



# IMPROVING INTERCHANGES

INTRODUCING BEST PRACTICES ON MULTIMODAL  
INTERCHANGE HUB DEVELOPMENT  
IN THE PEOPLE'S REPUBLIC OF CHINA

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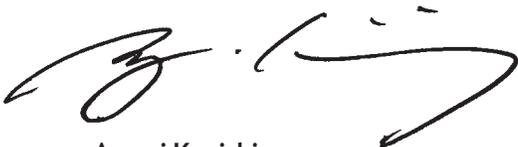
# Foreword

Over the past decade, there has been unprecedented urbanization in both scale and speed in the People's Republic of China (PRC). The creation of new urban districts and further expansion of the existing cities have resulted in a massive increase in motorization. The high-speed rail (HSR) system in the PRC was developed as a solution to rising passenger volumes and traffic congestion, to help connect cities for economic purposes, and to move large volumes of passengers between cities in an environmentally sustainable manner. The PRC has the world's largest, and still expanding, HSR network, with traffic growing from 128 million trips in 2008 to 672 million trips in 2013 (World Bank 2014). As new urban districts are now being planned and developed around urban rail stations, the role of the HSR system should also evolve. HSR stations can be designed as large-scale multimodal transport hubs that serve as the gateway to the city and as a central element of an integrated urban transport system and sustainable urban development.

To realize the potential of the HSR system in aiding the rapidly increasing transport demand in the PRC, the Asian Development Bank financed a technical assistance project, Developing Multimodal Passenger Transport Interchange Hubs, to develop guidelines and recommendations to assist the government in the planning, design, and operation of these interchange hubs.

The development of multimodal interchange hubs cuts across various disciplines, professions, and technologies. This report focuses more on the preliminary work of planning and designing the interchange hub. It aims to consolidate the general methods used in multimodal interchange hub development, based on local and international best practices. The report provides technical guidance for future interchange hub development, as well as for formulating norms and standards in hub operations and management.

The PRC has gained huge momentum in developing rail-based interchange hubs, with much of the design practice very progressive relative to international benchmarks. Detailed studies and continuous technical support are essential to sustain the progress in creating effective, integrated urban transport systems.



**Ayumi Konishi**  
Director General  
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# Abbreviations

CNY	yuan
CRC	China Railway Corporation
HSR	high-speed railway
PRC	People's Republic of China

# Executive Summary

The People's Republic of China (PRC) has reached a stage of urbanization where mobility has become crucial to the quality of life. Transportation is no longer as simple as moving from one point to another. Seamless connections between urban centers, enjoyable and convenient travel experience, integrated transport networks that facilitate efficient passenger transfers, sustainable and low energy infrastructure design, and transport-oriented development have become important elements of a transport system. The growing and evolving needs in the transport sector have laid a good foundation for the development of multimodal railway interchange hubs.

Much knowledge of and experience in the planning, design, and construction management of interchange hubs have been gained. However, the laws, regulations, and technical specifications that govern interchange hub design remain fragmented and often riddled with inconsistencies in the application of planning and design processes. This has affected the quality of the resulting hub design.

This report discusses the experiences and commonly encountered issues when developing railway interchange hubs. It proposes basic design principles as well as research approaches. The report focuses on the planning and design of interchange hubs with railway stations as their focal point. It is developed to serve as a good reference to assist pertinent government agencies, urban planners, architects, engineers, and other experts who are responsible in designing interchange hubs in the PRC, including personnel involved in urban and transport planning, engineering design, and construction management.

The development and increasing use of interchange hubs in the PRC is a result of urban growth and social progress. In recent years, the expansion and upgrading of regional transportation (e.g., high-speed railways, road passenger transport, and aviation), the rapid improvement and development of urban transport facilities, and the expansion and renewal of the cities in the PRC have all contributed to the creation of the modern interchange hub. Passengers are also now demanding more convenient and comfortable journeys through transport interchanges. They now have higher expectations in terms of reduced journey times and improved waiting experiences. This requires better planned interchange hubs, with greater capacity and service standards.

