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# Solutions to the Declining Bus Passenger Volume in Chongqing

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**Abstract:** To ease the downward trend in bus passenger volumes and improve bus system's level of services, this paper discusses the solutions to the decline through a case study in Chongqing. By exploring the data from four big information sources, including operation, services, safety, and maintenance, of bus system, the paper introduces the development of a big-data-integrated analysis system that can strengthen the capability of data analysis and simulation and transform the traditional coarse management style into the refined digitalized management and decision-making process. The paper demonstrates how to enhance transfer serviceability between bus and rail transit through optimizing the bus networks along rail transit lines and increasing or renovating bus stops. Focusing on arterial express bus and community bus lines, we establish a multi-level bus network to promote effective and convenient travel of residents. These techniques are helpful in improving the quality of bus travel and increase the attractiveness of bus service. **DOI:** 10.13813/j.cn11-5141/u.2019.0604-en

**Keywords:** bus; passenger volume; data analysis; traffic simulation; detailed management; Chongqing

## 0 Introduction

In recent years, China has vigorously promoted the development of public transportation and issued several policy documents, such as *Opinions of The Ministry of Construction on Prioritizing the Development of Urban Public Transportation* (urban construction [2004] No. 38), *Outline of the 13th Five-Year Plan for the Development of Urban Public Transportation*, and *Outline for Building China's Strength in Transportation*. In addition, China implemented several demonstration projects, such as the construction of transit metropolis and the promotion of public transit apps. All these efforts have created a good environment for the development of public transportation. The *Outline of Building China's Strength in Transportation* released in 2019 focuses on travel services and clearly proposes to primarily build the "national 123 transportation circle" by 2035, i.e., one-hour commute in urban areas, two-hour travel between cities in an urban agglomeration, and three-hour travel between major cities of the country. This document also proposes to promote the transformation of transportation from the pursuit of speed and scale to quality and efficiency, that of transportation modes from independent development to integrated development, and that of driving factors from traditional elements to innovation. The goal is to build a safe, convenient, efficient, green, economic, modern, and integrated transportation system.

Buses should continue to play a major role in the one-hour commute circle of a metropolitan area. The development philosophy of high-quality, integration, and innovation should be implemented to build a safe, high-quality, intelligent, efficient, responsible, and branded public transit system. Following the national policy guidance, the Chongqing Municipal Government has successively issued several documents, such as *Opinions on Prioritizing the Development of Urban Public Transportation in Chongqing* and *Three-Year Action Plan for Quality Improvement*. It is proposed to improve the quality of public transportation by enhancing the overall quality of the city and take public transportation priority as an important measure to relieve urban traffic congestion. A well-structured integrated development pattern for public transportation has been established in Chongqing, which takes rail transportation as the backbone and bus transportation as the main component.

## 1 Trend of bus passenger volume in Chongqing

Currently, nine urban rail transit lines are in operation in Chongqing with a total mileage of 313 km, increased from 70 km in 2011. The rail-transit passenger volume also grows drastically, which had reached 3 million per day in the first half of 2019. With the accelerating construction of urban rail transit, it is expected that a rail transit network with the

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pattern of "one circle and eight radial lines" will take shape in the main urban area by 2021. The operating mileage will then be more than 415 km and the passenger volume will continue to grow. The bus passenger volume in Chongqing has been declining for years since November 2014, due to factors such as the growth of cars and the development of rail transit. The average daily passenger volume was approximately 5.37 million passengers $d^{-1}$ in 2014, which fell to 4.88 million passengers $d^{-1}$ in 2018 (see Figure 1). After the operating organization and the line network were optimized, the decline of the average daily bus passenger volume has been controlled at about 2%, which was less than 1% in 2018 and was almost flat in 2019. This indicates that the change of the bus passenger volume is stabilized gradually.

