Interchange Means between Urban Rail Transit and Private Car

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Abstract. Urban rail transit such as subway is important means of transportation for people to travel. With the acceleration of urbanization construction throughout the country, urban rail transit has developed rapidly. More attention is paid to the interchange means between urban rail transit and other urban transportation systems, such as public transport, public bicycle, and private car, and the interchange means has gradually become an important indicator for assessing the level of urban transportation system. This paper analyzes the interchange means between urban rail transit and other urban transportation systems, and puts forward relevant suggestions on the interchange between between urban rail transit and private cars to contribute to the promotion of urbanization.

Keywords: Urban rail transit, Urbanization construction, Private car, Transportation interchanges

In recent years, urbanization is constantly accelerating, and transportation is the blood vessel of the city. Urban rail transit is the most important transportation system of the city, interchange between urban rail transit and other urban transportation has always been the focus of people's research and an important indicator for measuring the level of urban transportation system[1-3]. In the past, urban transportation relies on such means of transportation as public transport, and taxis. As social economy is developing rapidly, more and more private cars are used, and connection mode of urban rail transit are gradually enriched.

1. Research status of urban rail transit and its interchange

Compared with other urban transportation, urban rail transit has the characteristics of large traffic volume, which can quickly provide "station to station" services for passengers. But for passengers, "station to station" services can not meet their needs, so the connection of urban rail transit is particularly important. There are a great number of interchange means for urban rail transit, including bus, public bicycle, pedestrian, taxi, and private car. By analyzing the current situation of different connecting ways and making full use of different connecting ways of rail transit through reasonable planning, the efficiency of interchange for urban rail transit can be comprehensively improved and the waste caused by the competition among different connecting ways of rail transit can be reduced [4].

Relevant departments launched a survey on the interchange for urban rail transit, and the data
shows that 37.8% of subway passengers are walking when they entered the station, and 52% are walking when they are leaving the station. However, only 19.6% of passengers walk when they are walking and leaving the station [5], which shows that it is more important for passengers to interchange urban rail transit with other transportation.

2. Relationship between urban rail transit system and urban planning
From the perspective of composition, urban planning is made up of master planning and detailed planning. Planning for urban rail transit is included in the master planning. The detailed planning is the design and planning of rail transit stations because urban rail transit system concludes two aspects of master planning and detailed planning.

(1) Relationship between master planning and urban rail transit system
Urban rail transit belongs to urban transport, and planning for urban transport is part of master planning. Therefore, planning for urban rail transit should be part of master planning and cannot be listed separately. There is an inseparable relationship between them [6, 7].

(2) Relationship between detailed planning and urban rail transit system
The site planning in the urban transportation system is part of detailed planning, including the structural design of the stations. The detailed planning can maximize the social benefits of rail transit, which will affect the future development of urban rail transit. To sum up, excellent urban planning necessarily corresponds to excellent urban rail transit planning. There is a correlation between them. Therefore, the interchange level of urban rail transit will directly reflect the level of urban planning.

3. Research on the interchange means for urban rail transit

3.1 Classification of urban rail transit hubs
In general, the design of urban rail transit hubs will take full consideration of many factors. According to the transportation functions of rail transit stations, the urban rail transit hubs can be divided into three types, namely large comprehensive hub stations, hub stations, and general interchange stations. (1) Large-scale integrated hub station is an important stage of traffic conversion. Shanghai Hongqiao Hub Station and Beijing Airport Hub Station are all large-scale integrated hub stations. Generally, it includes more than 5 types of external internal traffic and transfer modes; more than 50,000 people transfer to and from the transportation mode every day; the area is above the city level and the surrounding area is used for transportation facilities [8]. (2) Compared with large-scale comprehensive hub stations, the hub station has a relatively poor traffic conversion capacity and does not have external traffic. There are relatively few passengers who transfer to other modes of transportation every day, but it has a strong traffic conversion capacity. Under normal circumstances, the transfer mode is more than 4 times; the daily number of transfers is 40,000 to 50,000. (3) General interchange station is located at the bottom of the urban rail transit hub, so its passenger transfer scale is relatively small and the transfer method is relatively single. Generally, the transfer mode is mainly pedestrian and non-motorized vehicle.

3.2 Division of passenger flow attraction range of urban rail transit hubs
The rail transit interchange means is different, and the range of its attraction for passengers also differs. According to the range of the attraction of rail transit hub for passengers, rail transit hub can be classified into three layers of passenger service circles: near, middle and far. (1) Short-distance passenger service circle covers a small area, which is about 800 meters centered on a rail transit hub. Therefore, this type of passenger often uses walking as a connection method [9]. (2) The coverage of the middle-distance passenger service circle is within 3km centered on the rail transit hub. Such passengers often use bicycles or walking as the connection means. (3) The coverage area of long-distance passenger service circle is about 5km centered on rail transit hubs. Such passengers often use motor vehicles as the connection means, including buses, private cars and taxis, which is also the connection method of private car that this article needs to study. Rail transit hubs often set
border passages such as car parking lots and escalators for fast transfers. This method also effectively controls the situation of cars entering the urban area and relieves the traffic pressure in the city center.

