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Analysis of the "Standard" Problem of Urban Rail Transit

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Abstract

This paper deeply discusses the selection of "standard" of metro rail transit, aiming at analyzing the influence of different standard on the development of urban transit in metropolitan area and the existing problems. By means of literature review, industry norm analysis and actual case study, this paper compares the differences between the metro system and the national railway system in terms of operation efficiency, passenger experience, construction and operating cost, and discusses the adaptability of metro rail transit under different systems. It is found that the selection of metro rail transit system should consider many factors, such as urban planning, passenger flow demand, operation subject and technical platform compatibility. The conclusion points out that in order to promote the public transit operation of metro rail transit, it is necessary to break the barriers of technology platform, promote the integration of four networks, flexibly select operation subjects, improve the service level of metro rail transit, and better meet the convenient and efficient travel needs of residents in the metropolitan area.

Keywords

Metro Rail Transit; Standard Selection; Metropolitan Area Development.

1. Introduction

With the expansion of urban areas and the increase of population density, big cities have become the core of economic exchanges, and their economic ties with surrounding cities have been significantly enhanced, gradually forming a new model of metropolitan area with interactive development between central cities and surrounding areas. However, the central city and its surrounding cities are also facing increasing pressure in terms of transportation, energy and environment. The adoption of efficient and large-capacity rail transit system has become an effective strategy to solve these traffic problems.

In recent years, rapid progress has been made in key areas such as the Beijing-Tianjin-Hebei region, the Yangtze River Delta, the Pearl River Delta and Hubao and Okyu. Many domestic scholars have carried out some research on the adaptability of rail transit standards. Zhang Li [1] analyzed the selection factors of urban rail transit standards and considered the coupling relationship between direct and indirect influencing factors. Yang Xiaoyu [2] used analytic hierarchy process (AHP) to study the adaptability of tourism rail system. Zhou Huazhen [3] studied the adaptability of system system based on the conditions of S2 line in Xuzhou City. Song Weiwei [4] analyzed the passenger flow and speed characteristics of the line and established a multi-dimensional model. Xu Jiqing [5] analyzed the status quo, standard characteristics and adaptability of China's medium and low capacity rail transit system.

In the process of promoting the integration construction of metropolitan area and the integration development of urban and rural areas, urban rail transit has played an important role. In recent years,

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the state has issued a number of documents to promote the construction and development of metro rail transit

2. The "Standard" Issue of Rail Transit

The system of rail transit is a technical category involving vehicle selection, power supply technology, signal system and other hardware configuration. Why has it become a problem in urban development? There are several reasons for this:

(1) The desire to "get through the subway"

Once the subway sounds, housing prices are rising for the time being. From the pure point of view of transportation, the fast and punctual characteristics of rail transit make the road vehicles trapped in congestion envious, and become the preferred way of travel for many office workers. The newly built conventional subway lines extending to the outer suburbs (such as Shanghai Line 9, Line 11, etc.), although the travel time is longer due to the long line and many stations, it brings a stable, efficient and convenient way to travel for residents along the line. Therefore, when the new wind of rail transit blows, "subway" has become the common pursuit of residents living in non-core urban areas.

(2) The current situation and problems of suburban trains operated by national railways are the opposite of the "subway" system, which is the "national rail system". At present, the suburban trains operated by national railways are divided into two categories: using existing railways and newly built lines.

The use of existing railway suburban trains started very early in China, such as Fushun electric Railway, Shanghai Jinshan suburban train and so on. In 2012, the Jinshan Railway, which opened after the renovation and upgrading of the original Jinshan Branch Line, opened the prelude of the new era of suburban trains using the existing railway. This mode mainly adopts local subsidies and entrusts railway departments to operate daily passenger services. Passengers can experience the ride experience similar to urban rail transit, such as swiping urban public transport cards and special entrance and exit channels. Up to now, the model has been promoted to Ningbo, Shaoxing, Lianyungang and other cities, making full use of the idle railway capacity, while providing convenience for residents along the line.

