

Urban Rail Transit Present Situation and Future Development Trends in China: Overall Analysis Based on National Policies and Strategic Plans in 2016–2020

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Received: 15 December 2017 / Revised: 6 February 2018 / Accepted: 8 February 2018 / Published online: 28 February 2018
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Abstract This study analyzes the development of the urban rail transit industry in China from an overall and macroscopic perspective. Multiple factors were considered, such as the degree of urbanization, non-public vehicle ownership, road capacity, and modal share of public transport in international metropolises, as well as planning and construction of urban rail transit systems in China's large and extra-large cities. Through extensive investigations and research, this paper presents a comprehensive, systematic, and in-depth analysis and explanation of the domestic social demands and environmental background for the development of urban rail transit in China. Based on national development policies and strategic plans, information on current cutting-edge technologies, the adaptability of various urban rail transit modes, industrial technologies, local finances as well as investment and financing models, this study analyzes the opportunities and challenges that the development of urban rail transit in China faces over the 2016–2020 period aligned with China's 13th Five-Year Plan. This paper aims to provide a forecast and outlook on the period's ten major trends. The predicted trends include expanded scale, differentiated development, networked structure, multimodal transit systems, industrial standardization, intelligent systems, self-developed technology, diversified funding, international

markets, and strategic planning. This article presents a comprehensive analysis of the current situation, development prospects, and future trends of urban rail transit in China and proposes corresponding measures and strategies. The findings can serve as an important and valuable reference for the development of urban rail transit in China and other countries.

Keywords Urban rail transit · Urbanization · Multimodal · Interconnection and interoperability · Internet Plus · Automation · Intelligent systems · One Belt One Road · Investment and financing

1 Introduction

At the beginning of the 2016–2020 period, hereafter referred to as China's 13th Five-Year Plan period, through extensive research and analysis, the author proposed the "Report on Urban Rail Transit Development in the 13th Five-Year Plan," which provided an overall and macroscopic perspective on the development of the industry and an analysis of the developmental environment and forecasts of developmental trends. Within the 18 months following the report, the author successively presented a supplementary report and a phase review on the developmental trends of the 13th Five-Year Plan based on the urban rail transit industry's development. This article combines these three reports in order to offer a comprehensive and in-depth reflection on the development and future prospects of the urban rail transit industry in China.

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2 Analysis of the Developmental Environment of Urban Rail Transit in the 13th Five-Year Plan

Five major factors of developmental environment were found to have a profound impact on the development of urban rail transit during the 13th Five-Year Plan period.

2.1 The “Five Major Factors” Boosting Large-Scale Development of Urban Rail Transit

In the 2016–2020 period, China will witness migration of approximately 100 million people into the cities, in addition to nearly 100 million new vehicles on the roads, substantial increase in the share of public transport travel, accelerated construction in cities with ongoing urban rail transit projects, and new construction in cities with plans to install urban rail transit systems. The combined effects of these five forces have facilitated the more large-scale development of urban rail transit.

2.1.1 Rise in Urban Population

The 13th Five-Year Plan period is the initial period of China’s New Urbanization Plan. It is also within the range of rapid development with an urbanization ratio of 30–70%, which implies further expansion at the scale of cities. In 2016, the population of Mainland China is 1.38 billion, 8.09 million more than 2015, accounting for an annual natural growth rate of 5.6%. The population of permanent urban residents reached 790 million, and the urbanization ratio was 57%. We can therefore estimate that the population of Mainland China will reach 1.45 billion by 2020. At this point, the expected urbanization ratio in national planning will reach 60%, which is approximately equal to 870 million urban residents, an increase of approximately 100 million people over 2016–2020. There are 656 cities in China, including 201 large cities (population above 1 million). Among the large cities, there are six megacities (population above 10 million people), 12 extra-large cities (population of 5–10 million), 21 Type I large cities (population of 3–5 million), and 164 Type II large cities (population of 1–3 million) [1]. With approximately 100 million people expected to migrate to cities during the 13th Five-Year Plan period, the size of existing cities is surely to expand, which will aggravate traffic congestion and increase the demand for urban rail transit.

2.1.2 Non-Public Vehicle Ownership Increasing

In terms of non-public vehicle ownership in China, 82.6 million new vehicles were added during 2010–2015, referred to as the 12th Five-Year Plan, at an average annual

increase of 16.53 million, or 14%. The vast majority of these vehicles were in large cities. There are 40 cities each with over 1 million non-public vehicles and 11 cities each with over 2 million non-public vehicles [2]. Consequently, traffic conditions have become a major issue. However, the national average vehicle ownership per 1000 people was only 125 vehicles, which was significantly lower than that of medium-developed countries (200 vehicles per 1000 people). Therefore, vehicle ownership will continue to grow over the 13th Five-Year Plan period. If the average annual growth rate during the 13th Five-Year Plan period is two-thirds of that in the 12th Five-Year Plan period (9.3%) and the scrappage rate remains the same as that of 2015 (3.9‰), then the number of private vehicles will increase by 91.5 million within 2016–2020. Among these new vehicles, 85% will be passenger vehicles (77.8 million), of which 85% (66.1 million) will be in large cities. However, the actual situation is likely to be far worse than the above estimation. In 2016, non-public vehicle ownership in China reached 194 million with the addition of 22.12 million new vehicles, which is 12.8% more than that in 2015 (172 million vehicles). Based on this growth rate, nearly 100 million new vehicles will appear on city roads during 2016–2020, which will inevitably lead to an increased demand for urban rail transit.