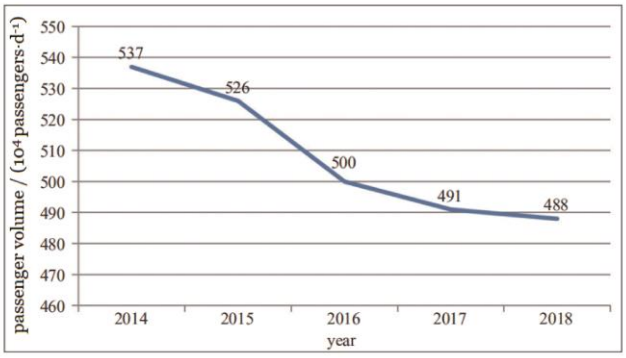


**Figure 1** Change in daily bus passenger volume within main urban area of Chongqing in the past five years

Source: 2014–2018 Annual Operating and Production Report of Chongqing Public Transport Group

## 2 Analysis of bus data

A big data system of buses was established based on big data resources such as public transportation IC cards, vehicle GPS, Traffic Analysis Zones (TAZ), and road networks, with operation and management as the core. It fuses the underlying data and includes the bus forecasting model, the derivation system of bus passenger flow, and the evaluation index system. This big data system can be applied to analyze the trip Origins and Destinations (OD) of bus passengers and simulate traffic at different network levels (such as the arterial express bus line and the community bus line). Moreover, it can evaluate the public transportation network, match transportation capacity with travel demand, and schedule tasks. It will further improve the level of refined management [1].

### 2.1 Passenger flow OD analysis of transit lines

Based on the daily data of public transportation IC card and vehicle GPS, bus passengers' boarding and alighting stops and travel directions can be derived based on the principle of closed trip chains, the time correspondence rule, the information coding principle, etc. [2]. This method basically ensures the time continuity of the trips, which is a real-time method. It solves the problem of how to determine the bus stop at which a passenger gets off the bus. The results are reliable with the accuracy of about 80% for the derivation of passenger OD.

### 2.2 Bus line operation simulation at different network levels

A TransCAD model was applied to assign bus passenger flow to proposed bus lines, which simulated and forecast the distribution of passenger flow on future bus lines [3] (see Figure 2). Through a comparison of passenger flow before and after the proposed projects, the impact on the travel of the residents and the passenger flow intensity of the bus lines were analyzed.

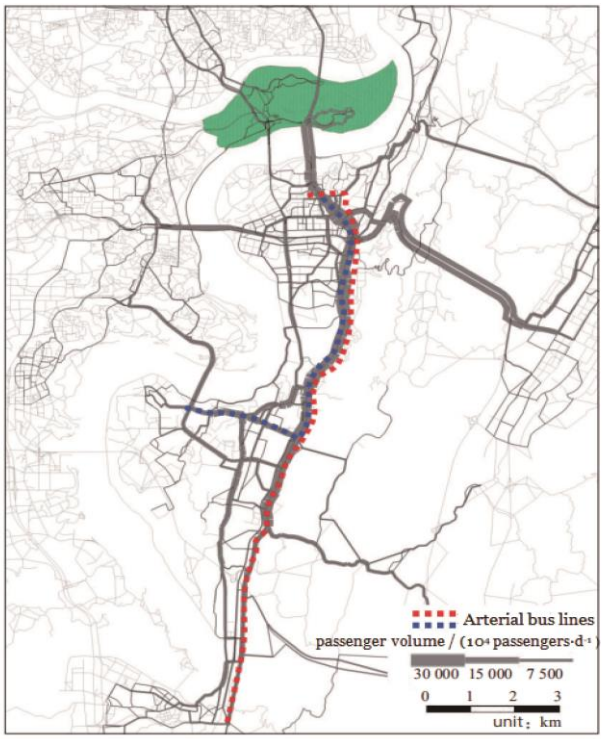


**Figure 2** Simulation of arterial express bus lines

Source: Chongqing Public Transport Group's 2018 Implementation Plan of the Arterial Express Bus Line on South Chongqing Avenue

### 2.3 Evaluation system of bus network

An evaluation system of bus network that is in line with Chongqing's characteristics and enterprises' operation and management was established [4] (see Figure 3). This evaluation system focuses on the core business of buses, i.e., "operation, service, safety, and maintenance". It evaluates the bus network in six dimensions, i.e., network scale, network structure, average monthly man-hours, efficiency, speed, and transfer. Moreover, it objectively assesses the operation quality of a bus line by comprehensively evaluating its demand intensity, turnover efficiency, vehicle utilization, and profit.