The new national railway operation typical commuter trains such as changzhutan intercity railway, the pearl river delta intercity, compared to the main high speed railway, the line selection further consider the needs of the villages and towns, site Settings and more close, for unified management, ticket and continue to use conventional railway mode.

After a period of operation of the project, some problems in the suburban line mode of national railway operation have gradually been exposed, mainly as follows:

1) Sharing line resources with other trains, the scheduling operation is dominated by the railway department, and the timetable is unstable and constantly changes with the adjustment of the national railway operating chart, so passengers have to adjust their travel habits frequently

2) The train departure density is not satisfactory, and it cannot follow the train.

3) Some lines follow the national railway ticket sale and inspection system and waiting system, which can not meet the needs of public transportation operation.

4) When the existing railway is used to run suburban trains, because the railway line has been fixed, it is impossible to carry out large-scale reconstruction and optimization according to the passenger flow demand along the line, and there is a common problem of station connection.

The above problems have become the reason why the urban line mode of National railway operation (the so-called "railway system") is generally popular but not popular.

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3. Industry Norms

3.1 Classification of Urban Rail Transit (T/CAMET 00001 -- 2020)

This specification is compiled by China Urban Rail Transit Association. According to the code, urban rail transit is classified based on five factors: transportation capacity, space scope, right-of-way form, design maximum speed and system standard.

(1) According to the division of space scope, urban rail transit can be divided into urban rail transit and urban rail transit. Urban rail transit mainly serves a variety of travel purposes such as official business, commuting (study), tourism and leisure within the city or metropolitan area; It mainly serves the passenger flow demand of the connection between the urban area or the peripheral area of the metropolitan area and the central urban area, and the main line is mainly located in the urban area or the metropolitan area outside the urban area

(2) According to the design of maximum speed classification

Table 1. Classification of urban rail speed grades

Classification Names		Design maximum speed (km/h)
Rapid rail transit	A	>120
	B	100 ~ 120
Universal speed rail transit		<100
The design maximum speed of urban rail transit should be selected in 60km/h, 70km/h, 80km/h, 100km/h, 120km/h, 140km/h, 160km/h, 200km/h speed classes. Note: The rapid rail transit is also called the express line, and the universal speed rail transit is also called the general line.		

According to the system classification: there are a total of subway system, municipal rapid rail system, light rail system, medium and low speed maglev transit system, cross-seat monorail system, self-guided rail system, tram system, guided wheel system, electronic guided wheel system ten standards, now show the subway, municipal rapid rail system related information.

Table 2. Comparison of technical characteristics of urban rail

Classification Name	Technical features					
	Transport capacity (passenger per hour)	Design maximum speed (km/h)	Right-of-way form	Laying method	Vehicle type	Maximum length of train (m)
Subway system	≥30000	80 ~ 120	Fully enclosed	Underground or above ground	A, As, B, L	185
Metro Express rail system	≥10000	120 ~ 200	Fully enclosed	Ground based	City A, City As, City B, City D	185
Light rail system	15000 ~ 30000	80 ~ 120	Fully enclosed	Ground based	B, C, Lc	100
	10000 ~ 15000	70	Partially enclosed	Ground based	C, Lc	75

3.2 Design Standard for Urban Rapid Rail Transit CJJ/T314-2022

(1) Definition:

urban rapid rail transit: Urban rapid rail transit: The maximum operating speed is 120km/h~160km/h, the travel speed is 45km/h or above, the rapid rail transit line using electric traction, the train runs on

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the completely closed line, combined with the urban planning and construction along the line and the environment using underground, ground, elevated and other different laying methods.

(2) About the vehicles:

The model is A, B, D type car in the city, the design speed is 120km/h~160km/h, the power supply system is Ac25kv/DC1500V/DC3000V.