2.1.3 Green Modes of Urban Transport

The National New Urbanization Plan (2014–2020) proposed that the proportion of urban public transport travel will account for 60% of total motorized travel by 2020. How is the modal share of passenger transport capacity that urban rail transit should take as the backbone of urban public transport? In most metropolitan cities, urban rail transit accounts for more than 50% [3–5], whereas in Tokyo, New York, and Hong Kong, the proportion is as high as 80–90% [6, 7]. However, in Mainland China, Shanghai has the world’s largest urban rail transit system, but its modal share is only 50%, while the national average modal share is only approximately 10% [8]. Therefore, it is necessary to substantially increase both the proportion of public transport commute and the modal share of urban rail transit over the 5 years. The substantial increases in these two areas would promote the development of urban rail transit.

2.1.4 Ongoing Urban Rail Transit Projects

The 40 cities with ongoing urban rail transit projects have developed the 13th Five-Year Development Plan accordingly. Among these cities, the four cities that have already established large urban rail transit networks (Beijing, Shanghai, Guangzhou, and Shenzhen) plan to invest RMB

695 billion to improve their urban rail transit system over the 5 years, which represents a 47.5% increase in investment compared to the 12th Five-Year Plan (RMB 471.3 billion). The expected length of the new rail lines is 982 km, which is 68.7% longer than the one constructed in the 12th Five-Year Plan (582 km). Some cities that plan to complete their urban rail transit network during the 13th Five-Year Plan period, such as Tianjin, Chongqing, Nanjing, Wuhan, and Chengdu, are constructing their urban rail transit systems at faster speed. Other cities with ongoing urban rail transit projects have also made large-scale construction plans for the 5 years. Over all, many cities with ongoing urban rail transit projects have accelerated their development.

2.1.5 Future Urban Rail Transit Plans

In addition to the cities with ongoing urban rail transit projects, some 80 additional cities have initiated the preparatory work required for the construction of urban rail transit (e.g., planning, surveying, design, and consulting) and are extremely likely to launch their urban rail transit projects during the 13th Five-Year Plan period. Since the beginning of the 13th Five-Year Plan period, more than 100 cities have formulated plans for construction of urban rail transit, giving rise to a new phenomenon of simultaneous development of urban rail transit in over one hundred cities. In the meantime, a sharp simultaneous rise of new lines has also occurred. In 2016, the length of newly added lines exceeded 500 km for the first time (525 km). It is expected that the length of annually added lines will soon reach 1000 km with the urban rail transit undergoing an explosive growth. Given this speed of development, by the end of 2020, more than 60 cities will have urban rail transit systems, with the total length of operational urban rail transit lines reaching 8000 km. The rapid surge in urban rail transit across the nation is the epitome of the general concept of “a hundred of cities cooperating to achieve the goal of 1000 km” proposed by the National Development Plans. Inevitably, China is one of the few countries that possess such a large-scale urban rail transit network, covering many cities and having an extremely high growth rate in operating lines.

In the future, driven by the joint forces of the five factors (the migration of approximately 100 million people into the cities, addition of nearly 100 million new vehicles on the roads, substantial increase in the urban rail transit share of public transport travel, accelerated new construction in cities already with urban rail transit, and new cities to join the urban rail transit community), the urban rail transit industry will usher in an unprecedented scale of development.

2.2 “Integrated Triple Plans” Government Policies Give Rise to a New Pattern of Coordinated, Multimodal Urban Rail Transit Development

Relaxation of policies for migrants obtaining household registration document in large cities, development of larger metropolitan areas, and establishment of state-level new areas have led to a significant demand for development of coordinated, multimodal urban rail transit systems.

2.2.1 Plan 1: The New National Urbanization Plan

The New National Urbanization Plan [9] proposed that “the limitations of obtaining a household registration document in large cities with a population of 1–3 million people should be relaxed reasonably” and that “reasonable criteria should be determined for obtaining a household registration document in large cities with a population of 3–5 million.” This major policy is likely to boost the population of large cities, stimulate demand for public transit, and increase the urgency for developing urban rail transit, which will have a profound impact on urban construction and development of urban rail transit. As some cities, particularly Type II large cities, only have moderate passenger traffic and limited financial resources, it is likely that the strong demand for low-to-medium capacity and low-cost urban rail transit systems, such as light rail, monorail, and trams, will grow significantly.

2.2.2 Plan 2: The Proposal on Formulating the Thirteenth Five Year Plan (2016–2020)

Given the increase in economic transformation and enhanced modernization, a series of highly efficient urban agglomerations with a strong radiating effect, excellent urban system, and strong complementary functions has been formed and is being continuously optimized in the eastern China. Urban agglomerations in the northeastern and midwestern regions are also under development. The Proposal on Formulating the Thirteenth Five-Year Plan (2016–2020) [10] on National Economic and Social Development, issued by the Central Committee of Communist Party of China, specified the following: “the radiating effect and leading role of urban agglomerations is to be emphasized; the development of the three major urban agglomerations, including the Beijing-Tianjin-Hebei Province region, Yangtze River Delta mega region, and Pearl River Delta mega region should be optimized; and the urban agglomerations of Northeast China, Central Plain, middle reaches of the Yangtze River, Chengdu-Chongqing region, and Guanzhong Plain should be developed.” The Proposal also suggested that “a batch of central cities should be developed, and regional service function