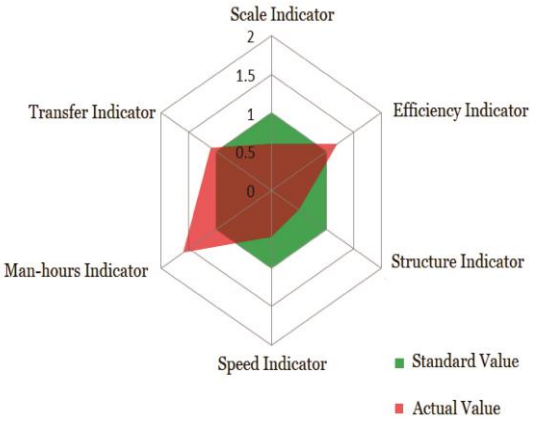


**Figure 3** Chart of indicators for bus network evaluation

Source: http://183.66.64.43:8089/bms/main.html

## 2.4 Analysis of matching bus capacity with travel demand

Through the balance analysis of bus capacity and travel demand, appropriate bus capacity is provided to match with the highest travel demand in peak hours and over peak segments. This analysis provides the basis for optimizing the capacity adjustments to achieve the goal of providing enough capacity during peak hours and reduce the waste of capacity during off-peak hours (see Figure 4).

Through the deep analysis and application of big data, bus operation and management have changed from manual reporting to automated reporting and from empirical judgment to scientific arrangement, which reduced costs and increased profits. Compared with 2013, the 500-meter coverage rate of bus stops is increased to 92.8%; the walking connection distance at both trip ends is reduced to 841 meters; the number of passengers per bus kilometer is increased by 14.6%; the passenger travel cost per kilometer is decreased by 12.5%; the average daily operating mileage of a bus is reduced by 21.2%.

# 3 Project to improve quality of transfer between rail transit and buses

## 3.1 Optimizing bus network along rail transit lines

Based on the idea of optimizing bus lines that have the same direction as the rail transit line and connecting bus lines with the rail transit line if they cross, duplicate bus lines were removed, and duplicate capacities were reduced. Bus lines that are in the same direction or intersect with the rail transit line were optimized. The repetition coefficient of the bus network and the rail transit network was reduced, and large- and medium-sized buses running in the same direction as the rail transit line were removed gradually. Since 2013, 200 bus lines have been optimized and adjusted, and the repetition coefficient of the bus network in the main urban area has been reduced from 4.25 to 3.25.

## 3.2 Strengthening connection between buses and rail transit

(1) Bus connections should be sorted out and optimized at the network level. The relationship between bus lines and rail transit stations was determined according to the following criteria: The number of bus stops that are at the same locations as rail transit stations is less than 3; the length of the bus line is less than 10 km; the direction of the bus line is different from that of the rail transit line. For each rail transit station with weak connections, two additional bus connection lines were added.

(2) Bus stops should be added or renovated to further reduce transfer distances. According to the construction plan of rail transit, 172 rail transit stations would be opened in the main urban area in 2019, among which 159 rail transit stations have bus transfer within 300 meters of the station entrances and exits with 398 bus connection lines in total. Bus stops were added or renovated to further shorten the transfer distance and improve the accessibility of bus stops (see Figure 5).