(3) About operation

During the initial peak period, the minimum operation interval of urban or main line should not be less than 10 pairs /h, and the group or branch line of urban periphery should not be less than 5 pairs /h, and should be adapted to the operation interval of each line after network operation. The minimum operating interval of urban or main line should not be less than 6 pairs /h, and the minimum operating interval of urban peripheral group or branch line should not be less than 4 pairs /h

3.3 "Urban (Suburban) Railway Design Code" TB 10624-2020

(1) Definition: Urban (suburban) railway is a transit, large volume, fast and convenient rail transit system that connects the central urban area with the surrounding urban groups and between the urban groups. It is an important part of the urban comprehensive transportation system.

(2) About the vehicle

a. City Type A cars

The basic technical standard of Type A car comes from Siemens subway vehicles imported by Shanghai Metro in the last century, which is one of the recommended models in GB/T 50157 "Subway Design Standard". In addition, the vehicle basic technical standards of Type A car in the city are the same as those of type A car, which is one of the recommended models in TB 10624 "Urban (Suburban) Railway Design Standards". The basic technical standards are as follows:

Body length: 22000mm;

Basic width of car body: 3000mm;

Floor height: 1130mm;

Body height: 3800-3850mm;

Vehicle distance: 15700mm;

Fixed wheelbase: 2300-2500mm;

Classic line: Shanghai Metro 1; Line 2 Shanghai Metro; Guangzhou Metro Line 1; Line 18 Chengdu Metro (AC25kV).

b. City Type B train

The basic technical standard of Type B car is improved from the early Beijing subway vehicles, and is one of the recommended models in GB/T 50157 "Subway Design Standard". In addition, the basic technical standard of the city type B car is the same as that of the City type B car, which is one of the recommended models of TB 10624 "Urban (suburban) Railway Design Code", the basic technical standards are as follows:

Length of vehicle body: 19000mm;

Basic width of car body: 2800mm;

Floor height: 1100mm;

Body height: 3800-3850mm;

Vehicle distance: 12600mm;

Fixed wheelbase: 2200-2300mm;

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Note that Beijing Metro Line 1, Line 2, Line 13, Batong line is not using the above standard B car, the basic width of the car body is only 2600mm, the height of the car body is slightly low, the classic use of lines: Guangzhou Metro Line 3, Hohhot Metro line 1, line 2.

c.A Model car

As is A customized model for Chongqing rail transit, s stands for mountain type, all known as mountain city Type A car. This model does not belong to the standard recommended model

Body length: 19000mm;

Basic width of car body: 3000mm;

Floor height: 1130mm;

Body height: 3980mm;

Vehicle distance: 13400mm;

Fixed wheelbase: 2200mm;

The use of classic As car line: Chongqing Rail Transit Line 5 Chongqing Suburban railway Jiangtiao line (double current power supply).

d. Type C car in city area

Its basic technical standards come from the intercity EMU of China Railway (such as CRH6, CJ1, etc.). This model is one of the recommended models of TB 10624 "Urban (Suburban) Railway Design Code". The basic technical standards of urban C car are as follows:

Length of car body: 25000mm;

Basic width of car body: 3300mm;

Floor height: 1260-1280mm;

Body height: 3900mm;

Vehicle distance: 17500mm;

Fixed wheelbase: 2500mm;

In the full longitudinal seat layout, the city C car has the highest standing area among all the models in this paper, so this model is also the model with the highest passenger capacity per car among all the models in this paper. The number of people standing in A single station under the AW2 standard is 1.244 times that of the Model A, and the total passenger capacity (standing + seated) in a single car under the AW2 standard is 1.258 times that of the Model A. Classic lines: Shanghai Municipal Railway Demonstration Zone line; Shanghai City railway airport liaison line.

e. City Type D train

Its basic technical standards combine the intercity EMU and Type A. The model is one of the recommended models in the TB 10624 Urban (Suburban) Railway Design Code. The basic technical standards are as follows:

Body length: 22000mm;

Basic width of car body: 3300mm;

Floor height: 1260-1280mm;

Body height: 3900mm;

Vehicle distance: 15700mm;

Fixed wheelbase: 2500mm;

Classic lines: Guangzhou Metro Line 22; Beijing Metro Line 22; Chongqing Suburban Railway Bi Tong Line.