4. Interchange means between urban rail transit and private car

The interchange of urban rail transit includes bus transfer, taxi transfer, pedestrian transfer, bicycle transfer and private car transfer (details are shown in Table 1) [10]. Passengers can reasonably choose the transfer mode according to their own needs and the characteristics of urban rail transit hub. The following mainly analyzes the interchange means between urban rail transit and private car. The connection mode of private car is mainly used for the connection of the long-distance passenger service circle, and some of the short-distance or medium-distance passenger service circles will also choose this connection mode. Based on the analysis of transfer tools, compared with bicycle transfer and bus transfer, private car transfer uses non-public resources. With the increase of the number of people who choose private car transfer, the traffic pressure on urban roads increases significantly, which will have a negative impact on the effective transfer of passengers. In this case, the rail transit hub often sets up public parking lot and underground parking lot when conditions permit, and establish “P + R” system. The establishment of this system realizes the transformation from individual traffic to public traffic, and effectively avoids the occurrence of a large number of private cars driving into the urban center to increase the traffic pressure of urban roads.

Table 1 Analysis of several common connection methods of urban rail transit

| Transfer mode     | Scope of application                                                                                                                                                                                                 | Location                                                                                      |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| bus transfer      | Applicable to any rail transit station, and its convenience need to be paid attention to.                                                                                                                              | Within 50 meters of the entrance and exit of rail transit stations.                           |
| taxi transfer     | Rail transit first and last stations and large interchange stations;                                                                                                                                                    | Near the first and last rail transit stations and near large interchange stations;            |
|                   | Stops need to be set up when traffic control exists at rail transit stations                                                                                                                                               | Stops are located at the intersection of urban expressways and rail transit.                 |
| private car transfer | Rail transit first and last stations and large interchange stations.                                                                                                                                                  | Rail transit station public parking lot and underground parking lot.                        |
| bicycle transfer  | Any station                                                                                                                                                                                                          | Rail transit station on the ground near the entrance.                                       |
| pedestrian transfer | Any station                                                                                                                                                                                                       |                                                                                               |

The connection of private car is often concentrated in the first and last stations of rail transit. The main reason for this kind of situation is that these two stations belong to the long-distance passenger service circle, and other connection methods can not meet the needs of passengers. For this kind of situation, the first and last two stations of rail transit must take the station as the center and the surrounding resources should be made full use of. During the designing process, considering the large number of private cars, it is necessary to ensure that the convenience and rapidity of the connection of private car. If conditions permit, this method can also be used at the initial and terminal bus stations.

By comparing the connection mode of private car with that of taxi, we can see that the coverage of both modes is about 10km. In some cases, taxi connection mode can be an alternative to private car connection mode. However, compared with taxi, private car is more flexible. For most passengers, private car is generally selected when conditions permit. In recent years, the rise of didi taxi is a huge challenge for the way of private car connection. Didi taxi retains the flexibility of private car to a large extent. However, compared with private car and taxi, didi taxi is more affected by traffic control and other factors, and has higher limitations. At present, it is less used in the interchange of urban rail transit [11].
Pedestrian transfer and bicycle transfer are mainly applicable to the short-distance passenger service circle and the middle-distance passenger service circle. Comparing private car transfer with these two transfer modes, its application advantages are mainly reflected in shortening the transfer time. When passengers carry more luggage, it is more effective to use a private car to connect, which can greatly reduce the burden on passengers. Generally, bicycle transfer will also be set on the ground near the rail transit hub, passengers need to reach the ground by an elevator to transfer, and the transfer time is relatively long. In addition, the coverage of bicycle transfer is small [13].

Bus transfers are distributed at various subway stations, which is the transfer method chosen by most passengers. In addition, bus transfer stations will be set up within 50 meters near the entrance and exit of the rail transit hub, so that passengers can transfer more quickly. Therefore, in terms of transfer time, there is no significant difference between bus transfers and private car transfers. However, buses have limited passenger carrying capacity and are greatly affected by external factors. Related studies have shown that the punctuality rate of buses is relatively low. As information technology has been developed rapidly in recent years, bus transfer information will also be displayed smoothly, which is beneficial to the development of interchange means for rail transit bus [13], and the private car is more punctual. By passing information with family members, passengers can wait for transfers on time, which greatly improves transfer efficiency and is also a way of connecting private cars to buses. Passengers can reasonably choose the connection mode based on their own situation and the characteristics of rail transit hub.

5. Conclusion
It has a direct relationship between the connection level of urban rail transit and the level of urban planning. At present, there are many ways to connect urban rail transit. The interchange of private car, as one of important ways, should be reasonably used, and the advantages of private car connection should be brought into full play by combining the level of urban rail transit hub and passenger attraction range to improve the transport capacity of urban traffic.

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