

# Tianjin Liuyuan Comprehensive Passenger Hub Connection Analysis

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**Abstract:** With the rapid development of China's economy, the continuous expansion of urban scale and the continuous growth of transportation demand have led to the leapfrog development of urban rail transit construction, and the role of rail transit in the urban passenger transportation system has become increasingly significant. The connection between rail transit and other modes will directly affect the passenger experience. Taking Tianjin Liuyuan Passenger Transport Hub as an example, this paper analyzes the current situation of the layout and connection between Liuyuan Metro and buses, cars and shared bicycles, and summarizes the problems existing in the current hub. Through field research on the proportion of convergence and query of existing data, the demand and distribution of passenger flow were comprehensively measured, laying a foundation for follow-up research.

**Keywords:** Rail transit passenger flow forecasting; Metro connection; Liuyuan Subway Station

## 1 INTRODUCTION

With a total length of 42km, Tianjin Metro Line 1 is an important part of Tianjin's public transportation system. Liuyuan Station is located in Beichen District, a suburb of Tianjin, and is an important comprehensive transportation hub in Beichen District. The coverage includes Tianjin Children's Hospital, Ruijing Middle School, Chenchang Road Primary School, etc., which is an important transportation hub for residential areas, hospitals and school districts, with greater commuting and school needs, and is one of the important central hubs in Beichen District; Secondly, Liuyuan Metro Station is a combination of urban and suburban areas, which is a necessary station for suburban residents to enter the city, and has a very important hub role; Third, the Liuyuan Station subway station coincides with a number of bus line stations and is a key node for passenger flow evacuation.

Passenger flow is the basic basis for all aspects of rail transit planning, design, construction and operation, so forecasting for passenger flow forecasting is the primary task of analyzing integrated transportation hubs.

In view of this problem, foreign scholars Oyama [1] et al. used simulation technology to analyze the flow law such as the path selection of passengers in the hub, explored the impact of building facilities in the hub on the choice of passenger paths, and proposed the bottleneck phenomenon of changing passenger flow traffic organization flow lines. Then, Daamen [2] et al. established a utility function model based on the survey data on the path selection and

traffic characteristics of passengers inside the hub through the tracking survey method, which considered the influencing factors inside the hub. At present, the domestic scholar Wang Zhuoqun and Luo Qin [3] use the Shenzhen phase II line network engineering station full-day inlet and outbound time-sharing passenger flow data, using clustering algorithm to obtain the main time-varying characteristic types of Shenzhen stations, and then, extracting the main influencing factors, constructing a multi-regression passenger flow prediction model of sub-categories, inlet and outbound stations.

For the problem of the connection between subway hubs and other modes of transportation, domestic scholar Hao Qianqian [4] et al. proposed different types of urban rail transit station traffic connection methods and the scale of traffic connection facilities by analyzing the traffic functions, regional locations, service objects, passenger flow characteristics, etc. of urban rail transit stations. Tang [5] et al. conducted in-depth research on the connection and transfer between the rail network and the ground bus network. Spring [6] et al. constructed a waiting model that considers the waiting time of passengers through the hub in multiple modes that considers the connection service and the connection service, and concludes that the main influencing factor of the transfer time is the connection service capacity and the connection service interval. Sara [7] et al. have studied the efficiency, accessibility and connection distance of light rail systems and other urban transportation transfers, and summarized general indicators of the impact of docking efficiency.

The establishment of passenger flow distribution model is an important reference for subsequent traffic flow analysis.

For the passenger flow distribution model, Gao Long [8] et al. in China used the Beijing South Railway Station Station of Line 4 of the Beijing Metro as the engineering background to simulate and calculate the passenger flow on the platform. By analyzing the traffic flow characteristics in the hub, Helbing [9] et al. simulated the distribution process of passengers in the hub, and established a relationship model of the basic parameters such as pedestrian flow rate and density of different transfer facilities in the hub under different conditions. Through the fitting model between the land use around the rail transit station and the passenger flow index, Ma Chaoqun [10] et al. selected five indicators such as the full-day distribution volume of the rail transit station, the inbound passenger flow and outbound passenger flow in the morning peak, the inbound passenger flow and the outbound passenger flow in the evening peak as the dependent variables, which can provide reference for subsequent calculations.

In summary, based on the important commuting needs of Liuyuan Subway Station, the junction of multiple bus lines, and the necessary stations for the process of residents in the suburbs, etc., the important hub function is important; As well as the current parking problems in suburban construction, shared bicycle parking problems, bus interchanges and other passenger flow evacuation problems, so take Liuyuan Station on Tianjin Line 1 as an example, investigate and analyze the current layout analysis of Liuyuan Station, the law of time and space change of passenger flow distribution and the main flow of passengers, providing a theoretical basis for follow-up research.

