

Fast and Focused – Building China’s Railways

John Scales, Jitendra Sondhi, and Paul Amos

World Bank Office, Beijing

Over the past few years, China’s railway sector has built an astonishing number of large and complex railway projects under its Mid and Long-Term Railway Development Plan. Many of these projects, such as high-speed lines, employ state of art technologies. They have been delivered much faster than is typical of just about any other country. How is it done? The paper argues that three factors dominate: the concentration of responsibility, power and access to resources in one organization; strong technical capacity and processes; and a program effect that delivers economies of standardization and scale. Whether the sheer speed of implementation has adversely affected the overall life-cycle costs and reliability of project infrastructure is not yet known.

THE CHALLENGE OF A CENTURY

China’s railways entered a new phase of development with the Mid and Long-Term Plan (MLTP) adopted in 2004 and revised upwards in 2008. It currently aims by 2020 to increase the total rail network from 75,000 to 120,000 route-km. It includes construction of 16,000 km of high-speed routes, three new regional inter-city networks, new dedicated coal lines and substantial double tracking and electrification. It is the world’s largest national railway development program for more than a century.

The government’s 2008 economic stimulus program encouraged and enabled the Ministry of Railways (MOR) to bring forward planned projects and ramp up individual project implementation speed to an unprecedented level. For example, the 1,068km Wuhan-Guangzhou high-speed railway, started construction in 2005 and was commissioned in December 2009. At the time of writing, this line and more than a dozen other high-speed lines initiated in the last five years have been completed.

A project that in China might take about 5-6 years from government approval of project concept to system commissioning would, in the authors’ experience, take 7-15 years in almost any other country. How has China, managed to deliver project after project so rapidly?

The World Bank has been actively engaged in the development of China Railways for the past 25 years. The authors, who have observed the development and implementation of some of the projects, believe that three factors dominate: single-point responsibility; strong technical capacity and process; and what might be called the program effect.

SINGLE-POINT RESPONSIBILITY

A notable feature of the rail sector in China is the commanding role of MOR, which has prime responsibility for both formulating and implementing development strategy for the railway sector, for planning and financing of individual projects, for creation of delivery mechanisms (such as the joint venture companies with provincial governments), and for administration of China’s national railway services (which carry over 95 percent of China’s rail traffic).

While the MOR proposes sector-wide plans, the State Council must approve these and the individual Five Year Plans into which MLTP feeds. The National Development and Reform Commission (NDRC) must also approve the Feasibility Study Report carried out for each project and agree the priorities for project implementation. But in just about every other material respect, MOR holds the keys. It enjoys a

potent combination of: (a) the responsibility to plan, design and deliver major projects; (b) the legal and institutional power it needs to do so, and; (c) access to the operating cash flows of one of China's largest single businesses to borrow against¹, together with a dedicated capital fund from railway construction surcharges on freight.



This heady confluence of responsibility, power and resources, has created a goal-driven culture at all stages of project delivery. It is a moot point whether management theorists would characterize this as a 'command and control' model in which everyone does what they are told, or a 'consensual' model in which clearly articulated goals are commonly shared. Either way (and in practice we observe elements of both approaches) the result is a collective commitment to an approved goal and to the milestones for achieving it. Some critics believe that this concentration of power in MOR and fixation on speed of project delivery, may have sometimes led to insufficient review of quality and safety features, particularly in the absence of an independent quality verification authority.

Public governance of the railway sector is not so institutionally concentrated in most other countries. Typically there are administrative divisions between policy making, regulation and financing, and between public administration and service delivery. Project goals and timetables are subject to internal and external

questioning and frequent reappraisal. Further, in many countries, public funding constraints mean that major new railway infrastructure projects are pursued through public private partnership (PPP) structures. PPP can sometimes attract finance and share risks with the private sector but typically take many years to assemble, approve, procure, evaluate, negotiate and finance, even before the first sod is turned. In China, MOR, in other words the sovereign², absorbs virtually all project and financing risks in major new railway projects.

Of course, none of this detracts from the strong technical capacity and process that China has demonstrated through this program and to which we now turn.

