method, and the three indicators were quantified and converted into one index, i.e., route value.

48. Some feedback information was analyzed, and the weighted proportions of the three indicators of population, industrial output value, and traffic volume were computed to be 9 percent, 55 percent, and 36 percent, respectively. Based on the 1987 and 1988 data, the route value of each of the 237 routes was calculated according to the following formula:

\[ Li = \left( \frac{R_i}{R} \cdot a_1 + \frac{G_{Ni}}{G_{N}} \cdot a_2 + \frac{T_i}{T} \cdot a_3 \right) \times 100 \]

- \( Li \): route value of Route Li
- \( R_i \): nonagricultural population density along Route i
- \( R \): average value of nonagricultural population
- \( a_1 \): weighted proportion of population density
- \( G_{Ni} \): industrial output value density along Route i
- \( G_{N} \): average value of industrial output value
- \( a_2 \): weighted proportion of industrial output value
- \( T_i \): traffic volume of Route i
- \( T \): average value of traffic volume
- \( a_3 \): weighted proportion of traffic volume

49. When route values of all routes were obtained, they were arranged in sequence from large to small, analysis was conducted based on the same method, and the route distribution planning was completed. The total mileage was 32,000 km.

G. USING SURVEY STUDY

50. On the basis of the above analysis and planning, experts in the transport system were surveyed. During the study, 23 copies of the questionnaire were circulated. By May 14, 1990, 19 copies, or 83 percent, were returned. Among the respondents, there were 11 professors (and/or research fellows and senior engineers), or 58 percent; 5 associate professors (and/or associate research fellows and senior engineers), or 26 percent;
and 3 engineers, or 16 percent. The respondents clearly had a high level of education and high-level positions.

51. Survey responses on road system distribution were as follows:

(a) On selection of the road nodes, 84 percent of the experts completely agreed on the approach of using industrial output value, population, and retail value as evaluation indicators. They held that the methodology based on provincial capitals, economic centers, traffic pivots, and ports was feasible. They were satisfied with the system node distribution. A small number of experts maintained that important military towns, tourist cities, and special economic zones should also be included.

The experts provided great help in selecting port cities open to foreign trade that had not been thoroughly studied during the process of node selection. More than 70 percent of the experts chose the nine port cities of Zhanjiang, Lianyungang, Yantai, Qingdao, Qinhuangdao, Dalian, Shenzhen, Ningbo, and Zhuhai; 50-70 percent experts chose the five port cities of Dandong, Wanding, Huocheng, Manzhouli, and Suifenhe; and fewer than 20 percent experts chose Hunchun, Ruili, Da’an, Yadong, Munanguan, and Shantou.

(b) On system route distribution, the experts all agreed on the approach of selecting routes that pass areas of concentrated industries, busy traffic, and dense population. Forty percent of the experts proposed that the trunk routes should also consider roads important to national defense, and that the routes should also be connected with neighboring foreign countries.

The experts were satisfied with the 13 national trunk routes selected. At the same time, 9 experts submitted their own route distribution charts. The differences are as follows: one route to be added in each of Jiangsu, Zhejiang and Fujian provinces; less than four experts chose the three routes of Hefei-Wuhan, Yichang-Chongqing, and Nanchang-Changsha. Based on political and nation defense considerations, a small number of experts hoped that important national defense roads in the northwest be included.

H. GUIDELINES FOR ROUTE DISTRIBUTION PLANNING AND THE RESULTS

52. After careful discussions from various angles, it was agreed that the route distribution should abide by the following principles:

(a) The general planning should meet the needs of future social and economic development, as well as political and military considerations. It should also suit the national social and economic pattern of development and productivity distribution.
(b) The national road system should use cities as nodes, and must link all provincial capital cities, important pivotal transport cities, and major port cities. The scope should be controlled at 30,000 km. Most of the cities covered should have a nonagricultural population of 500,000 by the target year.

(c) The road system should coordinate with the major national transport passageways; should take as priorities routes between major economic regions and provinces, with large or potentially great passenger and cargo transport volumes, and routes with significance to national defense; should take into consideration the future formation and connection of an interprovincial road network; and should be useful in promoting the correlation between the coastal regions and the inland regions in promoting the open policy, in forming the road system framework, and in further improving the comprehensive transport efficiency.

(d) The selection of routes between the nodes should be based on the principle of short distance and high efficiency. The routes should seek to pass as many cities as possible, which would have high industrial output value and dense population, and should be able to attract the largest possible traffic.