strengthened.” With the support of this policy, the radiating effect and leading role of central cities will gradually expand. Extra-large and megacities will continue to decentralize their economic and other functions as well as strengthen the infrastructure and sharing of public services with neighboring towns and cities and even neighboring provinces, thereby forming metropolitan areas with high commuting efficiency and integrated development. The construction of urban agglomerations and metropolitan areas will be implemented rapidly over the 5 years. As a result, the demand for public transit and commuting will also increase significantly. These changes will further increase the development potential of urban rail transit systems. In addition, the larger area of travel and commuting demand generated by the metropolitan areas and urban agglomerations is likely to create more opportunities for the development of different types of urban rail transit, such as urban rapid transit.

2.2.3 Plan 3: The National Development and Reform Commission (NDRC)

Following the establishment of the Pudong (Shanghai), Binhai (Tianjin), and Liangjiang (Chongqing) new areas, 13 additional state-level new areas were approved by the State Council in the 12th Five-Year Plan. A total of 16 state-level new areas in mideastern, midwestern, and northeastern China have been established. With the coverage of state-level new areas shifting from cities with national strategic importance to regional growth poles, more areas are expected to be approved in the future. The Guiding Opinions on Promoting the Healthy Development of State-Level New Areas [11] issued by the National Development and Reform Commission (NDRC) and other departments specifies that “the new areas will be developed into important windows for the all-round expansion and opening-up, to become major platforms for institutional and systematic innovations, forming crucial poles of growth in regions playing radiating and leading roles, and becoming the areas of demonstration for city-industry integrated development.” The construction of superior state-level new areas requires the support of a superior intraregional transportation network. Since state-level new areas are usually large (ranging from hundreds of square kilometers to more than two thousand square kilometers), with different functional zones distributed within the area, they tend to have specific demands for the intraregional transportation. Electric light rail is likely to become the main mode of urban rail transit.

Based on the Five-Year Plans launched by various provinces and cities in recent years, urban rapid transit, medium-size monorail, and trams have gradually become the main modes of urban rail transit systems in Tier II and

III cities, urban agglomerations, and extra-large cities. In the future, the relaxation of urban *household registration* policies, the development of urban agglomerations and metropolitan areas, and the construction of state-level new areas will create potentials for the accelerated development of urban rapid transit systems with a low-to-medium capacity, such as urban rapid transit, trams, light rail, monorail, and low-to-medium-speed maglev trains.

2.3 The “One Belt and One Road Initiative” Leads Urban Rail Transit Development to a New Global Stage

In 2013, China proposed a momentous strategic decision for the Silk Road Economic Belt (SREB) and Maritime Silk Road (MSR) in the twenty-first century known as the One Belt and One Road initiative (OBOR) [12]. Driven by the OBOR strategy, development of urban rail transit in China is likely to steer toward a favorable “Going Global” situation.

The China Association of Metros (CAMET) has studied the “Going Global” of urban rail transit and believes that, compared to those of other countries, the urban rail transit systems in China have strengths and weaknesses. The unique strengths are as follows: (1) the implementation of the OBOR strategy has guaranteed the intensified support of government policies for the development of urban rail transit. (2) The comprehensive industrial chain, a number of leading enterprises, and the echelons of their supporting businesses have formed a pattern of development characterized by industrial clusters. (3) The immense domestic demand for development has become a powerful impetus for the internalization of urban rail transit. (4) Urban rail transit is more cost-effective in China; in particular, the domestic market remains overall cost-effective. The relative weaknesses are as follows: (1) the overall underdeveloped strength of enterprises, with inherent deficiencies in their core competitiveness and innovation levels; (2) lack of certain core technologies; (3) lack of a sophisticated standardization and incomplete standards system; and (4) weak brand-building ability and insufficient brand promotion.

Compared to the high-speed rail, the urban rail transit in China also has strengths and weaknesses. Its strengths include having a more active market; being more competitive; and possessing a greater proportion of self-developed technology, which reduces the possibility of intellectual property disputes. Its weaknesses are lack of comprehensive management and poor industrial coordination. In addition, the enterprises in this industry are dispersed and have little industrial cohesion, and face severe and vicious competition. Overall, both high-speed rail and urban rail transit systems have advantages and

disadvantages. If the government, industry, and enterprises can work together to enhance the strengths and compensate the weaknesses in both systems, the urban rail transit and high-speed rail systems will become two competitive products that China can present to the global rail transport market. Taking this into consideration, the CAMET research report proposed several policy suggestions, including “strengthening national strategic planning and deployment, increasing support from financial and taxation policies, improving the innovation ability of the industry, and cultivating internationalized talents.”

After the report was submitted to the State Council, it received significant attention and recognition. Thereafter, a state-level “Coordination Group for the ‘Going Global’ of China’s Railway” led by the NDRC was established. The urban rail transit system was also included in the National Railway “Going Global” Strategy and was considered an important part of the tasks in the group.

Since the beginning of the 13th Five-Year Plan period, OBOR has become China’s paramount plan for the globalization and internationalization of its economic development, and it hopes to push economic globalization toward a more inclusive and balanced development. This trend is conducive to the internationalization of the Chinese urban rail transit, as it has a more comprehensive industrial chain and has formed industrial clusters. In the future, driven by the OBOR strategy, the Chinese urban rail transit will take great strides toward the global market and become a major highlight of the 13th Five-Year Plan.