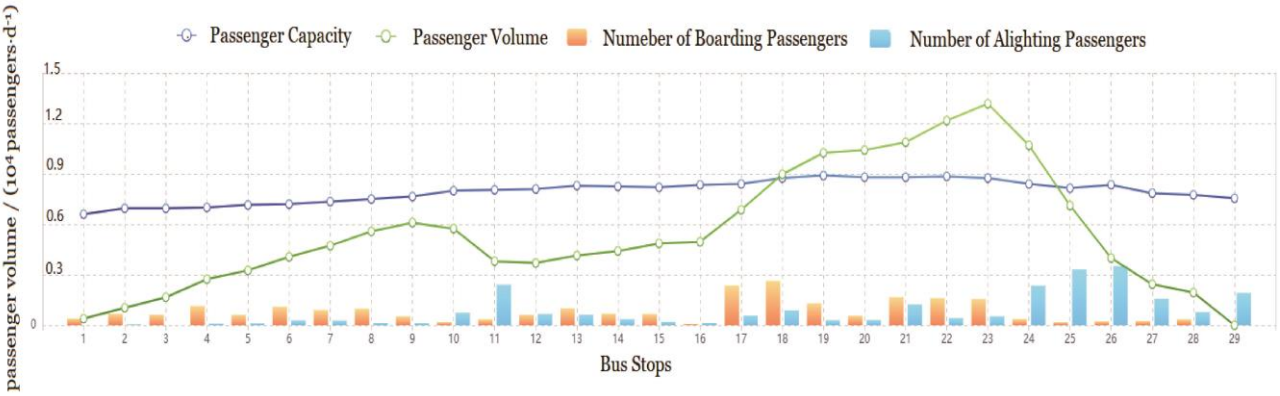


**Figure 4** One-way passenger capacity and volume of bus route 619 during morning peak hours (7:00–9:00)

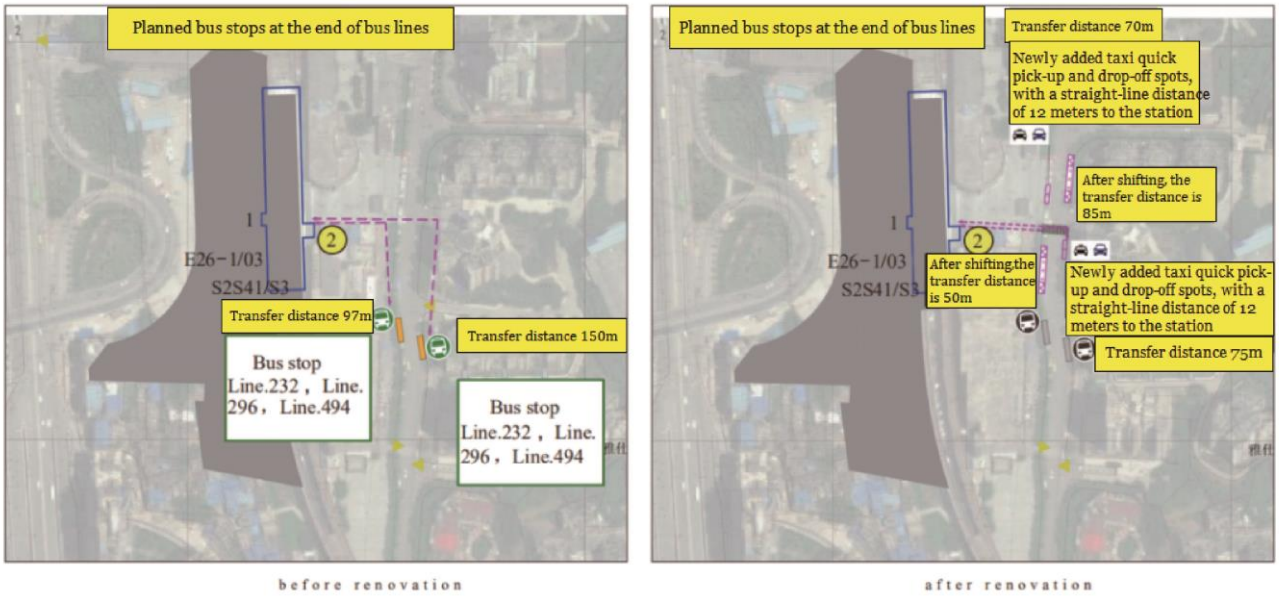


**Figure 5** Bus stops before and after renovation

Source: Design of Projects to Improve the Transfer Between Rail Transit and Buses in the Main Urban Area of Chongqing

The renovation of bus stops involved 15 rail transit stations. The addition of bus stops involved 43 rail transit stations, and the optimization of walkways involved 11 rail transit stations.

After the renovation, 120 rail transit stations have the bus transfer distance less than 50 meters (increased from 66 stations), accounting for 69%; 27 rail transit stations in the range of 50 to 100 meters, accounting for 16%; 20 in the range of 100 to 200 meters, accounting for 12%; four in the range of 200 to 300 meters, accounting for 2.4%. Only one rail transit station has the bus transfer distance above 300 meters.

(3) Quick pick-up and drop-off spots should be added. A total of 93 quick pick-up and drop-off spots were planned. Within the inner ring road of the main city area, only taxis are permitted to use the quick pick-up and drop-off spots; while outside the inner ring road, both taxis and private cars are permitted.

## 4 Stratification strategy of bus network

Bus lines are stratified into arterial express lines, arterial lines, community bus lines, and minibus lines. The design standards for each stratification should be developed, and the layout of the bus network should be improved gradually to build the bus network that is in line with the characteristics of the cities in mountainous areas. Whhich can enhance the customized service and improve the attractiveness of buses.

The purposes of bus network stratification are as follows:

1) To clarify functional positioning: Customized public transit products should be provided to meet the transportation needs at different levels.