53. In accordance with these principles, on the basis of the quantifying analysis, optimal selection and comprehensive readjustment, a general plan for the National Trunk Highway System has been formed. The road system consists of 12 national trunk routes, connects 95 cities, and is of 30,000 km long. The 12 routes are:

(a) Tongjiang - Harbin - Dalian - Yantai - Lianyungang - Huaiyin - Jiangyin - Shanghai - Hangzhou - Ningbo - Fuzhou - Shenzhen - Guangzhou - Haikou
(b) Beijing - Tianjin - Jinan - Xuzhou - Hefei
(c) Beijing - Shijiazhuang - Zhongzhou - Wuhan - Changsha - Guangzhou - Zhuhai
(d) Chongqing - Guiyang - Liuzhou - Nanning - Zhanjiang
(e) Dandong - Shenyang - Tangshan - Beijing - Huhehot - Yinchuan - Lanzhou - Xining - Lhasa
(f) Qingdao - Jinan - Shijiazhuang - Taiyuan - Xi’an - Chengdu - Kunming
(g) Lianyungang - Xuzhou - Zhengzhou - Xi’an - Lanzhou - Urumuq - Huocheng
(h) Shanghai - Nanjing - Hefei - Wuhan - Chongqing - Chengdu
(i) Hangzhou - Nanchang - Changsha - Guiyang - Kunming - Wanding

(j) Hengyang - Nanning - Kunming

(k) Xi'an - Wuhan - Nanchang - Fuzhou

(l) Manzhouli - Harbin - Suifenhe
CHINA'S TOLL ROADS

1. China's toll roads opened in the last two or three years, except for the toll bridges in Guangdong Province that went into operation earlier. High-class roads, such as the Beijing-Shijiazhuang class I motor road, Shenyang-Dalian Expressway, Shanghai-Jiading Expressway, Guangzhou-Foshan Expressway, and other roads recently built, have one after another started collecting tolls. Most new expressways recently opened, currently under construction or planned are designed as toll roads.

2. Toll management, staffing, and facilities are being perfected. Drivers and passengers have become aware of paying tolls, which has made timely, fast, and accurate toll collecting possible. However, it must be recognized that toll roads have just started in China, and it takes time to be accepted by the whole society. The present high-class roads in China have not yet formed a network; thus their benefits and advantages could not be fully brought out. Some higher-class roads are only a dozen kilometers long, yet tolls are collected. In addition, some drivers have not been fully informed of the rules, and have had to pay penalties for not paying tolls. As a result, some drivers prefer to take old familiar roads rather than the newly built high-class roads.

3. To acquaint the whole society with the rules of high-class roads is an important responsibility for road administrative departments. An urgent task for attracting traffic to high-class roads is to determine the toll standard under the current conditions by which high-class roads coexist with general roads. Overly high fees is one of the reasons why some high-class roads have not been fully utilized. The future of high-class roads depends in a sense on a reasonable and realistic toll standard, which should be determined on the basis of the local economic conditions and traffic volumes. All highway projects financed by the World Bank require economic studies to be conducted prior to setting toll rates.

4. Both open and closed toll collection systems are being used. For example, the Shen-Tao Expressway uses the former method, while the Shen-Da Expressway uses the latter. Most new expressways, however, are opting for closed systems. For the open method on Shen-Tao Road, Y 2 is collected on every small passenger or cargo vehicle each time it passes the toll station, Y 4 for medium-sized vehicles, Y 6 for large buses and trucks, and Y 8-16 for special vehicles. For the closed system on Shen-Da Road, tickets are issued at entrance and payments collected at exits. Fees are Y 0.05/km for small vehicles, Y 0.10/km for medium, Y 0.15/km for large, and Y 0.40-1.20/km for special vehicles.
5. Shen-Da Expressway adopted an automatic toll collecting system, which has combined the best from both at home and abroad. It is a card-reading/writing machine, and is stable and reliable. This system includes automatic card-issuing machines and automatic card-reading machines. When a vehicle drives in, the station staff will punch a key on the automatic card-issuing machine according to the type of vehicle. The card will automatically be sent to the card-writing machine, which will record the information, and send out the card. The whole process takes only 3-4 seconds. The card-reading machine includes a card-reading machine and a card box. When a vehicle drives through the exit, the station staff will put the card into the card box, and the card-reading computer will read the information and calculate the fee to be paid. After the driver has paid the toll, a receipt will be given, and the bar will automatically open. In case of violations, after the staff member presses certain keys, a penalty fee will appear on the screen.
INVESTMENT PLANNING AND FEASIBILITY
METHODOLOGY

Administration and Planning Process

1. The transport industry is under the administration of different ministries. The State Planning Commission (SPC), as the overall administrative department responsible for the entire national economy, is responsible for production planning and the overview of infrastructure planning and decides on the allocation of government investment in the different modes of transport. When doing so, SPC first makes an overall evaluation of the situation in the light of state policy guidelines for transport development, taking into account the requirements of all the national economic sectors and the availability of state funds. Thereafter, SPC decides on the amount of capital investment to be allocated to the different ministries responsible for transport during the five-year plan period in question. Based on this decision, the ministry responsible for a particular transport mode draws up an implementation plan for investment in its own sector. The provincial planning commission has similar roles in its own province.