2.4 “Internet Plus” Technology Revolution Leads the Urban Rail Transit Industry into a New Era of Automated and Intelligent Development

Currently, a new industrial technology revolution is emerging worldwide. Internet Plus, which integrates Internet innovations with various social and economic fields, strongly promotes the innovation of production methods, organizational structure, management concepts, and business models. In recent years, Internet Plus has transformed several industries, creating various new concepts such as e-commerce, Internet finance, online tourism, “Internet + manufacturing industry,” “Internet + agriculture,” “Internet + culture,” and “Internet + government administration.” The Internet Plus technology revolution has triggered a surge of innovation in all social and economic areas.

The main features of the Internet Plus technology revolution include cross-border integration, which stimulates disruptive innovation; self-revolution driven by innovation; and system restructuring that shapes new status of industries. Thus, utilizing Internet technology to its greatest extent and actively promoting “Internet + urban rail

transit” could greatly promote technological progress, improve efficiency, and reform organizations in the urban rail transit industry, thereby greatly enhancing the industry’s innovation ability and productivity.

The in-depth integration of the Internet and urban rail transit has been leading to continually derive many new automated and intelligent technologies.

Fully Automated Operating (FAO) systems According to the statistics of the International Association of Public Transport (UITP), by July 2016, 37 cities worldwide had applied fully automated metro technology to a total of 55 metro lines (803 km), accounting for 6% of all metros in km. By 2025, there will be 2300 km fully automated metro lines in operation, of which 88% will be contributed by Asia Pacific, Europe, and Middle East regions and in Europe 26% of their future fully automated metros in km will be from old line conversions [13]. This information indicates that the global metro construction will enter a period characterized by a rapid development of FAO technology. The first application of FAO technology in Mainland China is Metro Line 10 in Shanghai (35.2 km) built in 2010, and the technology was introduced by Alstom. The second metro line that utilized the technology was Zhujiang New Town Automated People Mover System (3.9 km APM line) in Guangzhou. The 16.6 km Yanfang Line of the Beijing Metro, which is currently under construction, is the first metro line to utilize a FAO system for which China has independent intellectual property rights. This project has been listed as a demonstration project by the NDRC and the CAMET and is to be opened for operation by the end of 2017. On its completion, there will be three FAO metro lines, with a total length of 55.7 km [14]. Simultaneously, 12 cities have established construction plans of FAO lines during the 13th Five-Year Plan period, for a total length of 1150 km. These cities include Beijing (202.4 km), Shanghai (170.5 km), Guangzhou (37.2 km), Shenzhen (142.5 km), Nanjing (35.7 km), Chengdu (23.7 km), Wuhan (33.6 km), Zhengzhou (43.8 km), Jinan (243 km), Nanning (127 km), Suzhou (44 km), and Wuhu (46.7 km). Thus, by the end of 2020, China will have 1206 km FAO metro lines, covering 37 lines in 12 cities. This development will be a new milestone for the automation technology of urban rail transit.

Cross-System Interconnection Technology: Cross-System interconnection technology has been widely applied in countries other than China. In Tokyo, urban rail transit consists of the Tokyo metro, Japan railway, and suburban railways. Although each system is a different mode of rail transit and is operated by different companies, the majority of metros and suburban railway lines are interoperable, and the majority of Japan’s railways and suburban railways are also interoperable. This effectively satisfies passengers’ diversified needs, such as direct connections, multiple

choices of speeds, and cross-platform interchanges. The vehicles, signals, and lines of the Paris Métro and Réseau Express Régional (Regional Express Network, RER) systems are interoperable and interconnected. The S-Bahn and U-Bahn (rapid transit) in Berlin, Hamburg, and Munich share the same tracks through urban areas, which separates into various branches based on the level of passenger traffic. The application of interoperability and interconnection technology has alleviated the pressure caused by the interchanges, facilitated passenger travel, encouraged the sharing of resources, and improved the balance of transport capacity. In China, a state-level demonstration project on the application of interconnection technology is being implemented in Chongqing. The vehicles, signals, dispatching, communications systems, integration testing, and commissioning of the four lines in Chongqing will be interoperable and interconnected, permitting shared-line and cross-line operations. Thus, passengers are able to reach the surrounding suburbs, transportation hubs, and commercial centers directly and swiftly. The time spent waiting, commuting, and transferring will be significantly shortened. In addition, single points of malfunction on the lines will not affect the normal operation of the entire system. The distribution capacity of station facilities will also match the carrying capacity of the corresponding trains. Interconnection and interoperability are important for the development of urban rail transit.

Improving the Intelligence and Automation of Work Processes The continuous integration of Internet Plus in the planning and designing of urban rail transit, engineering construction, operation management, equipment maintenance, and passenger service will result in a greater number of automation and intelligent technologies. One such example is the Building Information Modeling (BIM) technology. BIM is an advanced technology that provides reasonable scientific solutions for construction projects. By applying digital information in all the project stages, such as design, construction, and operation, BIM simulates the physical construction of the project, detects the problems that may arise during the construction phase in the early design phase, and provides solutions accordingly. BIM technology has been widely applied in Europe, the USA, and Japan and has also been adopted by projects in Beijing, Shanghai, and Guangzhou. BIM is the future of intelligent construction of urban rail transit projects.