## **2 ANALYSIS OF PASSENGER FLOW COMPOSITION AND TRANSFER CHARACTERISTICS OF TIANJIN LIUYUAN BUS STATION**

### **2.1 Distribution of passenger flow between Liuyuan Subway Station and Bus Station**

Liuyuan Subway Station passes through more than a dozen bus lines such as 174, 318, 649, 725, 734, 909, etc., and there are also bus and bus connection stations such as 34, 602, 734, and Express 2 around it. However, some passenger flow is concentrated in the bus to the bus transfer, passenger flow direction does not flow to the direction of subway transportation, so the platform of these bus lines is set in the subway connection hub, the value of the subway is not high, and the scattered bus stations cover a large area, the use of land resources is not reasonable, the following will be the Liuyuan subway station near the bus part of the representative line passenger flow source and direction analysis.

The 649 bus line is a node in Liuyuan Subway Station, divided into two parts, half of the line is Liuyuan Subway Station to Hebei University of Technology Beichen Campus, this line and 319 line basically coincide, mainly for Liuyuan Subway Station to Hebei University of Technology student connection line dedicated; The other half is Liuyuan subway station to Dingzigu line, this part of the line and the 34 bus route basically coincide, a small part of this line passenger flow for Hebei University of Technology Beichen Campus to Hebei University of Technology Hongqiao Campus students commuting, and the remaining part of the main passenger flow is for the Dingzigu neighborhood, Benxi Road, Jiayuanli, Jianingli residential area residents commuting, these main stations of the main station of the passenger flow destination is not Liuyuan bus station, so the demand for transferring to the subway in Liuyuan is extremely small.

The purpose area of the 734 and 332 bus lines is Hanjiashu Market, which is mainly used for people commuting between Hanjiashu and Liuyuan, and has two main functions: one is for residents living in Hanjiashu to commute back and forth to the children's hospital near Liuyuan, and the other is from the main residential areas of other lines (specific residential areas are mentioned in other line analysis) at Liuyuan Station to Hanjiashu Market for commercial activities. In summary, these two lines have very little demand for connection to subway stations.

The destination area of the 317 and 318 bus lines is the residential area in the northern part of Beichen District, and the focus of 317 is on residential areas such as Verdant Garden and Chixia Garden, and important commuting centers such as Beichen Building; Bus No. 318 leads to Yinheli North Road, Zetianxia and other areas. The intersection of the two lines is a public line from Liuyuan Subway Station to Ziruiyuan and Liuyuan Village, which is mainly used to transport the commuting needs of pedestrians to children's hospitals at the important residential gathering points mentioned above. In summary, the passenger flow of these two lines has little demand for the connection of subway stations.

### **2.2 Liuyuan subway station with taxis and cars transfer status**

Taxis and public transportation such as public transport is very different, taxis are fast, direct, convenient, so more flexible, and go out to take the bus, reduce the search for the distance,

and wait for the time of bus transfer, Liu Yuan's entrances and exits are close to Chenchang Road or Longyan Road, taxi convenience, which can greatly improve the transfer efficiency, to provide passengers with higher quality transportation services. However, the higher cost of taxis and the lower carrying capacity are not conducive to saving transportation resources. If you can use a self-driving car, it is much more convenient, but because the entrance is close to the main road, the private car storage is tight, and the long-term parking interferes with the surrounding traffic, and there is no reasonable parking lot.

### **2.3 Status quo of Liuyuan Subway Station and shared bicycle transfer**

Liuyuan subway station from exit A, about 15 meters away from Chenchang Road, about 35 meters away from Longyan Road, both sides are set up as motor vehicle parking spaces, and set up a narrow bicycle parking area, shared bicycles are parked around Chenchang Road, looking for convenience. The current problem is that it is difficult to find resources during the peak period of shared bicycles, and the use of low peak periods is scattered to affect the pedestrian traffic experience.