2. SPC has now established a strict procedure for the appraisal and approval of major projects. It has two stages: appraisal and approval of the project proposal (prefeasibility report), and then the project feasibility study report. The whole process of project appraisal and approval is as follows: (a) ministry submits report for approval and appraisal to SPC; (b) SPC entrusts consultants to appraise report; (c) consultants return report and their conclusions to SPC for approval; (d) SPC approves report and determines the investment amount needed for implementation by the appropriate ministry. Other projects are appraised and approved by the ministry concerned or the provincial or local planning and transport departments, but procedures are essentially the same as for major projects (Chart 1 of this Annex).

3. The highway development plan (medium and long term) is drawn up based on (a) national transport policy and strategies; (b) the existing situation and local condition; and (c) future demand and financial resources. The planning of national highways is carried out centrally by MOC, while the planning of provincial highways and roads of lesser importance is the responsibility of the PCDs. National highways or other major projects have to be approved by MOC, but the remaining infrastructure is planned under the guidelines of MOC. Main guidelines include "Methodology for Highway Network Planning," MOC/1990, "Methodology for Waterway and Highway Project Feasibility Study," MOC/1988, "Guideline of Feasibility Study for Highway Project," HPDI of MOC/1990," "The Road Techno-Econominc Indices, HPDI of MOC/1990" and "Highway
Engineering Technical Standard, MOC/1988." Those guidelines are normally revised every five years. The PCD prepares the provincial five-year road development plan to reflect national and provincial development policy guidelines and objectives of the plan period. The highway administration units at the prefecture and county levels have some autonomy in planning small road investments, such as county and village roads, subject to approval by the PCD.

4. Annual planning is generally done by a planning body consisting of authorities from the provincial communications departments (PCDs) and provincial highway bureaus. Plans are drawn up on the basis of three factors: the present condition of the highway system, the long-term highway development plan of MOC, and the predicted revenue (mainly maintenance fees). The planning body prepares annual highway construction and maintenance programs for the province and submits them to the provincial planning commission for approval. If the plan is large in terms of financial investment or it has other great significance in the national level, MOC and/or SPC are involved in the decision making. PCDs pass on the approved plans to lower-level authorities for execution. The latter set their own seasonal and monthly schedules to assure smooth plan implementation.

Weakness of the Current System

5. The system is decentralized enough to promote local initiative in planning development with the efficient use of local revenues. The central government is involved mainly in decision making for large projects. While this system is intended to allow faster decisions that are more adapted to local needs, by inconsistency and lack of uniformity in what provinces do, it may also create problems such as suboptimal investment and inconsistency of design and construction standards, which frequently reflect availability of funds. Under the current system, there is a need for MOC to function with stronger coordination at the central level in order to ensure attention on national priorities, to keep uniformity in design and construction standards for highways, and to avoid misinvestment or suboptimal decisions.

6. In this connection, MOC should strengthen its role in coordination, research, training, and the development of methods and standards. First of all, the current project evaluation and feasibility method need to be reviewed and improved. A proposal has been made by the World Bank and MOC to review the highway investment evaluation and feasibility methodology in China. This should be undertaken as soon as possible. On the other hand, staff should be trained at the central, particularly at the provincial or local level, since most of the individual highway investment proposals are initiated and evaluated by the PCDs.

7. As a long-term process, efforts should be strengthened and expedited to put in place “building blocks” for highway planning, i.e., RDB and PMS. A well-established RDB and PMS system at national, provincial, and prefectural or city levels would be a helpful tool for investment decision, network programming, and project evaluation. But it should be well conducted in all three levels by MOC to serve the purpose, and particular
Chart A5.1: Flow Chart for Planning and Approval Process of Highways

National Road

Provincial Road

County Road

Rural Road

Long-Term Planning

Five-Year Plan (FYP)

Proposal

Preliminary Design

Approval

Feasibility Study

Evaluation

Approval

Proposal

Preliminary Design

Approval

Feasibility Study

Evaluation

Approval

Proposal

Preliminary Design

Approval

Design

Approval

Proposal

Design
attention should be given to its planning and evaluation function on engineering as well as economic aspect rather than being limited to inventory characteristics.

**Comments on the Current Project Evaluation Methodology**

8. **Approach and Scope.** The objective of a feasibility study is to come to conclusions on the best highway improvement strategy for the corridor as a whole. While this will often be based on a new highway, it would usually also include improvements to the existing road. However, current feasibility studies in China look only at new roads and practically disregard other reasonable alternatives.