In the future, Internet Plus is predicted to lead the urban rail transit industry into a new era of automated and intelligent development.

2.5 “Three Major Factors” Influence the New Progress of Urban Rail Transit

Urban rail transit construction in the 13th Five-Year Plan period is unprecedented in terms of the number of cities covered, the scale of projects, the level of standards, the modes of rail transit included, the amount of investment involved, and the likelihood of China’s urban rail transit entering the global market. Given this large-scale and rapid development, issues caused by lack of talent resource, limited funding, and inadequate preliminary preparation will become more prominent. These three factors may affect the development of the urban rail transit industry in this new era.

2.5.1 Major Factor 1: Human Resources

First, lack of professionals stems from an insufficient supply of talent, as well as limited capabilities of existing resource persons. To fulfill the goal of constructing 3000 km of new rail lines during the 13th Five-Year Plan period, 180,000 new employees will be required over 2016–2020. Professionals trained by existing pre-service education can only meet approximately half of the current demand; the insufficient supply of employees has become a growing concern. On the one hand, with regard to talent capabilities, there is growing demand from passengers for people-oriented, personalized, and diversified services. On the other hand, the development of urban rail transit has generated a greater demand for new network and intelligent technologies. These “five changes” have led to new requirements for employees. Therefore, strengthening the pre-service education and in-service training and providing more qualified management personnel, technicians, and production personnel have become major influential factors for the smooth development of the urban rail transit industry.

2.5.2 Major Factor 2: Limited Funding and Financing Channels

Second, the accelerated development of the industry has led to a surge in the demand for funding; however, it has become increasingly difficult to obtain funding from traditional financing channels. With the growing scale of construction and operations, the required construction funds and operating expenses will increase substantially. The demand for funds in the 13th Five-Year Plan period will be substantially higher than that in the 12th Five-Year Plan period. According to a preliminary estimation, the construction funds during the 13th Five-Year Plan period is likely to reach RMB 2 trillion, which is nearly twice the investment in the 12th Five-Year Plan period (RMB 1.15

trillion). Such a high demand for funds is unprecedented. However, in terms of funding capabilities, first, China's economic development is entering a new normal, and the growth of government finances will also slow down with the declining rate of development. Second, urban transferable land, which was an important financing channel in the past, is now strictly controlled by government policies. This has led to the reduction in land resources and affected the revenue of local governments. Moreover, the state has paid increasing attention to the prevention of financial risks and control of local debt, which has influenced the fund-raising ability of local governments. In short, government investment in the 13th Five-Year Plan is unlikely to meet the substantial growth in funding demand. The ability to introduce marketization mechanisms and expand fund-raising channels has become an important condition for the sustainable development of the urban rail transit industry.

2.5.3 Major Factor 3: Project Planning and Preliminary Preparations

Third, current preliminary preparations, including planning, surveying, design, consultation, and approval, do not appear to be adequate. The urban rail transit industry will develop on a larger scale in the 13th Five-Year Plan period; however, such development is more likely to be affected by the increasingly complex environmental conditions. Specifically, in cities that have sophisticated urban rail transit systems, such as Beijing, Shanghai, Guangzhou, and Shenzhen, the central city areas have a dense rail network. The increasing addition of new lines is resulting in more complex underground pipe networks. In the cities that are establishing urban rail transit networks, such as Tianjin, Chongqing, Nanjing, Wuhan, and Chengdu, several new lines will be constructed simultaneously, some of which may be interoperable, thereby significantly increasing the complexity of the projects. In addition, cities that are new to urban rail transit are likely to encounter greater difficulties due to lack of qualified talent and project experience; a number of cities that plan to install multi-modal systems are facing issues such as inadequate standards, technology, experience, and talent. In this regard, preliminary preparation has become an important stage in the healthy development of the urban rail transit industry.

In the future, addressing the three limiting factors, namely talent and human resource cultivation, fund-raising, and preliminary preparations, will be crucial for the developmental progress of urban rail transit during the 13th Five-Year Plan period.

3 Forecast of Future Trends for Urban Rail Transit in the 13th Five-Year Plan Period

In response to the changes in the developmental environment, urban rail transit is likely to exhibit ten significant trends during the 13th Five-Year Plan period.

3.1 Expanded Scale

During the 13th Five-Year Plan period, a large-scale development of urban rail transit will occur. First, the number of the cities that are installing and operating urban rail transit will double. Among the 201 large cities, approximately 100 cities have proposed plans and designs for the development of an urban rail transit system. In addition to the 40 cities that have already begun construction, the majority of the cities will begin construction during the 13th Five-Year Plan period. Although the remaining 100 cities have yet to propose development plans, some may also construct urban rail transit systems in the future. Therefore, during the 13th Five-Year Plan period, more than 80 cities plan to construct urban rail transit systems, and more than 60 cities plan to operate them. Thus, by the end of the 13th Five-year, the numbers of cities constructing and operating urban rail transit will have doubled from those of the 12th Five-Year Plan period. Second, the length of the newly built rail lines will be doubled. The estimated length of the newly built rail lines during the 13th Five-Year Plan period will be more than 4000 km, which is twice that of the 12th Five-Year Plan period. Third, the investment in the development of the urban rail transit systems will double. As mentioned earlier, the investment in urban rail transit during the 13th Five-Year Plan period may reach approximately RMB 2 trillion, which is twice that of the 12th Five-Year Plan period. When dealing with a development scale that has doubled, we must strive to the best of our abilities while acting with awareness of our limitations. The explosive growth of the urban rail transit industry will significantly pressurize fund raising, professional talents training, and preliminary preparations. It would be advisable to specially emphasize such issues and ensure steady development through appropriate planning and combination of rail types, and reasonable progression. Second, we should control the implementation process and prevent possible risks. Enterprises involved in urban rail transit should conduct in-depth research for the construction projects, particularly for the design and planning during the preliminary preparations. They should also strictly review fund-raising channels and corporate debts to prevent risks caused by the hasty launching of projects and to ensure the healthy development of the urban rail transit system. Third, we must