2) To promote refined management of the bus network: The premise of refined management in the bus network is that the network is stratified. Different management modes should be adopted for different levels to prevent the disadvantages of "one size fits all".

3) To optimize resource allocation: Road (priority road) resources, vehicle resources, station resources, facility resources, service resources, and information resources should be reasonably allocated to different levels to maximize resource efficiency.

### 4.1 Constructing arterial express bus lines

1) Plan implementation

The arterial express bus lines should be constructed along with the construction of bus-only lanes, following the principles of making the overall plan, integrating resources, creating pilot projects, and implementing the plan step by step. Based on the experience of cities such as Beijing, Shanghai, and Foshan, the design standards for arterial express bus lines were developed [5]. The arterial express bus line has the characteristics of large transportation capacity (its peak-hour one-way capacity is slightly lower than the light rail), high frequency, fast operation speed, high reliability, and high effectiveness in saving travel time. Its peak-hour one-way transportation capacity is about 10 000–15 000 persons per hour. The bus stop spacing is more than 1 km, and buses only stop at major bus stops. The arterial express lines are mainly bus-only lanes that are restricted to buses at certain time of the day and expressways, with the one-way travel time less than 60 minutes. Initially, the operating plan of the arterial express bus lines was developed by integrating bus lines and infrastructure resources based on north-south and east-west urban skeleton corridors, such as Yunan Avenue, Shiyang Road, and Jichang Road. Four arterial express bus lines were planned (see Figure 6). The first batch of arterial express bus

 

lines on Jichang Road, i.e., Lines 608 and 609, have been officially launched, and the overall transportation capacity has increased by 20% compared with that before optimization. The frequency of buses has increased to four to six minutes per bus, and the travel time has been reduced by 10 to 15 minutes. The bus travel experience between the Lianglu Area in Yubei District and the main urban area has been greatly improved.

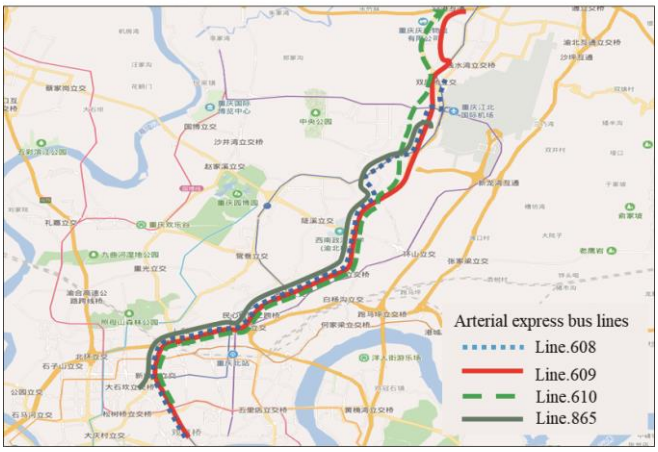


**Figure 6** Arterial express bus lines along Jichang Road corridor

Source: Plan of Arterial Express Bus Lines of Liangjiang Ltd. of Chongqing Public Transport Group

2) Implementation effect

Through the construction of the arterial bus lines on Jichang Road, the travel distance and congestion nodes in the Lianglu Area have been effectively reduced, and the travel time between Lianglu Area and Guanyinqiao Area has decreased by about 15 minutes. The passenger volume and benefit indicators of the arterial bus lines have decreased compared with those before the adjustment, but they showed an upward trend based on the data of the first two weeks after implementation. Meanwhile, the passenger volume and benefit indicators of related bus lines on this corridor have increased to different extents (see Figure 7).

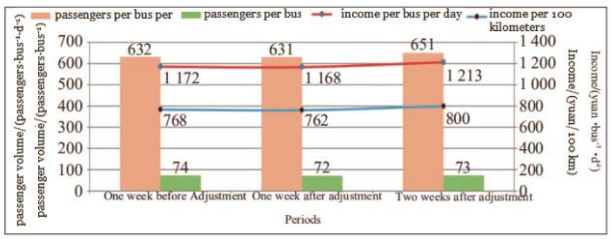


**Figure 7** Operation indicators of arterial express bus lines

## 4.2 Constructing community bus line network

The main goal of community buses is to solve the problem of short-distance travel for citizens between homes and transfer stations (see Figure 8). The community bus service has the following characteristics: 1) It provides short connecting bus lines with fast turnover to transport passengers quickly to rail lines or backbones and arterial bus lines. 2) It is specifically oriented to serve transfer stations or connection stations that are close to trip intensive areas, such as residential areas, to achieve the many-to-one connection of community bus stops and the connection station. 3) It mainly provides horizontal connections by operating community buses mostly on branch roads and secondary roads with appropriate detour to collect passengers along the way. 4) It mainly serves residents in the residential areas during the early peak hours.