9. All reasonable alternatives should be subject to detailed evaluations to help make the best choice and not merely to justify a choice already made. A feasibility study should identify a range of options for existing highway upgrading and for aligning and staging a new highway. All these options should then be subject to detailed evaluations. In most cases in China, only one option was subject to detailed evaluation, the other options (if identified) having been discussed and discarded previously.

10. Evaluations should be made for major sections along a road and for the road as a whole in order to facilitate the setting of priorities and staging. Many evaluations just use weighted average parameters covering the entire route in one section. This obscures important differences along the route, and makes consideration of priorities and staging more difficult, if not impossible.

11. **Existing Road Conditions.** A full feasibility study requires an adequate assessment of existing road conditions in the corridor. Route inventories should include physical characteristics, such as width and geometric alignment, and also information on the nature and extent of development along the route, detailing whether open countryside, sporadic settlements, suburban development, or full urban development. This information is critical for assessing existing highway conditions and capacity. Sections should be short enough to identify differences in these characteristics along a route.

12. **Capacity of Highways.** Currently, Chinese feasibility studies do not compute highway capacities, instead they use fixed capacity values for a given class of road based on MOC design manual. These capacities are probably adequate for master planning work, but not for feasibility study purposes or traffic operation purposes.

13. China should develop a highway capacity manual to calculate capacities of access-controlled highways, multi-lane noncontrolled access highways, two-lane roads, urban roads, intersections, interchanges, etc. It could be based on manuals from other countries, especially those of similar conditions, but it should take into account the special problem of mixed traffic on Chinese highways. Some basic work on traffic volume-speed relationships for various classes of highways has to be done.
Traffic Speed and Congestion

14. Some studies assumed a given speed for a given class of road and that this speed stays the same throughout the analysis period despite increases in traffic volumes. In those studies that do allow a variation in speed with traffic volume, the formula used need upgrading and modification to make them yield realistic results.

15. Use of a single speed-volume relationship for an average daily traffic volume also ignores important variations in speed, and hence, vehicle operating costs, by time of day or season of year. This is a shortcoming of many highway feasibility studies, and it deserves more attention.

16. Capacity should be considered in assignment of traffic. Once a preferred road reaches capacity, additional traffic should be assigned to the next preferred road.

Existing Traffic

17. Available traffic count information should be examined critically. Location of counting stations is important in ensuring that the counted traffic is representative of the traffic or a given road segment. In some cases, continuous count survey sites are located close to an urban or town area, so that counts are inflated or even dominated by very short distance local traffic and do not reflect the volume or characteristics of the given road section.

18. Traffic is sometimes not adjusted for monthly, daily, and hourly variations. Well-located continuous counting stations are essential in adjusting short-period traffic counts.

19. Speed data are generally not collected. Speed is an excellent indicator of the adequacy of a highway to meet traffic demands. Speed data should be collected simultaneously with traffic counts to be more useful.

20. Origin-Destination (O-D) Survey. No data on purpose of trip are collected. Such data are useful when calculating the value of time savings. Also, it is not necessary to interview 100 percent of the traffic; the percentage interviewed could decrease with increasing traffic volumes. The zone system used in identifying origins and destinations of trips is coarse; a finer system should be used for the immediate area of influence of a given road. Traffic counts at O-D stations should be carried out during the whole day (24 hours) and not only for the hours of interviews (mostly 16 hours). Too much effort is spent in collecting data, and too little attention is given to analyzing the results.

21. Traffic counts at intersections are generally not being collected. This should be done, since turning movements at intersections are useful in analyzing interchanges and in checking the results of traffic assignments.
Traffic Forecasting

22. Some studies use simple approaches for forecasting, such as a fixed percentage growth based on an analysis of past trends. Most studies base traffic forecasts on projections of economic growth, which is a better approach to the task, but the methods used need some further review. Consistent guidelines are required for the projection of traffic growth and its relation to economic growth indicators, the estimation of traffic diversion, and the use of O-D survey.

23. Generally, only one traffic projection is made in studies. In view of the uncertainties involved in traffic forecasting, forecasts should be made for a range of scenarios: high growth, medium growth, and low growth.

24. No adequate consideration is given to major existing and planned traffic generators in the area of influence of a road. This affects the volume of traffic and the location, type, and number of lanes at interchanges and at grade intersections.

25. Analysis of traffic diverted from existing roads to new or upgraded roads needs strengthening by taking speed-volume-vehicle operating cost relationships and capacities of roads into consideration.

26. Future trends should be taken into account. There is no consideration given to conversion of travel from small trucks to big trucks and from buses to small passenger cars.

27. Calculation of generated traffic needs to be improved. Case studies should be made of recently constructed roads in China.