The important characteristics of interchange hubs are efficient operational management, effective focal point of multimodal integration, catalyst for urban development, and attractive user experience. Further, there are five basic principles that must be observed in the planning and design of interchange hubs: overall optimum design, efficiency and flexibility based on optimal planning functions, planning and design of public transport as a priority, rational and efficient land use, and ease of implementation and operational management.

The planning and design of an interchange hub should be managed based on three major stages: (i) overall project planning stage, which works toward project approval (project proposal); (ii) regulatory detailed planning stage, which should be combined with the project feasibility study; and (iii) implementation stage, which lays

the groundwork for the subsequent engineering design phase. This report focused specifically on the overall project planning and design stage, which consists of site selection, transport planning, core area planning, and ancillary service planning.

For rail-based interchange hubs, site selection depends on the location of existing railway stations, site opportunities, and city planning objectives. The design of a passenger railway station requires a comprehensive analysis of potential locations, including consideration for transport and urban planning objectives. Common factors to consider during hub site selection include linkage with external transport options, support for comprehensive urban transportation planning, as well as the potential role of the interchange hub in urban renewal and development of new areas. Land use regulations, resettlement issues, and existing zoning restrictions are also important aspects of the preliminary work associated with interchange hub planning and design. Allocating open space is also a key element of a good interchange hub design.

Transport flow analysis and forecasting is a fundamental aspect of the planning and design of an interchange hub. Aside from passenger demand statistics, regional socioeconomic patterns, in city transport network condition, and inter-city connectivity also, influence passenger flow forecasting and its scope. This report outlines the approaches to passenger flow forecasting within an interchange hub, including two-way distribution of passenger flow forecasting (for external transport and internal and external traffic). It also provides basic approaches in multimodal integration, and recommendations on the identification of different routes or subdivisions for each mode of transport. It also suggests associated roles of passenger flow operations, together with urban layout, and supporting methods and facilities.

Passenger flow analysis should focus on the complex relationship between imbalances in passenger demand, long-term uncertainty, traffic management, and surrounding commercial development. It should also facilitate urban development and the provision of a high-quality public transport. The routes and transport modes that will be used to access the interchange hub should be carefully considered during site selection. As a gateway to the city and a catalyst of sustainable urban development, the hub should be well linked with existing transport networks within the city. It is also necessary to determine the size and standards of various transport facilities within the interchange hub in accordance with traffic demand. The internal organization of traffic flow routes within the interchange hub should place emphasis on multiple modes, including subway connections, if any; access and parking requirements for buses, private cars, and taxis; and tracks for walking and cycling. The report provides recommendations for managing the surrounding road traffic system, the introduction of urban rail transit systems, as well as the size, standard, grade, and comprehensive design of the main station.

Core area layout planning reflects the intended functional and spatial uses of the interchange hub. The functional layout of various transport facilities, such as rail transit, bus stations, boarding and drop-off areas for motor cars and taxis, parking lots, walking and cycling tracks should be designed for efficient mobility within the interchange hub area. The planning of core area layout should incorporate the following factors: relationship between the railway yard and the urban structure; feasibility of locating stations on both sides of the railway, potential types of railway stations, condition of surrounding roads, introduction of a rail transit system and station, feasibility and rationality of the project, integration of the components of the interchange hub, and commercial development within the interchange hub.

Carefully planned ancillary facilities within the hub enhance the journey experience. Comfortable waiting lounges, various restaurants, cafes, and shops, well positioned escalators and mobility facilities, clean washrooms and toilets, good information systems and waymarking, and so on, all contribute to a worthwhile experience—making the hub a destination in itself rather than just a structure for passengers. Ancillary facilities within the interchange hub must be based on a multi-perspective design principle incorporating the perspectives of the hub operator, the passenger, and the commercial operator. Hub facilities should be able to cover the wide-ranging needs of all users to ensure a more user-friendly access to the hubs and more efficient day-to-day operations.

