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Analysis of Hangzhou Metro Planning from the Perspective of Sustainable Development

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Abstract

With the urbanization and economic development, the urban population is increasing. In this way, a growing population leads to an increasing demand for travel. The city has been improving its public transportation system to reduce the pressure of urban traffic. Taking Hangzhou metro as an example, this paper analyzes the current planning status of Hangzhou metro, the existing problems, and the corresponding suggestions. It also proposes that intelligent transportation is one of the ways to achieve sustainable urban development, which requires the use of information technology to plan and improve urban transportation.

Subject Areas

Technology, Urban Planning

Keywords

City Traffic, Metro Planning, Intelligent Transportation

1. Introduction

From the perspective of the city's overall interests, public transportation is an efficient and cheap mode of transportation, which has irreplaceable advantages compared with private transportation. Among the public transportation, the metro has the advantages of large capacity, high speed, pollution-free, on-time and comfort, making it a preferred choice for many developed cities. As public transportation continues to improve the service level, it will certainly occupy a dominant position in urban transportation.

Through the social observation and interview survey by living in Hangzhou for many years, and comparing the metro layout of Shanghai and Beijing, the author finds some problems in the planning of Hangzhou metro. The author al-

so hopes that the discussion in this paper will provide some suggestions for Hangzhou metro planning and provide reference for similar cities' public transportation.

2. The Importance of Proper Planning and Development of the City Metro

Public transportation, especially the planning and construction of the metro, has a key impact on the development of urban. First, the metro stations affect the development of commercial areas. In China city, large commercial centers are certainly located at the intersections of several metro lines, and malls will be formed at some separate metro stations. This is because the metro has a larger passenger carrying capacity than other public transportation. It can gather a large number of people in a short time, thereby increasing the economic value of a specific area. Several major commercial centers in Hangzhou are currently located in the Wulin Square of West Lake District. There are five subway stations nearby and two largest subway lines 1 and 2 intersect in this area (Figure 1). The most famous shopping mall is Hubin Mall In77. In 2018, the passenger flow exceeded 60 million and the revenue reached 4.5 billion (Financial News, 2019) [1].

Second, the planning of the subway affects the form of urban. The planning of the metro often represents the geographical direction in urban development. The metro connects the relationship between the surrounding areas and the center, and convenient public transportation promotes integrated development. It is helpful to build a network structure with the central area as the core, and the central area with the sub-central area can reasonably allocate city functions, realizing multi-center development goal.

Third, the metro meets the goals of urban sustainable development. The mission of a transport plan is to design a system that fulfills its role in society in a useful, efficient and effective way. This includes not only its internal efficiency,

Figure 1. Partial Hangzhou metro line map in 2020. Source: Hangzhou Metro https://www.ditietu.com/dir-10.html.

but also its role in social equity, spatial development and environmental protection (Schiefelbusch, 2010) [2]. Due to the huge carrying capacity of the metro, it can encourage the reduction of private transportation and alleviate the congestion of public transportation on the road. Besides, the level of pollution emission of the subway is low. It also helps improve the use of land resources, developing a new metro economic model. Therefore, it is important to plan the development of the metro reasonably to improve the urban environment and quality of life.

3. Problems in Hangzhou Metro Planning and Layout

As mentioned above, the construction of the metro will involve changes in land prices, the interests of commercial centers, the travel of residents and the development of blocks. The areas through which subway lines pass can not only meet the needs of transportation, but also realize the economic growth. This is a multifaceted game process. There is no doubt that most people hope that subway stations will be built in front of their homes, while too many subway stations will cause waste of resources. Besides, the construction of metro between districts also involves an interest game among district governments, because the surrounding areas want to connect with the central area for faster development. Such challenges have always existed in the planning of Hangzhou Metro.

Hangzhou Metro is the rail transit system in Hangzhou, Zhejiang Province, and it is the first metro line in Zhejiang. However, the density and the length of the metro cannot meet the needs of travel in Hangzhou city. As a quasi-first-tier city, Hangzhou has a population of more than 10 million and a large migrant population. The daily commute needs are very large, but the development of metro in the past was not very fast, and mainly depended on buses and private transport. This has brought the pressure of rail transportation in recent years. According to the China Metros' analysis report, Hangzhou ranks 17th in metro length in 2018, which is lower than Suzhou and Shenyang, far from Shanghai and Shenzhen. The rail traffic in Hangzhou still lags behind the growth of urban scale and the level of economy.