28. Where toll road is proposed, results of analyses of traffic volumes by type of vehicle for each major road segment should be presented for both cases of tolls and no tolls.

Vehicle Operation Costs (VOCs)

29. MOC developed a standard formula to calculate the VOC, which relates vehicle operating cost per ton-kilometer to the average speed of travel. This was transformed into vehicle operating costs by considering average vehicle loadings (and in the case of passenger vehicles by also assuming that 1 ton was equivalent to 10 passengers). This is a crude approach; a more scientific procedure is required based on one of the many available vehicle operating cost models. VOC should be developed for various major types of vehicles and types of roads. Relationships between VOC and speed and traffic volumes for various types of roads and vehicles should be developed to reflect China’s conditions.
Construction, Maintenance, and Operation Cost Estimates

30. Per kilometer construction cost estimates vary greatly between different studies. While some variation is to be expected, some of the variation must be attributable to differences in estimating techniques and existing crude MOC methodology. There appears to be a need for considerably improving the estimation of construction costs. A common and consistent approach to estimating construction costs should be developed for all of China, with some provision for adjustment to local conditions in each province.

31. Current cost estimates for routine and periodic maintenance as well as for operating toll facilities are coarse and need refinement and upgrading.

Application of Evaluation Methodology

32. MOC should develop a common guideline for applying project evaluation methodology to different types of road improvements. For new expressways and major new construction, strong analysis is required under all categories. For other types of projects, such as main road and secondary road improvements, rural roads development, and ferry replacement, and bridge building, methods can be adjusted according to the nature and scale of project.
DEVELOPMENT OF PLANNING AND ANALYTICAL TOOLS

1. The increasing need for efficient and scientific management of highways has led to the development of a series of planning and analytical tools by adopting global state-of-the-art technology. These include the Road Data Bank (RDB), Pavement Management System (PMS), and Bridge Management System, as well as other information systems to be developed for this purpose. The former two most important systems are stated as the following.

A. ROAD DATA BANK

2. The RDB is one of several data banks being developed for the Ministry of Communications (MOC) Transport Economic Information System, aimed at strengthening and improving decision-making ability, managerial skills, and the technical level in highway subsector. Its development and implementation are an important step toward this target, and great social and economic benefits will be achieved from RDB due to savings in the cost of Road Condition Survey, Archives Management, Information Updating and Utilization, and inter alia, the cost of unreasonable decisions in planning and management, which could result in unpredictable and serious losses and waste. The RDB has a great importance in all the political, economical and social aspects.

3. RDB is an integration of the modern technology, such as computer science, systematology, and informatics. It combines all the road-related information and the geographical information into one integral system that functions as an efficient tool for data processing, updating, retrieval, statistics, reporting, and so on. It will contain all important road information at the national, provincial, and prefecture or county level, such as road lengths, type, classification, function, geometry, and pavement type, thickness, and bearing capacity, as well as traffic volumes, material sources, and quantities, providing the basis for improving the economic rationale for decisions on expanding, rehabilitating, strengthening, and maintaining the road networks.

4. A computerized RDB has been designed and developed by the Highway Planning and Design Institute (HPDI) and some other institutions of MOC for nationwide application. A standard format for the data was designed and a set of guidelines prepared to introduce the system to the provinces in phases.

5. The RDB will be operated at three levels, namely central, provincial, and prefectural, with unified specifications and formats. It will comprise eight major files with a total of 285 independent data items that would be required at all three levels: the central
level comprising details of all national highways plus statistics of the entire state network, provincial level comprising details of national and provincial highways within the province, and prefectural level comprising all roads within the prefecture or major city. Bridge details will be kept on a separate Bridge Data Bank, but summarized on the central level RDB. At provincial and prefectural levels, the data banks could include other items not specified for the central level.

6. A pilot development and application of the RDB at the provincial and prefectural levels being carried out in Shaanxi Province has achieved encouraging preliminary results:

(a) **Data Dictionary.** A third draft of "Provincial-Level Highway Data Bank Requirements" has been completed by Shaanxi Provincial Transportation Department (SPTD) and is ready for final expert review and printing, incorporating input from provincial and prefecture staff and departmental directors. Review by MOC is awaited. The proposed data bank size is large, with 858 items at the provincial level, and 893 items at the prefectural level, compared with 235 at the central MOC level. Although attempts were made and may be continued to reduce the size for some information groups, most were required for the dual function of reporting statistics both upward to MOC and downward to prefectures and counties, and of direct decision-making and managing of the network.

(b) **Road Inventory.** The coding and naming of all 8 national and 52 provincial roads, 875 national bridges, and 863 provincial bridges was completed in January 1991. All road classes in Baoji trial prefecture, and boundary points, main structures, and maintenance or management units in the province were coded by the end of last year.