TECHNICAL CAPACITY AND PROCESS

Although project delivery time is short this follows years of investment in building skills and know-how. For high-speed passenger lines, for instance, specialised units were set up many years in advance to study and adapt technologies employed internationally such as track systems, rolling stock design, signalling and communications, and electric traction. The technologies selected were absorbed, in some cases by technology transfer agreements with foreign manufacturers, but with considerable adaptation to match China's needs. MOR undertook years of capacity building leading up to the program.

MOR has adopted what it calls the "six in one" principle as the foundation for railway project implementation; it encompasses quality, safety, completion time, investment benefit, environmental protection, and technical innovation. This six-faceted principle requires strong technical capacity at all stages of the project cycle from planning and design through to commissioning.

¹ Bond issues are also subject to MOF approval.

² In the case of joint venture railways provincial (that is, sub-sovereign) government, contributes to financing.

Planning and Design

There are six major railway design institutes in China. All except one are legally independent of MOR though they are commercially dependent on MOR contracts, for which they compete. All are state-owned enterprises.

Their role typically includes route surveys, environmental assessments (sometimes with specialist environmental firms), project feasibility reports and preliminary and detailed designs. Typically each major design institute employs about 3,000-4,000 people. This capacity together with a singular focus provides the means and the ability to produce a feasibility report within a 6-12 month time frame. In most countries feasibility studies for major railway construction projects take up to 2 years to specify, procure, complete and report.



The feasibility reports and associated preliminary designs together with the environmental impact assessment are first reviewed by MOR and, when accepted, are submitted to the NDRC that uses its own engineering and economic consultants to check the technical parameters, cost estimates and the estimated rates of return. MOR and other sponsors (if any) must demonstrate that they have sufficient investment funds available. NDRC then sets the priority and time-frame for project implementation: crucially, the project budget, technical parameters, preliminary design, and schedule for each project are 'frozen' at the point of NDRC approval. On receiving necessary clearance from the Ministry of Environment,

Ministry of Land Resources and Ministry of Water Protection, the project is ready for implementation. The detailed design for the project is then completed by the contracted design institute in accordance with the approved parameters. Project managers implement them with little or no further questioning of the concept or design and so there are minimal changes during construction.

Design Standardisation

Published technical specifications for high-speed railways utilize a standardisation of designs and technical specifications not only to simplify the design process, but also to help manufacturers to attain economies of scale and contractors to develop cost-effective 'repeat' processes for construction. For example, the length and design of beams for viaducts has been standardised, helping to maximising the production rate of bridge beams, improving quality control and optimising the cost of production.

Procurement

Procurement is typically administered by professional tendering companies using routine processes. As in other countries, the bidding process for contracts requires that bidders must meet the qualifying criteria of past experience of similar work and project scale, and availability of physical and financial capacity to carry out the contract in the required time frame.

Traditionally, China's railway construction industry was part of MOR. These units were separated in year 2000 as part of railway reforms. Construction activities were transferred to what is today two large holding companies: China Railway Construction Co. (CRCC) and China Railway Engineering Corporation (CREC). Each controls 15 to 20 subsidiaries that specialise in particular aspects of railway construction. They may have more than one subsidiary specialising in the same activity such as bridge or tunnel construction, but these may compete with one another for contracts. Some railway construction and engineering companies are listed on the stock exchange but the state usually remains the

majority shareholder. In addition to the railways construction companies, road construction companies have begun to win sizable railway construction contracts.

In domestically-funded procurement³ the process is typically skewed toward the interests of the employer rather than the contractors and the design institutes, much more so than is typical internationally. For example, the time given for submission of contractors' bids is very short, typically four weeks. The bid evaluation process is then completed within two or three weeks of bid opening. Thus, the entire contracting process may be completed in less than three months. Internationally, procurement rarely takes less than 12-18 months for very large infrastructure projects, partly because much longer response, review, and possible clarification or appeal times are built-in as this is thought to contribute to fairness in process and effectiveness in outcome.

In China, turnkey contracts for rail projects are unusual and separate contracts are usually awarded for goods and equipment that are to be installed for track, signalling, communications, traction sub-stations, overhead catenary, power and train dispatch centres and so on.

Land Acquisition

In recent years, MOR has tried to reduce the requirement of land for projects to the minimum as reluctance of the population to part with land is growing and its costs are increasing. In addition, prime agricultural land is protected by national laws. MOR is now placing a much larger proportion of new railway lines on bridges and viaducts and in tunnels. For example around 81 percent of the new 860km high-speed rail line currently under construction between Guiyang and Guangzhou is on viaduct or bridge or in tunnel. This reduces the land-take and time to acquire land, but increases the cost of construction.