Second, the order of planning and construction is not scientific enough. In some area, population density does not match carrying capacity. The section of Line 1 (the red line in **Figure 2**) towards Linping District has few passenger flows, but priority is given to construction. In the first year of opening, the passenger flow is significantly lower than the estimated amount (Shen, 2018) [3]. It leads to the waste of resources and reduces operational efficiency. However, the construction of metro in the old district with dense population and traffic congestion has been delayed. Besides, the "Future Science and Technology City" in the northwest of Hangzhou has a large number of technology companies and industrial parks.

Third, the density of metros on the east side of West Lake is high, while there is almost no metro on the west side of lake. In the central area, multiple lines

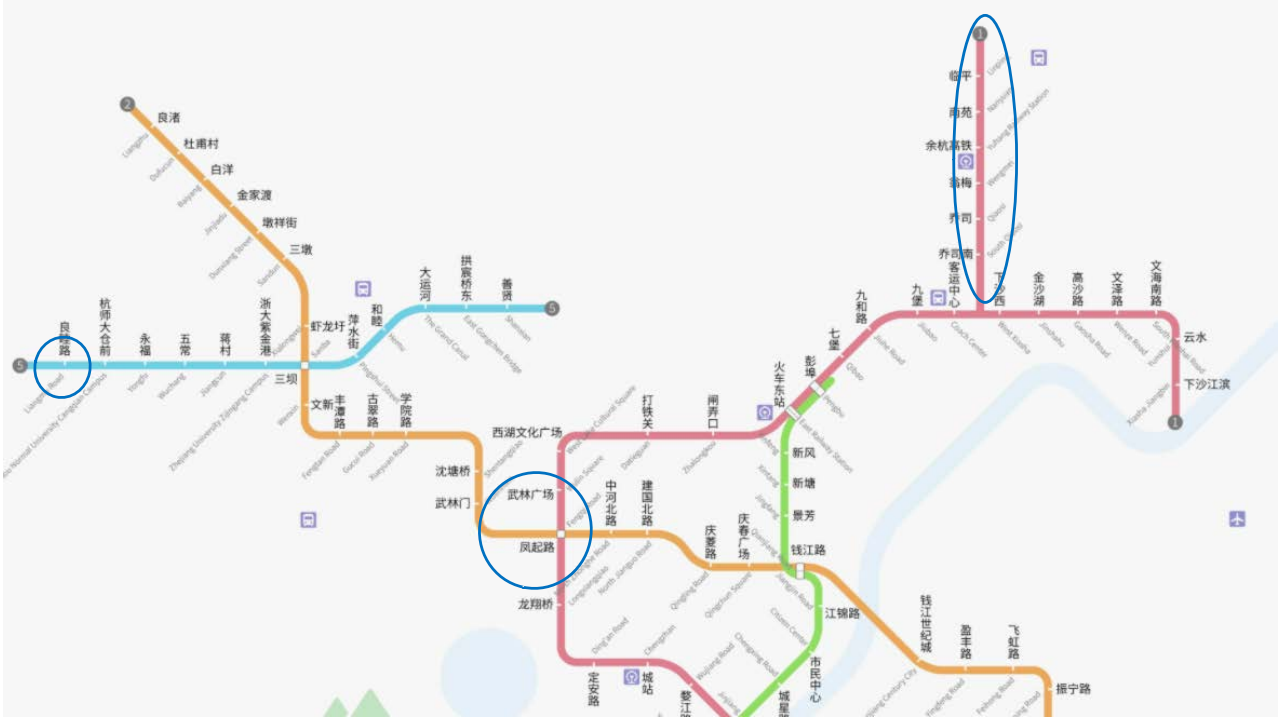

Figure 2. Hangzhou metro line map in 2020. Source: Hangzhou Metro https://www.ditietu.com/dir-10.html.

converge, and multiple subway stations are concentrated. Meanwhile, the development of commercial areas and the multiple interchange stations in Wulin district lead to a particularly huge flow of people. Although the profit of the commercial center is guaranteed, it also causes heavy transportation pressure, and has brought about a bad travel experience for passengers.