broaden our mindset and encourage innovation. It is necessary to be open-minded and strengthen innovation in terms of fund-raising methods, technology application, and management mechanisms, in order to ensure the sustainable development of urban rail transit.

3.2 Differentiated Development for Different Cities

In the 2016–2020 period, differentiation in the development of urban rail transit between cities will become increasingly apparent. *First, the stages of development will differ.* Simultaneously, some cities would be developing a denser and more optimized urban rail network, some would be about to establish their urban rail network, some would be increasing construction of backbone lines, and some others would have only started urban rail transit construction. *Second, the demand for rail transit modes will differ.* Some cities will focus on the construction of metros; some will mainly develop light-rail systems, monorail systems, and trams; some will speed up the development of urban express rail transit; and some others will simultaneously construct low-, medium-, and high-capacity urban rail transit. *Third, the priority of development will differ.* Cities with an already established urban rail network will focus on improving project construction and operation management. Cities that are forming an urban rail network are likely to invest more effort on project construction and likely to begin considering network management issues. Construction management and professional talents training will be the priority of cities that are just beginning to install an urban rail transit system. Differentiated development goals and priorities should be set according to the different development stages of each city, in order to promote the systematic construction of urban rail transit based on local conditions.

3.3 Enhancing Networked Structure

According to the 13th Five-Year Development Plan for urban rail transit, by the end of 2020, more than 30 cities will have more than 100 km of operating rail lines and more than 20 cities will have more than 200 km of operating rail lines. Beijing and Shanghai will have a giant network of rail lines exceeding 1000 km. Cities such as Guangzhou, Shenzhen, Chongqing, Tianjin, Nanjing, Chengdu, Wuhan, and Zhengzhou will have large world-class metro networks exceeding 400 km. China will lead global development of the urban rail transit system in terms of the number of cities with urban rail networks, the overall size of urban rail networks, and the speed of network development. In the same time, a number of regional rail transit networks that integrate urban rail transit and inter-city railways will also emerge during the 13th Five-Year

Plan period. The new development of network structures will lead to new management requirements, where systematic and network-oriented thinking will be needed to formulate network-based guidelines that provide standardized guidance for operation management and resource sharing.

3.4 Promoting Diversity in Operating Modes

During the 13th Five-Year Plan period, mega- and extra-large cities will intensify their expansion toward suburbs, satellite cities, and even surrounding cities, which will provide opportunities for the rapid development of urban rapid transit. The construction pace of light rail, monorail, and tram systems in large cities and that of satellite cities, new areas, development zones, and functional zones of mega- and extra-large cities will also be accelerated. In terms of urban planning, among the 100 plus cities with an urban transit system, 52 cities have plans for metros, 89 cities have plans for tram systems, 32 cities have plans for monorails, and eight cities have plans for maglev trains. In addition, Guiding Opinions of the State Council on Giving Priority to Public Transportation in Urban Development was issued by the five departments and ministries of the central government, including the NDRC, urban agglomerations and metropolitan areas have also begun to plan urban rapid transit systems. This is suggestive of a new pattern for the formation of the urban rail transit industry in China, characterized by coordinated and complementary development of various modes of rail transit systems (metros, monorails, urban rapid transit, and trams). Therefore, guidance and planning requirements for multi-modal development should be developed to promote the healthy development of the urban transit industry.

3.5 Industrial Standardization

Currently, there are a number of national, industrial, local, and enterprise standards guiding the development of urban rail transit, which have played a significant role in supporting and guiding industry development, however, in general, all the industry's development needs. The development of the urban rail transit industry in the 13th Five-Year Plan period gave rise to higher requirements for industrial standardization: World-class development requires the guidance of standardization, multimodal development demands discipline from standardization, network development requires the support of standardization, and the "Going Global" strategy necessitates the assurance of standardization. Therefore, in accordance with the trend of standardization reform initiated by the central government, one of the top priorities is to develop and expand collective standards, establish, and promote

standard systems, and vigorously improve project quality during the 13th Five-Year Plan period.

3.6 Intelligent Systems

Urban rail transit requires a wide range of expertise, multiple processes, a large quantity of equipment, and high-level technologies. The application of Internet innovations will promote the development of intelligent urban rail transit systems. Specifically, the development and application of digital technology will allow the establishment of construction management platforms that can promote coordination and cooperation in all project aspects, including planning, design, construction, and operation, and assist with the digitalization of engineering construction. The establishment of a collection and analysis system for passenger behavior using technologies such as big data and Internet of Things can further improve the railway traffic control system and emergency response systems, thereby creating a dynamic and intelligent dispatch and command system. The introduction of technologies, such as the Internet of Things and mobile Internet, can enable real-time collection of information related to key equipment such as vehicles, power supply, and signals, thereby forming a new equipment maintenance model characterized by real-time device sensing, online monitoring, early fault warnings, and online maintenance and protection. The application of the Internet, big data, and intelligent terminals can provide passengers with customized travel plans, real-time navigation, and ticketing services, thereby improving service quality. The exploration and application of a series of information technologies, such as automation, interoperability, and interconnection, will propel the development of urban rail transit into a new, automated, and intelligent development stage.