## **3 COMBINED WITH THE CURRENT LAYOUT AND THE ANALYSIS OF THE EXISTING PROBLEMS OF THE LINE**

### **3.1 The demand for bus and subway transfer does not match the current situation, and the bus station setting is unreasonable**

From the analysis of the current bus lines, it can be seen that in Liuyuan Subway Station, in addition to the students of Hebei University of Technology on some lines such as 649 and 319 lines, as well as the residential areas of Xinzeyuan and Shengcang Xinyuan at the end of the 317 and 318 bus lines, the demand for transferring subways is high, and the passenger source of Duwang New Town in the center of Beichen District represented by the rest of the lines such as 725 Road, and the western Hanjiashu customer source represented by 734, which flows to the commuting demand of children's hospitals and Ruijing Middle School in its two large residential areas. The remaining lines are used by the city's passengers in Liuyuan Bus Station and other bus lines, so the bus stations with demand for Liuyuan Subway transfer and the bus stations without transfer needs should be built separately, and special subway connection buses and other lines are connected to buses, and other passing bus stations are set up separately to improve the transfer efficiency.

### **3.2 Inconvenience in the transfer of private cars due to the absence of parking lots.**

According to the layout analysis above, it can be seen that the current main mode of transfer transportation is still mainly bus, supplemented by shared bicycles, and most people with inconvenient transportation in remote areas choose to rent, which is inconvenient and expensive. As far as the current situation is concerned, in fact, the demand for private cars is very high, but because there is no parking lot near Liuyuan Subway Station, there have been great limitations for the travel of private cars. If a perfect and convenient parking lot can be established to facilitate the parking of people who have travel needs for hospitals or other public facilities near Liu Yuan, then the efficiency of travel will be greatly improved, and the

cost of travel will be reduced, the most important thing is to improve the comfort and convenience of pedestrians.

### 3.3 Waste of resources with imperfect infrastructure and idle wasteland resources.

On both sides of the intersection of Beichen Road and Chenchang Road, two vacant lands have not been developed, one is Liuyuan Nursery, one is Shuncheng Farm, the current problem we are facing is that bus and bus connection stations should be separated from bus and subway connection lines, then it is necessary to set up some bus bus stops inside and outside, and the current land resources required are not enough; Second, the self-driving transfer or self-driving travel caused by the lack of reasonable parking lot is extremely inconvenient, and expensive rental travel can only be taken; Third, there is no public toilet near Liu Yuan, and the toilet needs to be checked again, and the current location of Liu Yuan to build a toilet is not reasonable, occupying a large space, affecting the aesthetics, and the utilization rate is not high. Therefore, under the premise of such demand, there are still large areas of wasteland that cannot be developed and utilized, which is actually a great waste of land resources. Therefore, how to rationally plan this open space and solve the above problems is a key issue.

## 4 OPTIMIZATION OF CONNECTING BUS NETWORK

### 4.1 Calculation of passenger flow at Liuyuan Station

At present, there is no detailed introduction of the passenger flow of Liuyuan Station, so we refer to the research results of our predecessors for analysis and calculation.

According to the conclusion of the article "Application of Radar Chart Analysis Method Based on Big Data in Passenger Flow Evaluation of Urban Rail Transit", this paper uses radar analysis method to process the outbound passenger flow data of each station of Tianjin Metro Line 1 in a dimensionless process. The highest value of the passenger flow of each station is taken as 1, and the dimensionless treatment is carried out in equal proportions, and the result is used as the calculated value of the outbound passenger flow of each station, as shown in the following table:

**Table 1.** The passenger flow of each station of Metro Line 1 is relatively proportional

University of Finance and Economics Station	Outbound passenger flow calculation value
Station name Outbound passenger flow calculation value Liuyuan Station	0.336
Nishi Yokotori Station	0.209
Cider Mill Station	0.193
Benxi Road Station	0.178
Qinjian Road Station	0.204

Honghuli Station	0.237
Honghuli Station	0.126
Northwest Corner Station	0.266
Northwest Corner Station	0.311
Erwei Road Station	0.181
Haiguang temple station	0.432
Anshan Road Station	0.337
Yingkou Road Station	1
Yingkou Road Station	0.536
Lower Wafang Station	0.32
South Building Station	0.315
Tucheng Station	0.341
Chentangzhuang Station	0.088
Fuxingmen Station	0.182
Huashanli Station	0.303
University of Finance and Economics Station	0.343