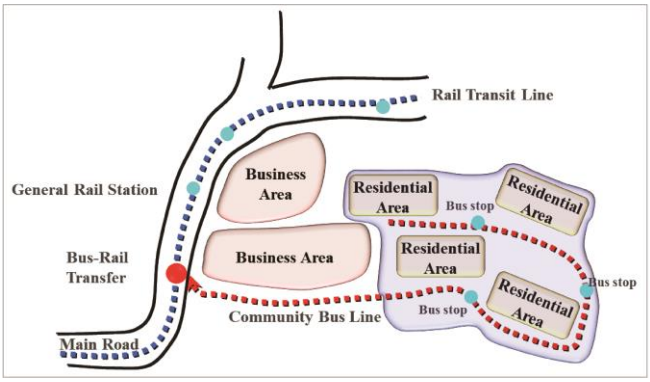


**Figure 8** Community buses

Source: Community Bus Layout Plan of Chongqing Public Transport Group

A basic information database of the community was developed, including data such as the land use type, move-in time, number of households, apartment layout, and number of parking spots. Based on the community's basic information database and service complaints, the demand for community bus trip was forecast, and community bus services were planned. These community buses strengthened the connection of the community with the supporting public resources around it such as education, commerce, and medical services. Furthermore, they helped fill the gap and connected secondary and branch roads to buses on main roads. Besides, they realized point-to-point connections and served short-distance trips around the community. Since 2013, 20 community bus lines have been opened each year. Currently, the number of community bus lines has reached 173, accounting for more than 1/4 of the total number of bus lines in the main urban area. There are in total 993 community buses, covering 891 km of secondary and branch roads and carrying 450,000 passengers per day on average.

## 4.3 Developing minibus lines

To further improve the structure of the bus line network and enhance its coverage depth and breadth, Chongqing has made every effort to develop a four-level network of "backbone, arterial, branch, and microline". Chongqing has also added micro-circulation lines, i.e., community green minibuses, and optimized vehicle selection to break through the constraints of existing road conditions and achieve the service goal of being "short, frequent, fast, and small".

1) Functional positioning

The community green minibus is used to cover small and medium-sized streets and blind areas that are restricted by road conditions which cannot be reached by buses. It smooths the microcirculation of residents' production and living circles in the community and opens up the connecting channel between the residential community and surrounding education, medical, and commercial services. Minibuses' characteristic of being mobile and flexible should be given full play. Private cars should be reduced, and the living space of illegal vehicles such as motorized tricycles should be squeezed by providing quick bus services that can provide a better travel experience.

2) Operation modes

The length of a minibus line should be less than 3 km. Seven- to nine-seat electric minibuses that meet relevant national standards should be developed. The end of the minibus line should be placed at the main entrance or exit of a community, and supporting facilities should be installed around it. The bus stop spacing can be between 100 to 200 meters as required. Through intelligent dispatch, the departure interval during morning and evening rush hours should be 1 to 3 minutes. IC cards should be accepted on minibuses for passengers to enjoy the free or discount transfer policy.

Compared with community buses, minibuses have shorter lines, smaller vehicles, and closer stop spacings. The operation and dispatch of minibuses are flexible and intelligent, so they respond more quickly to residents' travel demand. According to the needs of residents, 13 minibus lines are included in the preliminary plan, among which two pilot lines are expected to be launched in the western region in 2020.

## 5 Conclusion

The refined management based on big data employs digitalized tools to accurately reflect the needs of the passenger transportation market and find the problems of operation management. Guided by these needs and problems, the refined management can implement a hierarchical division of the bus line network accordingly and improve the quality of transfer between buses and rail transit. It will help match the supply of public transportation better with the travel demand, reduce inefficient investment in business operations and production, and improve social and economic benefits. Since the operation of minibus lines is still in the research stage, the operating plan needs to be refined. As a demand responsive service, the minibus service is the innovation and extension of the existing bus operating model, which needs to be improved in terms of line planning, operation scheduling as well as information assurance.

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