(c) **Conceptual Design of Data Bank.** This is reflecting the responsibilities for reporting up to MOC, managing at the provincial level, and assisting prefecture and county levels. The Entity-Relationship Map was drawn based on the survey of the requirements.

(d) **Procurement of Equipment.** About 22 items of equipment were procured by international shopping, which mainly include the computer system, road geometry data acquisition system, falling weight deflectometer, skid resistance and roughness survey equipment and the GPS transponder.

(e) **Location Reference System.** The combination of GPS for the location of nodes, boundaries, and major points, and conventional surveying (e.g., RGDAS) for intermediate points was proposed in consideration of the shortest time for data collection. A reasonable and practical Location Reference System to be used in software is sought through learning from other countries and a combined geo-coordinate and km-post system may be adopted.
Data Collection. Priority is to be given to those items that will permit the RDB to be used at the earliest opportunity, that is road, bridge and traffic items, with historic project and institutional inventory data being given lowest priority. Data volumes are large, with 49 items per road totaling 89,425 items and 48 items per bridge totaling 225,888 items for Shaanxi Province. The priorities will largely follow MOC guidelines from HPDI. The processing of data items that currently exist is 50 to 90 percent complete. Some items are delayed by lack of cooperation from other ministries and departments, particularly accident data which will probably have to be reduced in scope. High-level assistance from higher government is needed to resolve these problems.

Network Data Adjustment. Reconciliation of existing records, and modification and reclassification of certain roads is completed for all roads in the provinces.

Computer System Architecture. The current SPTD system comprises a distributed network of microcomputers, with a 486-chip computer storing principle data for SPTD, two high storage computers for the high-class Highway Bureau and Highway Bureau, and 21 386- and 286-chip microcomputers at prefecture, county and institute levels. The systems will have high graphics capabilities, including scanning, digitizing, and plotting capabilities.

The Prefectural Level Road Data Bank. The result of the Baoji trial will be a completed prefectural level RDB model, which is now in its embryonic stage. The embryonic software model has the main functions for processing data and graphics. The ARC/INFO system has been used for graphic management, including graphic input, editing, mapping, retrieval, and output. Modification and improvement of this model will be completed in the first half of 1993 and implementation to other prefectures will proceed afterwards.

MOC's RDB is inventory-oriented, storing data on the road and structures stock, usage levels, projects, and road funds, and is a national norm for data definitions. However, it is crucial for the system to include key performance indicators (for economic, functional, and structural performance) of the highway network and not be limited to inventory characteristics. The identification of incipient and potential performance constraints, such as congestion, impaired surface characteristics, and structural deficiency, are important measures of need and agency performance for planning purposes.

The intensity, frequency, and methodology of the data collections and surveys have significant implications for the cost, quality, and volume of data involved in operating the management system. Clear distinctions should be made by MOC between the different levels of data needs for (a) inventory and planning; (b) network works programming; and (c) project evaluation and design because, for example, survey methods
for the information quality suitable for project design would be unnecessarily voluminous, slow, and expensive for planning and programming purposes.

9. On account of the levels of investment and information technology involved, and the pace of technology change, MOC should develop harmonized end result, rather than method-based, specifications of the data and surveys to provide a suitable climate for equipment procurement and service provision. At the same time, traditional methods of surveying traffic and checking vehicle axle-weight are particularly important to be improved nationwide as an integrated part of the application program of RDB.

10. Modification and enhancement of the software will be made in the near future for the prefectural level RDB. Well-prepared guidelines and specifications should be available before it is further implemented in other areas based on the experiences of the trial in Baoji Prefecture. Feedbacks should be incorporated into the development of the provincial level RDB, as well as the central level, and input from other provinces should be encouraged at this stage.

B. Pavement Management System

11. Large lengths of the highway network of each province have inadequate strength and pavement depth for the traffic loadings now occurring, and inadequate width or geometric standards for the current volumes of traffic, which are also growing rapidly at 10 percent or more per year. Although the surfaces are generally well maintained, the riding quality is generally poor. The highway transportation authorities need a systematic method for identifying the needs and estimated costs, optimizing the treatments to maximize the economic benefits, and prioritizing the works in annual works programs and longer-term five-year plans (FYPs) for the major investments involving betterment, reconstruction, or rehabilitation. The method needs to be supported by compatible procedures for detailed pavement evaluation and the detailed design of pavement thickness and materials for both pavement strengthening and new construction. To determine the economic benefits of a strategy, methods for quantifying the savings in road user costs as a function of surface condition and traffic flow need to be finalized for Chinese conditions, and the modeling of road deterioration and maintenance effects needs to be calibrated and adapted to Chinese materials, construction, and climate.