3.7 Self-Developed Technologies

The large development scale and diversified demands pertaining to urban rail transit have created a solid potential market for self-developed technologies. The implementation of the *Made in China 2025* Initiative has generated strong policy support for the creation of self-developed technologies. A large number of enterprises have made significant progress in developing their own technologies and creating Chinese brand equipment based on the demand of the domestic market, thus becoming the main driver of the progress of self-developed technologies. With increasing demand in the market, strong support from the government, and the rise of local enterprises, the development of the urban rail transit industry in the 13th Five-Year Plan period will shift from “localized” to “self-developed” technologies and equipment, thus achieving

independent breakthroughs in innovation. Self-developed technology will become a major trend in industrial technology development.

3.8 Diversified Funding

Traditional fund-raising channels, which were heavily dependent on government investment, are unlikely to satisfy the immense capital demands of the large-scale development of urban rail transit in the 13th Five-Year Plan period. The developed market economy and the reform of investment and financing system have provided regions along the rail lines with favorable conditions for the comprehensive development and utilization of land, and absorption of social capital. Management’s awareness and owners’ abilities have been continuously enhanced. Property, commercial, and other resource management that depends on the urban rail transit system have undergone vigorous development, which will repay the development of urban rail transit system by significantly enhancing its capability. In addition, urban rail transit projects are suitable for the public–private partnership (PPP) model, as they tend to be government-led, nonprofit projects with large-scale investment, long construction cycles, and slow capital recovery. Cities such as Shenzhen, Shanghai, Lanzhou, and Urumqi have achieved satisfactory results and accumulated valuable experience in comprehensive property development and application of the PPP model. The industry is gradually exploring and has steadily charted a feasible path with divergent funding sources. In the 13th Five-Year Plan period, government support, social capital, business owner revenue, and overseas capital will be the key funding sources for the construction of urban rail transit. The financing of the construction and operation of urban rail transit will become increasingly more diversified.

3.9 Entering and Preparing for International Market

Currently, approximately 15 megacities (with a population of over 10 million) worldwide do not have urban rail transit systems. Many cities that do have urban rail transit systems are faced with the task of technological transformation and upgrades. Therefore, the demand in the global market remains substantial. China has 40 years of experience in providing economic aid exports for urban rail transit projects, 10 years of experience in commercial exports, and has achieved good results in contracted projects. These provisions of support include full systems of urban rapid transit (such as metro, light rail, urban express rail, trams), include all series (such as rolling stock, signaling traction), and involve all project stages (such as survey and design,

construction, operation, and supply of equipment), and cover all continents of Asia, Africa, Europe, America, and Oceania. Since the beginning of the 13th Five-Year Plan period, Chinese enterprises have successively undertaken a number of projects with international influence, including supply of metro and tram trains and light-rail projects for construction and operation. In particular, following its first international project for the light-rail transit service in Addis Ababa (Ethiopia), Shenzhen Metro has also been awarded for service on light-rail projects in Hanoi (Vietnam) and Tel Aviv (Israel). Since 2016, China Railway Rolling Stock Corporation (CRRC) has successively signed metro vehicle contracts worth USD 1.854 billion (RMB 12.7 billion), involving 1089 vehicles in Chicago, Boston, Los Angeles, and Philadelphia. This progress demonstrates that China's urban rail transit industry has the ability to participate in the global market. Driven by the OBOR strategy, the urban rail transit together with high-speed rail system in China will jointly become significant players in the global market during the 13th Five-Year Plan period.

3.10 Conducting Strategic Planning

Due to the rapid, large-scale, high-level, and influential development of urban rail transit, the industry's economic and social status has increased rapidly and has strategic significance. First, urban rail transit plays a fundamental role in the implementation of major economic and social tasks, such as upgrading the level of urban development and environmental quality, facilitating the travel people and raising their standards of living, achieving a harmonious and hospitable environment, stimulating urban vitality, promoting urbanization, and fostering optimized urban agglomerations. Therefore, the industry's strategic position in urban development has become more apparent. Second, as an urban infrastructure, the urban rail transit system is expected to become a new point of growth in the national economy and a special point of emphasis in infrastructure investment during the 13th Five-Year Plan period. It is expected to play a decisive role in boosting domestic demand and promoting steady growth under the new economic normal. As one of the strategic emerging industries and a key component of the Made in China 2025 Initiative, the urban rail transit industry plays an irreplaceable role in achieving breakthroughs in independent innovation and promoting the transformation and development of the industrial structure. All these roles highlight its strategic position in China's economic development. Third, with the implementation of the "Going Global" strategy, the combination of urban rail transit and high-speed rail systems will lead to the realization of more extensive interoperable and interconnected infrastructure both at home and abroad. To achieve the "Coordinated

Development of the Beijing-Tianjin-Hebei region," the efficient connection of urban railway lines is the core and foundation for the establishment of the "Beijing-Tianjin-Hebei Railway Region." The role of urban rail transit in the implementation of major national strategies is thus further strengthened.