Forth, the design of the subway lines is tortuous, for there are many transfers, and the travel time is increased. The transfer point of Line 2 and Line 5 is the Sanba Station. However, the starting and ending points of Line 5 are closer to Wenxin Station, which will increase the travel distance. What's more, when transferring from other lines to the train station, there are few lines can go straight. In many cases, the time taken by metro is much longer than private transportation. For example, from the starting station of Line 5 Liangmu Road Station to East Train Station, the metro takes about 1 hour (including transfer time), while private transportation only takes 30 minutes. As a result, the convenient public transportation no longer exists. Obviously, when government planned for the metro, it considered to go through as many locations as possible, but did not achieve high efficiency and convenience.

4. Government and Groups Practices

The Hangzhou government plans to add nine new subway lines by 2022, which will ease the pressure on public transportation. The new Line 3 and Line 6 will mainly connect places far from the main city in the east-west direction. Line 7 extends from the central area to the southeast and mainly connects Xiaoshan

District. Line 8 is an extension of Line 1 and also connects Xiaoshan District. Therefore, Xiaoshan District will be one of the key areas for metro construction. Line 9 runs through several subway stations along the Qiantang River and extends towards Linping in the northeast side of Hangzhou, connecting the suburbs. The north-south direction of Line 10 is short, from Zhejiang University to Yuhang District.

These newly added subway lines form a dense public transport network in Hangzhou's urban area, covering almost all areas and important locations. These new metros greatly increase the transportation capacity of public transportation, improve travel efficiency, and strengthen the flow of people in various districts. Besides, it is worth noting that there are multiple intercity metros connected to the new subway lines, and the surrounding areas are included in the integrated development of the metro.

Lin'an District on the west side changed from Lin'an City to Lin'an District of Hangzhou in 2017, which would ease the land tension in Hangzhou and also provide favorable land and policy conditions for the construction of the subway. Fuyang District, also on the west, became a part of the Hangzhou area earlier. But when no metro was built, this district was more like a separate county. The transportation to Hangzhou's main urban area mainly relies on private transportation, and public transportation is inefficient. Lin'an Line and Fuyang Line address public transport in the western suburbs. Lin'an Line is connected to Line 3 and Line 5, avoiding transfer to other transportation. Fuyang Line is connected to Line 6.

In addition, the Haining Line and Keqiao Line on the east side connect Jiaxing City and Shaoxing City respectively, which will strengthen the communication between Hangzhou and the cities on the east side.

5. Possible Challenges

Hangzhou is in the peak period of rail transit construction, and will build metros at a faster speed and a larger scale in these years. There is no doubt that this plan will improve public transport, but there are many challenges.

First, the time to evaluate subway investment options is limited. The government finance will face tremendous pressure. Although Hangzhou's private capital is strong, there is no suitable investment and financing model to encourage private capital to join. Furthermore, the initial investment in metro construction is large, and capital needs to bear high risks. Thus, it is difficult for capital other than financial funds to participate in urban rail transit project construction. Hangzhou will still rely on government financial investment and bank loan payments. Obviously, this way is difficult to meet the capital needs of the future development of rail transit (Zhu, 2016) [4].

Besides, system design, system implementation and process control need more scientific planning. The intersection of multiple subway lines will lead to excessive crowding, which may exceed the carrying capacity of the station management.

Especially in some period, this situation will affect the commute efficiency. What's more, engineering accidents are also prone to occur during the construction, such as collapse. Also, there may be a large gap between the predicted traffic flows and the actual situation, leading to challenges in resource allocation and management. Thus, the planning of metro needs to be continuously adjusted according to actual conditions, which requires professionalism, coordination, and sustainability.