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(3) About operation

Relevant regulations have been made on the two modes of new lines (which are not necessary for national railway operation) and the use of existing railways. Due to the large space, only the highlights are selected:

a. Train formation shall comply with the following provisions:

The train formation of urban (suburban) railway shall be determined according to the forecast passenger flow, vehicle capacity and transportation organization plan after technical and economic comparison, and the number of train formation shall not be more than 8;

When the existing railway is used to run the urban (suburban) train, the train formation shall be determined according to the predicted passenger flow, existing equipment and facilities and passing capacity comparison.

b. Train running intervals shall comply with the following provisions:

The initial peak period should not be more than 10min, the peak period should not be more than 15min; Long-term peak period should not be greater than 4min, peak period should not be greater than 10min;

When the existing railway is used to operate the urban (suburban) train, the average train running interval should be determined according to the existing railway capacity surplus and passenger flow demand, and the peak period should not be greater than 15 min, and the peak period should not be greater than 30min.

3.4 Analysis of Key Information

The regulations from different industries have both intersection and discrepancy with respect to the provisions of metro rail transit. As can be seen from the Urban Rail Association's description of urban rapid rail systems, it covers higher design speeds (200km/h), but does not include urban rail vehicle systems that meet national rail standards (Urban C cars, also including the CRH6 urban type). The Design Standards for Urban rapid Rail Transit and the Design Code for Urban (suburban) Railway come from different industries, and there are many overlapping points in the description of urban rail transit. The difference is that the latter also includes lines that meet the national railway standards and the mode of utilizing existing railways. It should be pointed out that the above specifications from different industries all believe that urban rail transit/urban (suburban) railway should carry out public transit operation. In addition, the specifications do not restrict the main operators of urban rail transit. The vehicle technology platform and the operator should not be the restricting factor of whether a line can provide public transit operation service.

4. Existing Cases and Analysis of Urban Rail Transit

4.1 Urban Rail Transit Construction Planning Reporting Cases

The recent construction plan of Shanghai Rail Transit (2017-2025) includes nine lines: Line 19, Line 20 phase I, Line 21 phase I, Line 23 phase I, Line 1 West Extension, Line 13 West Extension, Jiamin Line, Airport Link Line and Chongming Line. In addition to the traditional subway system of 19, 20, 21, 23, 1 extension and 13 extension, Jiamin Line and airport link line adopt the CRH6 platform of the national railway system, and Chongming Line adopts the city type A train.

This plan in Shanghai is the first time that the urban rail transit construction plan includes lines other than the traditional subway/light rail system, which also provides ideas for diversified approval channels for urban lines.

4.2 Cases of Existing Urban Rail Transit Operating Models in China

According to the current situation in China, the operation of urban rapid rail transit mainly consists of two modes: local self-run and railway operation, and the technology platform used has covered urban area A, B, D, railway area C and even idle passenger cars, etc. At present, it has presented a diversified development situation. The main operating cases are shown in Table 3.

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Table 3. Comparison of urban rail in operated cities

	Operating subjects	Vehicle platform	Marshalling (section)	Design speed (km/h)	Number of running times (pairs/day)
Beijing sub-center line	National Railway Operation	CRH6A (Jingtong)	8	160	6
Shanghai Line 16	Local self-run	City-owned Model A car	3/6	120	190
Shanghai Jinshan Railway	National Railway operation	CRH2A, CRH6F	8	160	30
Suburban trains in Haikou	National railway operation	CRH6F-A	4	160	61
Canton Line 18	Locally-owned	City Type D car	8	160	>100
Guangqing, Guangzhou east ring intercity	Local self-management	CRH6	8	200	42
Chang-zhu-tan Intercity	National Railway operation	CRH6, CJ6	4/8	160	100
Line 18, Chengdu	Locally-owned	City Model A	8	140	>100
Nanjing Line S9	Locally-owned	City-owned B cars	3	120	70