12. Recognizing the need for a systematic method of evaluating and managing the pavement as stated above, MOC has developed a China Pavement Management System (CPMS) by its Highway Scientific Research Institute (HISRI) in cooperation with some provincial highway authorities and some universities. The CPMS based on a synthesis of concepts from the British BSM model applied in Liaoning, Yunnan and other provinces, the Finnish PMS from Shandong pilot study, and economic aspects from the Bank’s HDM-III model. The system allows for the development of economically appropriate standards for pavement design and maintenance, leading to improved decision-making and timing of investments.
13. The BSM was introduced to China in 1983 through a British government aid cooperation program, and then, after conversion into a Chinese version, was applied in such provinces as Liaoning, Yunnan, and Fujian. In 1988, the Bank's HDM-III was incorporated into the work in Yunnan Province, and in 1989/90, a pilot study was carried out by applying the Finnish PMS model in Jining District of Shandong Province. Based on these experiences and in the course of cooperation with other countries, the research projects on PMS in China, which began in 1986 and which were sponsored by the State Planning Commission (SPC), MOC, and the Ministry of Science and Technology, have been carried out including:

(a) Research on vehicle operating costs, particularly fuel consumption by Tongji University (TU).

(b) Research on vehicle speeds under congested flow by HSRI.

(c) Pavement evaluation methodology developed by HSRI.

(d) Research on road deterioration modeling by TU.

(e) Research on pavement management systems by HSRI.

14. Finally the CPMS was completed in 1990 and reviewed by Chinese experts in January 1991. The system then got approved and won a national award.

15. The CPMS is composed of three parts: pavement data base, project level management system, and network level management system.

**Pavement Data Base**

16. The pavement data base is made up of a code subsystem and basic data subsystem. The code subsystem includes eight files, i.e., road code, administration region code, section code, subsection code, surface type code, base type code, sub-base type code, and treatment code.

17. The basic data subsystem includes six files, i.e., traffic volume data (classified into 11 groups), road distress data (classified into 12 categories and 24 items), pavement deflection data (with 20 measurement points) comprehensive index data (including PCI, RQI, PQI, and SI), pavement treatment historical data, and macroeconomic data (industrial and agriculture revenue, etc.).

18. The data base is the information center of CPMS and performs such functions as data editing, retrieval, calculation, tabulation, statistics, drawing, and creation of other data files, as required.
Network Level System

19. The network level system is a macro decision-making system, which performs investment analysis, maintenance demand analysis, and pavement condition analysis at the network level.

20. The network level system comprises five parts: data preparation, model parameter modification, optimization, demand analysis, and result output.

(a) Data Preparation. This part prepares network data from the pavement data base as required, usually such data as International Roughness Index and pavement distress data.

(b) Model Parameter Modification. All the parameters and functions used in the network system, such as \( V = f(IP) \), \( IP = f(BI) \), and \( RQI = f(IP) \), could be modified by this model.

(c) Optimization. Optimization is a key decision model in the network level system. It is a linear program model with socioeconomic benefit as the target function.

(d) Demand Analysis. The decision results can be analyzed statistically with this model to get different output as required, which can be displayed with two- or three-dimension drawings. Both summary and detailed result output are available.

(e) Result Output. The result can be either displayed or printed out in tables, charts, or diagrams.

Project Level System

21. The project level system is a decision-making system for maintaining one or several road sections. Similar to the network level system, the project level system is composed of five modules: data preparation, model parameter, maintenance decision, maintenance planning, and result output.

22. More detailed data are required for the project level system's data preparation, which includes pavement deflection, roughness, distress, friction coefficient, etc. Decision tree method is used as decision model in the project level system. The decision depends on both technical and economic factors (Life Circle Cost, LCC). A group of maintenance treatment alternatives are created by decision tree on the basis of technical decision, and the selection is made by LCC. The user is advised by such decision as what treatment, how many costs will be needed at which road section.

23. The Project level decision is made on the basis of network level system analysis.
24. Implementation of the system has been made since 1991 and was approved as a key Technology Implementation Project for the 8th FYP by MOC. Ten provinces were selected for implementation at the first stage, which include most of the provinces having the Bank-financed highway projects.

25. A comprehensive system and organizational plan showing the interrelationship of various factors in the implementation of CPMS have been established by HSRI based on experience in pilot projects. Leading groups and technical steering groups have been set up in provincial highway departments concerned as well as in MOC to manage and coordinate administrative and technical details of the implementation. The steps to ensure successful implementation of CPMS may include the following:

(a) Working out a program for developing awareness and mobilizing support among senior officials in the provincial governments and highway departments to ensure coordinated action for the many departments involved.

(b) Strengthening liaison between implementing provinces and the pilot study of RDB in Shaanxi province, to provide feedback on implementation methods and the performance of the two management systems.