³ That is, procurements that are not funded under the rules of International Financial Institutions (IFIs)

Local county and township governments implement land acquisition and resettlement, not the MOR.

Project Management

MOR establishes a project management team and assigns to it the responsibility of delivering the project in the agreed time frame. Teams consist of professionals in project management and implementation and are drawn from the construction management divisions of the regional railway administrations of MOR. Each project management team is delegated the funds, the design and above all the authority to implement the project. The project team is supported by the system integration unit that is responsible for testing and commissioning of various sub-systems as well as the complete new railway system.

Following award of contracts, the project team prepares a detailed schedule for delivering the project. Critical path activities are closely monitored and in the case of actual or perceived slippage remedial measures are taken immediately. The worksites are monitored from the project team's headquarters, in several cases by real-time video systems. This also allows video conferences between contractors, site managers and the project team. Meeting the delivery schedule is sacrosanct and the project team has the authority to incur additional costs to maintain the schedule for example, by air freighting of urgent components.

Typically the project team remains together until the job is done and is held fully and collectively accountable. This continuity, together with significant financial incentives built into team earnings for timely delivery of the project, acts as a strong motivator of team performance. Project management teams are provided temporary housing accommodation, normally without their families.

Major projects are usually divided into specialised contracts such as for earthwork, bridges, tunnels, track-work, signalling,

communications, and electrification. Coordination and interface management between contractors is the responsibility of the project management teams but contractors face financial penalties if they fail to meet the agreed schedules. The chronic 'gaming' that dogs major contracts in many countries, with hold-ups pending resolution of contract disputes, allocation of blame for delays, and quests for variation payments, seem not to be tolerated. Both market power and contract rights fall clearly in favour of the MOR's project teams and not with contractors.

Quality Monitoring

Each contract and its various components contain not only technical specifications but also quality control parameters. The contractor follows an agreed quality control system that is monitored by an independent contract management unit reporting to the project management team.

Internationally experienced consultants are engaged for contract supervision of projects that use high-precision technologies new to China (such as railways with maximum speed of 350 km/h and more). These consultants employ internationally acquired systems for quality assurance which in turn helps strengthen China's own long-term quality monitoring expertise.

Commissioning

Several sub-systems of a railway need to be integrated seamlessly for safe, reliable and efficient operation. MOR has, in recent years, developed comprehensive testing systems benchmarked against specified standards of reliability, availability, maintainability and safety.

This regime was instituted by MOR during its successful efforts over two decades to raise speed of passenger services, in steps from 100km/hr to 200 km/hr, by upgrading existing railways. Methods were refined as MOR moved on to building new high-speed railways with maximum speeds of 250 to 350 km/hr. Advanced technologies are used in measurement,

transmission and analysis of data collected during static and dynamic tests.

The tests include measurement of various track parameters under static and dynamic conditions. Laser camera, image processing and digital signal processing technologies are used for non-contact measurements. The dynamic response of the electric multiple unit train-sets (EMUs) is measured through accelerometers, displacement sensors, pressure sensors as well as instrumented wheel sets. The data is analysed to evaluate horizontal and vertical forces on the wheel and the rail, forces on the axle and the derailment coefficient. Other tests measure the pressure inside and outside passenger cars when trains pass each other in the open and in tunnels. Electronic tests are conducted on track circuits and signalling and other systems. Similarly, the various parameters of a pantograph under operation are assessed.

The commissioning process includes the running of normal and test trains on the new railway to carry out integrated tests that verify performance, and lead to adjustment and fine tuning to optimise the whole system as an integrated unit. In the case of Wuhan-Guangzhou line these tests lasted about 12 months and covered 17 major sub-systems including power supply and sub-stations, signalling, electromagnetic capability, vibration and sound shields, track structure, aerodynamics of train at turnouts, bridges and tunnels, and safety monitoring systems. Failure simulations are carried out to test back-up systems. The commissioning tests include adjustment and fine tuning of track and switches based on test results of dynamic performance of trains. Similarly the overhead catenary system is fine-tuned for removing flaws in respect of stagger, hard spots, excessive or continuous sparking. Such tests are conducted at progressively higher speeds. In most part this commissioning has helped to ensure quality but, as demonstrated by the Wenzhou accident, there is room for improvement.