6. Possible Reasons

The main reason for these problems is that the speed of social and economic development exceeds the speed of construction of public transportation. According to the Hangzhou Statistical Yearbook (2019), Hangzhou has achieved a GDP of 1350.92 billion yuan in 2018, an increase of 6.7%. At the same time, from 2012 to 2018, Hangzhou's registered population increased by 740,000. In 2018, Hangzhou's total population reached 7.74 million, of which 5.15 million were urban residents. Meanwhile, in 2012, Hangzhou Metro Line 1 began operation, with an operating mileage of 54 kilometers and a passenger volume of 5.61 million passengers. In 2018, the total length of metro lines was 117.6 kilometers, and the annual passenger traffic was 530 million. Otherwise, Hangzhou's bus traffic has reached 1.32 billion passengers in 2012 and increased to 1.59 billion passengers in 2018. It can be inferred that buses are still the main force of public transportation in Hangzhou, and the transportation volume of the metro cannot meet the flow of people in some areas. Thus, the development speed of the subway lags behind the growth rate of public transportation demand.

According to No. 13 Document of the Central Government of China, the Xiaoshan District and Yuhang District officially became the urban areas of Hangzhou in 2001. After that, the government vigorously developed these two districts, established an international airport in Xiaoshan, and established a number of science and technology parks in Yuhang District. According to the statistical yearbook (2019), the population of Xiaoshan District in 2018 was 1.32 million, and the population of Yuhang District was 1.1 million, which were the two most populous areas in Hangzhou. What's more, according to the government talent policy plan of Yuhang District in 2018, the goal was to attract 320,000 talents to move to Yuhang in 2020. The rapid development of these two regions has led to a rapid increase in population. Compared with the population of 740,000 in the West Lake District, the demand for transportation in both places has grown rapidly. However, there are currently only two subway lines to Xiaoshan, and one subway line to Yuhang was just opened in 2019. Therefore, the density and destination accessibility of the subway cannot meet travel needs.

The most obvious problem is that the metro lines are intertwined and there are many overlapping areas. For example, on the south side of the West Lake District, Line 1, Line 5 and Line 7 are intricate and interchange stations are concentrated. Besides, there are also four subway lines on the north side of the West Lake District, which greatly increase the complexity of transportation. What's more, there are many overlaps in the newly built subway lines in Yuhang Dis-

trict.

Compared with Beijing and Shanghai, where the subways are mostly distributed in straight lines and complete circles, Hangzhou's subway line needs to be built along the river. It is obvious that Hangzhou's geological condition has influenced subway planning. By collecting news reports, since the construction of Hangzhou Metro, six water seepage and collapse accidents have occurred, which poses challenges to the future construction of Hangzhou metro. Moreover, the layout of the subway will be affected by different interest groups, including real estate groups, commercial groups, governments, and residents. Especially, the construction of new subway lines has become one of the important signs of land price changes. For example, according to the information of the real estate company, the price of Linping subway station in 2017 has reached 20,000 yuan per square meter, while the price of the Cangqian, also in the north of Hangzhou, used to be 8000 yuan per square meter. After planning the Cangqian subway station, the nearby house prices quickly rose to 20,000 per square meter. Thus, all regions will strive for the construction of subway stations. But these human factors are difficult to reflect in the policy.

7. Some Suggestions for Hangzhou Metro

At present, the daily passenger flow of Hangzhou metro exceeds 2 million (China News, 2019). It is necessary to increase the number of metros, and use the metros to provide direct passenger service to destination.

Firstly, Hangzhou focuses on the technology industry and tries to build a smart city. The metro system could use traffic big data to conduct the multi-level transportation network evaluation, which will help to support the formulation and adjustment of management policies. In addition, metro managers can choose to study the characteristics of passengers through information platform and can arrange priority to the densely populated areas. Such as the Linping Line, the current passenger flow is less than other subway lines, so that other lines, especially Line 5, Line 7, and K1 Line can be prioritized for development. For according to the development plan released by the Hangzhou government, the northwest direction of Hangzhou will be the first to develop the future technology city, attracting a large number of technology companies. Besides, the area will also build new railway stations, and the traffic volume will grow rapidly. What's more, according to the 2019 Hangzhou Statistical Yearbook, Xiaoshan District has the largest number of industrial enterprises, with 1575 units in 2018. Also, the largest international airport in Hangzhou, Xiaoshan Airport currently has only buses without subways. When planning the metro network, it should be consistent with the main passenger flow direction, as far as possible to improve the accessibility and transportation efficiency of public transportation (Ren, 2019) [5].