(c) Acquiring consultant services from the advanced countries to learn state-of-the-art technology and acquire experience on the development and implementation of PMS in order to keep up with the international level.

(d) Strengthening training of the technical key staff in the implementation provinces to provide a stable and reliable technical core in every province.

26. Further technical development and research is essential to improving the reliability and versatility of the system models for producing planning projections and for ensuring cost-effectiveness, economic levels of structural and functional performance, and the appropriateness of technical solutions. This would build on the initial basis through the following:

(a) A program of verification and improvement of predictive models for road deterioration and maintenance effects, for the range of construction and maintenance practices in China.

(b) Updating and extending the Chinese vehicle operating cost relationships through controlled surveys and data collection, particularly related to speed-flow relationships, vehicle maintenance cost, and utilization.

(c) Further review of the prioritization and decision criteria, to optimize economic, functional (safety, speed, and ride) and administrative objectives.
(d) Staged enhancements of the software, incorporating interfaces with the Geographic Information System software environment being developed for the RDBs, and continual upgrading of the user interfaces, for example, automating the data inputs and enhancing the reporting formats for senior and technical endorsers.
WORLD BANK HIGHWAY PROJECTS

SUMMARY OF STUDIES, INSTITUTIONAL STRENGTHENING, AND TRAINING

Objectives: To improve the management of the road agencies, study highway sector issues such as finance, road transport services, construction industry, train agencies' staff, and strengthen the capacity of various highway institutes and Provincial Transportation Technical Schools

<table>
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<th>Project/location</th>
<th>Starting year</th>
<th>Foreign exchange cost</th>
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<tbody>
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<td>National level</td>
<td>1986</td>
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</tr>
<tr>
<td>National level</td>
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<td>Shaanxi Province</td>
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<tr>
<td>Shandong Province</td>
<td>-</td>
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<tr>
<td>Jiangxi Province</td>
<td>1989</td>
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<td>Fujian Province</td>
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</table>
LAW AND REGULATIONS

1. Laws and regulatory work have been strengthening in the last decade. Since 1984, more than 20 codes and regulations on transport have been issued by the State Council, and more than 150 have been issued by MOC or jointly with other related ministries. Meanwhile, provinces have also issued many specific regulations in accordance with the State Council and MOC codes and regulations. Up to now, a framework for codes and regulations has been formed, which helps a lot in carrying out highway administration and operation.

2. Efforts have been put in drafting the "Highway Law" in recent years. A joint working group under MOC's Engineering Administration Department, with the participation of all provincial highway departments and various ministries in the central government, was set up to prepare the Highway Law. Now the draft is ready and will be approved by the Minister of MOC. It will then be submitted to the State Council in early April for review and approval. It is hoped that the approved draft will be submitted to the People's Congress in August 1993 for final approval.

3. Although the achievement was remarkable, with the deepening of reform, particularly with the reform towards market economy, some of the existing documents are no longer suitable for implementation, and some new areas need further study. Hence, there is a need to review and update all of the existing codes and regulations and to study the new areas and fill the gaps. Particular attention should be given to the codes and regulations on construction industry, road user industry as well as consultant industry to provide them with a sound environment for their healthy development. Meanwhile, a monitoring and feedback mechanism should be developed for enforcing implementation and timely upgrading of codes and regulations.

List of Major Laws and Regulations

- "Implementation Method for Code of Road Administration of PRC," issued by MOC.
- "Technical Standards for Highway Engineering," issued by MOC.
- "Management Method for Highway Capital Construction," issued by MOC.
* "Acceptance of Completed Highway Construction," issued by MOC.
* "Provisional Code for Highway Maintenance Management," issued by MOC.
* "Code on Collection and Usage of Highway Maintenance Fee," issued jointly by SPC, MOC, MOF and PBC.
* "Provisional Code for Road Transport Management," issued by MOC and State Economic Commission (SEC).
* "Regulations on Purchasing Motor Vehicles, Motor Boats and Tractors for Transportation by Individuals and Cooperatives," issued by MOC and SEC.
* "Regulations on Management of Rural Individual Transport Unit," issued by MOC and SEC.
* "Provisional Method for Auto Maintenance Industry Management," issued by MOC and SEC.
* "Rules for Implementation of Road Cargo Transport Contracts," issued by MOC and SEC.
* "Provisional Regulations on Road Transport Management," issued by MOC and SEC.
* "Regulations on Collection and Use of Road Transport Management Fee," issued by MOC and SEC.
* "Regulations on Use and Management of Road Transport Certificate," issued by MOC and SEC.
* "Regulations on Road Passenger Transportation," issued by MOC.
* "Regulations on Road Cargo Transportation," issued by MOC.
* "Regulations on Road Transportation for Dangerous Goods," issued by MOC.
* "Regulations on Road Transport Tariff," issued by MOC.