THE PROGRAM EFFECT

So far the paper has described the implementation cycle of individual projects but the fact that each project has been part of integrated much larger program should not be forgotten.

The fact of there being not one but many of the largest railway projects in the world in the program might be thought to challenge rather than aid expeditious project delivery. But the scale of the MLTP created a whole new industry that was confident in the continued long-term development of China's railways, a confidence that led to a huge increase in the capacity of the industry, from technical institutes through to contractors, manufacturers, service suppliers and many others.

Survey and design institutes were geared up to produce project documents and detailed designs in short order. Factories worked round the clock to manufacture standardized components such as slab-tracks, bridge beams, tunnel linings, and so on. Worksites hummed constantly beneath daylight and floodlights, 7 days a week, with workers confident that when one site closed another would open up.

In other words, building new railways has become 'routine' in China in the way it was routine in, say, Europe, North America and India in the nineteenth century, when there were comparable feats in project delivery times. There is a common saying that if you want something done quickly, give it to a busy person. China's railway industry was never been busier than in the last decade.

WAS QUALITY AND SAFETY COMPROMISED?

But the routine of responding to pressured deadlines also has its own risks. As the authors know well from their experiences in project management outside China, routine may also breed a potentially unfounded sense of security and continuity that can reduce vigilance – a

sense that what has not gone wrong so far cannot go wrong.

The recent train crash in Wenzhou has led some observers in China to doubt whether such challenging program delivery schedules as have been achieved in the last few years can be maintained without some diminution of attention to the review and scrutiny necessary for the highest life-cycle quality and reliability. A recently published investigation report on the Wenzhou accident finds that the root cause of the accident was insufficiently robust signalling equipment that malfunctioned when struck by lightning. This equipment went into service in late 2007 with little testing. It further concluded that the focus on speed of the railway project construction, neglect of safety management and corruption in award of contract also contributed to the accident. MOR has prudently undertaken a China-wide review of standards of recent and planned projects that extends beyond the individual accident concerned.

MOR also decided, on the grounds of energy savings, to cap the maximum speed of trains at 300 km/h effective July 01, 2011.

COULD THE CHINA EXPERIENCE BE REPLICATED?

The question is often asked if it is possible to replicate the speed of project implementation on China Railways in other countries. The authors believe there are good and important lessons for many countries to learn, or re-learn, from China about the importance of vision, preparation, commitment and focus in pursuing large, complex but 'mould-breaking' infrastructure investments.

On the other hand, the program effect is not easily replicated in most countries which typically have few major new lines to build and may not have either the need of or resources for a large-scale program. Those other countries that are planning to build new railway lines are typically dealing with only one 'headline' project at a time, which is typically subject to a unique

or highly customised design and delivery process.



It is also the case that the concentration of responsibility, power and resources that is evident in MOR is not favoured by most countries. Most have opted for sector governance arrangements involving more checks and balances in the public administration of the railway sector, and more external scrutiny of and wider accountability for major public projects and their funding. Such arrangements have strong support in public governance theory but inevitably add complexity and time to the process of delivering major public infrastructure.

Even in China, the high rate of project implementation experienced between 2008 and 2011 has been curtailed. The economic stimulus package that prevailed over that period increased the number of projects and compressed project timetables and thereby brought forward a significant portion of the MLTP. But it has also led to a rapid ramp-up of railway debt, while net revenue returns from the additional capacity created will take much longer to accrue.

The economic stimulus has now been phased out in China including within the railway sector. Annual investment levels can now be moderated from those years without compromising the attainment of MLTP by 2020, but raising sufficient finance against the backdrop of the accrued debt may now become the main

constraint on the future speed of network development.

John Scales is Transport Co-ordinator, Beijing Office of the World Bank.

Jitendra Sondhi is a railway engineer and is currently a Consultant to the World Bank's railway lending program in China.

Paul Amos is a transport strategy and management consultant to the World Bank and previously the World Bank's Transport Advisor.

This note is part of the China Transport Note Series to share experience about the transformation of the Chinese transport sector. For comments, please contact John Scales (jsc@worldbank.org) or Gerald Ollivier (gollivier@worldbank.org), from the Beijing World Bank Office.

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