Secondly, the intercity rail should provide fast and direct service between the city center and surrounding towns. Department could consider to form a rail transit network to connects nearby counties, especially Tongxiang, Deqing, Anji, Tonglu, Zhuji. These counties are closely communicating with Hangzhou, and traffic flow is heavy, especially daily commuting. In addition, the government should improve

the connection between the rail transit system and other public transportation to reduce the time consumption outside, such as the waiting time, or the exchanging time. For instance, when there is no intercity subway or subway transfer is inconvenient, if passengers travel from Alibaba company to Anji county, they must first take public transportation for 1.5 hours to the bus station on the east side, and then choose bus to the destination on the west side, totally 3 hours. However, if passengers drive private cars, it only takes 50 minutes. Therefore, it is critical to improve the efficiency of transfers.

Thirdly, in the construction and operation stage, the interests of the government and social capital need to be balanced. In order to ease financial pressure and encourage social capital to participate in operations, it is recommended to adopt the Public-Private Partnership model (PPP). The cooperation between the government and the enterprises will improve the efficiency of resource allocation based on market and reduce risks. What's more, as the initiator of the PPP project, the government always expects to maximize social benefits, while social capital is focus on investment benefit. Besides, the government needs to formulate a reasonable cooperation plan, and subsidize some funds or resources to support companies. Otherwise, the government and companies should attach great importance to the construction risks and geological safety issues in the rapid development of the current subway construction. Managers should evaluate the geological risk more completely before construction, and make emergency plan during construction.

Lastly, after the metro is completed and operated, operators need to improve the management and services of supporting facilities. Urban catalyst theory believes that injecting new development elements into cities will bring a series of chain developments to cities. Because of subway stations, the construction of surrounding transportation facilities will be promoted. In addition, the facilities and services during the subway travel need to be constantly updated. The flow of people should be guided. Managers can guide and control the traffic demand from the four dimensions, total quantity control, space balance, time balance, and structural optimization, to form a precise management policy (Wang and Chen, 2019) [6]. In order to meet the diversity of residents' travel needs, more data needs to be collected in the design of subway lines.

8. Conclusions

The planning of Hangzhou metro lags behind the speed of economic development, and is affected by topography and other factors, resulting in some confusion in metro planning. It hopes to achieve sustainable development through intelligent transportation.

The goal of China's intelligent transportation development is to make full use of new information technologies such as mobile Internet, data computing, and artificial intelligence to achieve the coordination of urban development. Then, managers should make an intelligent response to various personalized activities and logistics needs of people, helping to realize the intelligent operation of the city,

and ensuring the sustainable development of the city (Quan, 2018) [7].

The complexity of urban transportation is that the planning and engineering design have clear deadlines, while urban expansion and renewal are a continuous process, and the effects of construction continue for a long time. The previous urban transportation theory believed that the development of public transportation was passive to meet the needs of passengers. Differently, intelligent transportation focuses on data, intelligent technology and the sharing economy, actively guiding the demand (Ji, 2016) [8]. Moreover, intelligent transportation builds a scientific and orderly transportation network. It faces both long-term facility construction and short-term or real-time management and regulation. There is no doubt that intelligent transportation is more suitable to current cities, and it is also the evolution direction of public transportation.

Metro construction is part of urban spatial planning. In the process of smart transportation construction, the Hangzhou government should lead the role of overall planning and coordination, which includes designing an effective system, coordinating the daily work, ensuring public security, big data management and cooperating with other departments (Shi, 2019) [9]. Modern information and communication technologies must be used to evaluate the interactive development of transportation and cities, as well as changes in influencing factors.

In a word, intelligent transportation is to use technology to rationally allocate social resources, balance efficiency and fairness, and realize the sustainable development of urban transportation. It hopes that Hangzhou will plan the metro according to the social demand, and establish a comprehensive urban transportation system with clear levels and reasonable functions based on the urban development pattern. What's more, Hangzhou will regard rail transit as trunk, hub system as the conversion node, and combine multiple public transport to form a multi-layer network. In addition, the city will strengthen ties with surrounding areas and build a public transportation system for city clusters, achieving regional sustainable development.

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Conflicts of Interest

The author declares no conflicts of interest.

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