Since the beginning of the 13th Five-Year Plan period, all regions have paid increasing attention to the development of urban rail transit and have strived to promote it as the "No. 1 Project" of urban construction. Moreover, a dozen cities have plans in motion to become "world-class" metro cities. The strategic position of urban rail transit is further highlighted in Tier I megacities, such as Beijing, Shanghai, Guangzhou, and Shenzhen, which already rank the world's leading metro systems in size. Summarizing, the development of urban rail transit in the 13th Five-Year Plan period will significantly enhance its position in urban development, economic construction, and national strategies.

4 Conclusion

By combining national development strategy and plans, current cutting-edge technologies, the adaptability of various urban rail transit modes, the development of industrial technologies, local finances, and investment and financing models, this article conducted an in-depth analysis of the opportunities and challenges faced by the development of urban rail transit during 2016–2020, the 13th Five-Year Plan period. Based on this analysis, ten major trends of development in China's urban rail transit over 2016–2020 were forecasted. Over 2016–2020, with the development of urbanization, approximately 100 million people will migrate to the cities and nearly 100 million new vehicles will be added on the roads. Urban development also requires a substantial increase in the proportion of travels by public transport, while 40 cities have ongoing urban rail transit projects and 80 cities are planning to construct urban rail transit systems. The joint effect of the five forces could facilitate a larger-scale development of urban rail transit. The relaxation of policies related to urban household registration, development of urban agglomerations and metropolitan areas, and construction of state-level new areas will generate an immense demand for the development of coordinated, multimodal urban rail transit systems. Internet Plus technology revolution will lead urban rail transit into a new era of intelligent and FAO development. The OBOR strategy will lead the development of urban rail transit industry in China toward the global market. However, it is only by cultivating qualified talent, expanding funding channels, and implementing preliminary preparation that it is more likely to control the development

progress of the urban rail transit industry in the 13th Five-Year Plan period.

More than 100 cities have formulated 13th Five-Year Plans for 2016–2020 urban rail transit construction, which will generate a new phenomenon of simultaneous construction of urban rail transit in 100 cities. New lines are simultaneously rising sharply. In 2016, the length of the newly added rail lines exceeded 500 km for the first time (525 km). A hundred cities working on and annually opening 1000 km urban rail transit will be soon realized with such an explosive growth. Based on this speed of development, by the end of 2020, more than 60 cities would have established urban rail transit systems, with the total length of operating rail lines reaching 8000 km. China would be one of the few countries in the world such a large-scale urban rail transit network in place and covering so many cities as well as with such a high growth in the operating lines. When handling such large-scale development, we should strive to the best of our abilities, but also act taking into consideration our limitations, take practical measures to guard against risk, and broaden our mindsets to achieve innovative development.

The differentiation in the development of urban rail transit between cities will become increasingly apparent over 2016–2020. Different cities will be at varied stages of development, thus requiring different modes of urban rail transit, and with different priorities. Therefore, it is necessary to create respective differentiated development goals and set priorities in accordance with the different development stages of each city, in order to promote the systematic construction of urban rail transit based on local conditions.

During the 13th Five-Year Plan period, China's urban rail transit system will be superior to that in other countries in terms of the number of networked cities, the scale of networks, and the speed of establishing networks. Hence, it is important to develop a systematic and network-oriented thinking, and to formulate network-based guidelines that provide standardized guidance for operations management and resource sharing.

Over 2016–2020, a new pattern will emerge within the urban rail transit industry in China, characterized by the coordinated and complementary development of multimodal rail transit systems (metro, monorail, urban express rail, modern tram, and low-to-medium-speed maglev transit). Therefore, guidance and planning requirements for multimodal development should be developed to promote the healthy development of the urban rapid transit industry.

The development of the urban rail transit industry in 2016–2020 will place higher requirement for industrial standardization. Hence, developing and expanding collective standards, establishing, and promoting standard systems, and vigorously improving project quality are top

priorities in following the trend of standardization reforms initiated by the government.

In 2016–2020, the exploration and application of a series of information technologies, such as Internet Plus, will lead the urban rail transit industry into a new era of automated and intelligent development. The application of such technologies will provide users with higher quality, safer, and more convenient services and offer technical support for more efficient and safer planning, construction, and operations.

With increasing market demand, strong government support, and rise of independent enterprises, the development of the urban rail transit industry in 2016–2020 will shift from “localized” to “self-developed” technologies, thus achieving breakthroughs in independent innovation.

Government support, social capital, business owner revenues, and even foreign capital will be the key funding sources for the construction of urban rail transit over 2016–2020. Financing for the construction and operations of urban rail transit will become increasingly more diversified.

Driven by the OBOR strategy, China's urban rail industry will further extend its participation in the global market and enhance its competitiveness over 2016–2020. The urban rail transit together with high-speed rail systems will jointly change the global market scenario.

In 2016–2020, such rapid, large-scaled, high-level, and influential development of the urban rail transit industry will significantly enhance its role in urban development, economic construction, and national strategies, and its strategic position will become even more prominent.

This article systematically presents the current development and future prospects of China's urban rail transit industry during the 13th Five-Year Plan and gives proposal on strategies and measures for its development. It aims to strike a chord in the sector and serves as a reference for the development of urban rail transit systems in China and other countries.

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