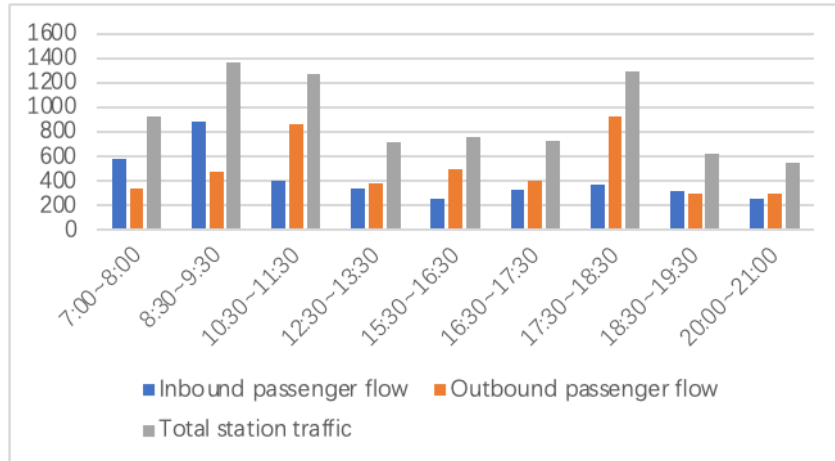
This data ratio is basically consistent with the observations in one day, so according to other literature forecast data, the daily passenger traffic of Tianjin Rail Transit in 2022 will be 5,130,000 person-times, and the number of passengers on Metro Line 1 will account for about 10% of the total number of rail transit people, so the daily rail transit passenger traffic of Metro Line 1 will be 513,000 passengers. Liuyuan Station predicts that the passenger flow can account for about 6% of the number of people on Metro Line 1 through this ratio, so the daily passenger flow of Liuyuan Metro Station in 2022 will be 30,780 passengers.

#### **4.2 Average and peak hour passenger flow analysis of Liuyuan Subway Station and other modes of transportation**

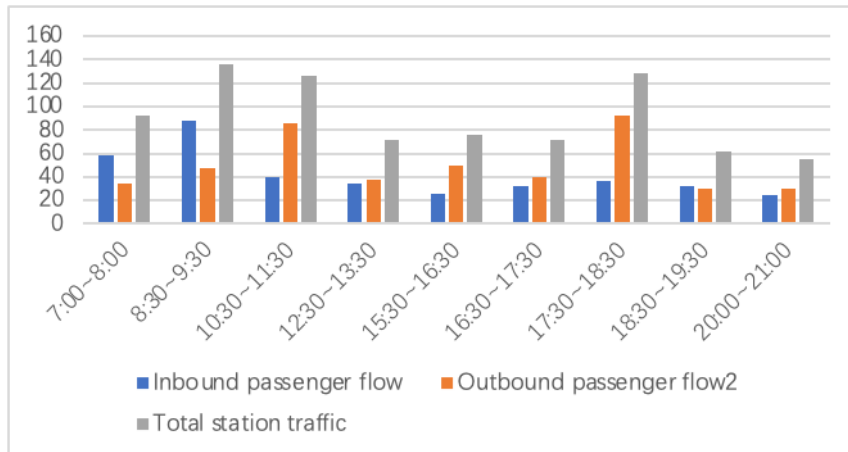
The distribution of passenger flow with transport time is very uneven, especially for urban rail transit. In order to measure the unevenness of the time distribution of passenger flow, there are three indicators: the monthly inhomogeneity coefficient, the daily inhomogeneous coefficient and the hourly uneven coefficient.

This design conducts a weekday and a non-working day of passenger flow surveys, so the uneven coefficient of hours is required here.

According to the predicted results, the statistical results of the survey hourly passenger flow of Liuyuan Metro Station on a typical working day, as well as the number of people entering the station, the number of outbound people, and the total number of passengers can be drawn as shown in the following two figures:



**Figure 1.** Liuyuan Subway Station typical weekday passenger flow hourly statistics



**Figure 2.** Liuyuan subway station non-working day passenger flow hourly statistics

Based on the survey results of passenger flow of Liuyuan Station and the historical data of passenger flow of Tianjin Rail Transit, the passenger flow demand forecast of Liuyuan Station is as follows: during non-working days, the difference between the average and peak hours is small, and it can be calculated according to the maximum value of passenger flow in and out of the station during peak hours, as the data of non-working days. During weekdays, the morning peak inbound station is far from the outbound station, and the maximum value of the peak period can be used as the calculation basis for the inbound passenger flow, and the outbound passenger flow is more special and the volatility is larger, and the average of the three highest passenger flow periods can be used as the calculation basis; During the evening peak period and the morning peak period, the outbound passenger flow is calculated according to the peak of the peak hour, and the inbound passenger flow is calculated according to the average; During the peak period and non-working days, the passenger flow is basically the same, and the average value is used as the basis for calculation.

## 5 CONCLUSION

Liuyuan Station is the starting station of Metro Line 1, located in Beichen District, a suburb of Tianjin, and is an important comprehensive transportation hub in Beichen District, as well as an important transportation connection point for the urban and suburban junctions. Therefore, the current situation of Tianjin Liuyuan Passenger Transport Hub connection and future development needs are analyzed, laying the foundation for follow-up research.

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