Note: 1. The number of operating lines is constantly changing with the adjustment of the operating chart, this article only takes the recent higher level

Based on the operating modes and technical standards in the above table, the following permutations and combinations of the operating modes of urban rail transit can be made:

(1) National railway operation, the use of existing lines;

(2) National railway operation, new lines (connecting to the national railway network);

(3) local self-support, new lines (urban rail standards, not connected to the national railway network);

(4) local self-support, new lines (national railway standards, can choose to connect to the national railway network)

4.3 The Relationship between the Number of Trains and the Operating Subject

In general, the number of lines operated by the current national railway is generally lower than that of local self-operated urban rail mode lines, but it is not absolute. For example, the number of daily operation of Changzhuzhou-Xiangtan intercity railway exceeds 100 pairs, and the number of weekend operation of Haikou suburban train reaches 64 pairs, which has approached or even surpassed the number of self-operated urban rail transit in some other cities. For the general public, it can be regarded as a mode of rail transit.

4.4 Local Self-run Railway System

The analysis of industry norms has shown that there is no strict binding relationship between the system of urban rail transit and the operating body, which is further confirmed by 3.1. Simply put, the local rail transit enterprises need to set up a complete, in line with the standard railway transport technology system, apply for the railway passenger transport permit, you can become a national railway standard line operation qualification of the "railway transport enterprise", this practice has

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been successfully practiced in Guangzhou. Guangdong Intercity Railway Operation Co., LTD., a wholly-owned subsidiary of Guangzhou Metro (commonly known as "Sheep's horn"), has successfully operated Guangqing and Guangzhou East Ring two pure intercity railways of national railway standards, and will undertake more intercity lines in the Pearl River Delta in the near future. In the future, Shenzhen Metro and Shanghai Shentong Metro will follow suit and undertake the operation of urban/intercity railway projects in the city or surrounding areas.

Four-network integration and interconnectivity is not a concept that can only be realized in the distant future. Compatibility on the technology platform is the basis of integration and interconnectivity. Perhaps with the passage of time, the relevant technical and institutional restrictions will be solved one by one. In the future, local autonomous urban/intercity trains will interconnect with the national railway, bringing more travel choices to the people, and the urban circle on the track will no longer be just a term. At the same time, it must be objectively acknowledged that through independent operation of lines, local areas can indeed have greater autonomy in ticket sales and inspection services, waiting organization, schedule scheduling and other aspects, and provide more flexible and rich travel services. For example, Jiamin Line and airport liaison line of Shanghai will be connected with national railway and urban/intercity railway of surrounding cities, and have the conditions of stopping national railway EMU, and its daily operation will be similar to the existing urban rail transit network, which can be used as a key project of four-network integration, for reference and reference in the future.

5. Summary

The struggle between "railway system" and "subway system" is based on people's longing for convenient and efficient transit rail travel. No matter what kind of technology platform is adopted, providing passengers with bus travel experience should be the goal that operators strive to pursue, and it is realistic to achieve at present. Recently, Hohhot Shengle Airport rail transit is also in the pipeline.

With the promulgation of the Measures for the Management of Municipal Infrastructure Assets (Trial), under the new policy environment of "suspending large-scale infrastructure projects", the subway line construction of Hohhot Shengle International Airport is facing challenges. However, given that Shengle International Airport is located in the core area of Hubao Eyu city Circle, its integration into the regional rail transit network is particularly critical. Considering that Hohhot Metro has adopted B-type vehicles, in order to maintain technical consistency and system compatibility, it is particularly reasonable to choose B-type vehicles as the optimal scheme for vehicle selection and system integration. This scheme can not only effectively promote the seamless docking of urban rail transit and metro system, but also significantly improve the overall efficiency and interconnectivity level of urban transportation, which has far-reaching significance for optimizing the urban transportation planning of "Hubao Eyu" urban circle.

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