Overall, planning for interchange hubs is a complex process as there are various requirements, often with competing issues. Due to the vast territory of the PRC, the requirements of all regions are different and will require a slightly different approach. The design of the interchange hubs should reflect these contextual differences, meaning that individual hubs should be of different scales and internal designs. The effectiveness of hubs goes beyond its function as a structure for passenger transfers. It is also a destination in itself, a gateway to the city, and a major element of sustainable urban development.

This report is published as a complementary document to *Improving Interchanges: Toward Better Multimodal Railway Hubs in the People's Republic of China* (ADB 2014).

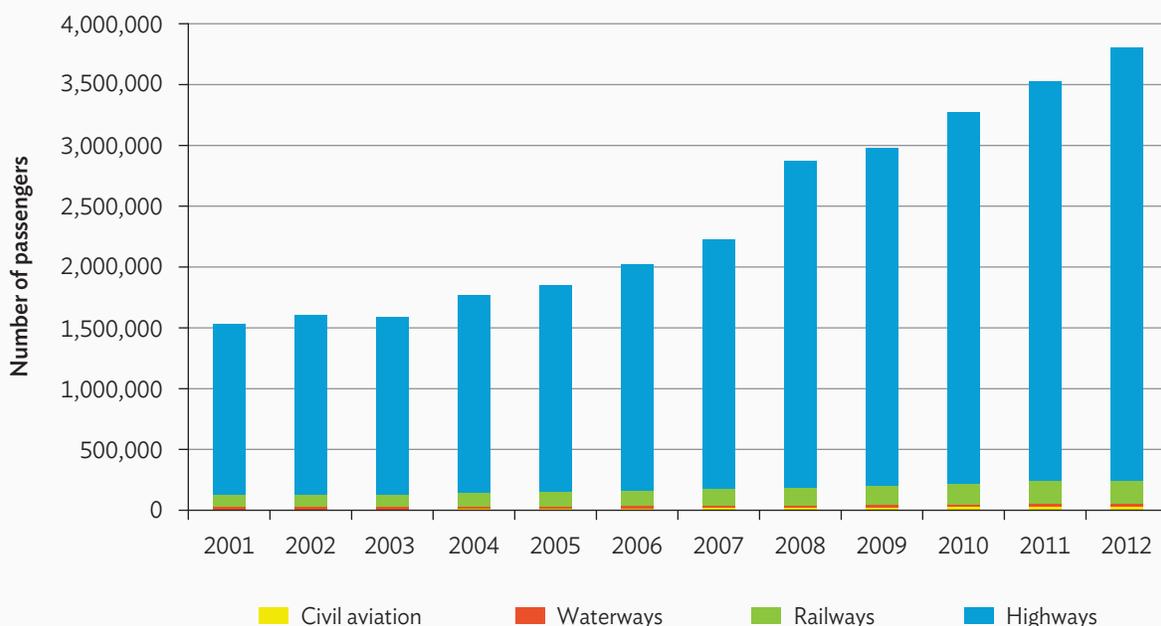
## INTRODUCTION

## Interchange Hubs in the People's Republic of China: Challenges and Prospects for Development

The People's Republic of China (PRC) has gone through rapid urbanization in recent decades and is at a point where the need to establish an efficient public transportation system has become critical. In 2013, 53% of the population (700 million) was urbanized, and by 2030, an expected 70% of the population (about 1 billion) will live in cities (Ollivier et al. 2014). Thus, the competitiveness of new urban centers will be strongly influenced by how well existing transport networks (e.g., road, rail, water, air, and nonmotorized transport) are integrated with each other and into the overall urban fabric.

In the PRC, 93% of passengers travel by road which leads to added pressure on a single (most preferred) transport mode (Figure 1.1). Where there is a lack of an integrated transport system, the pressure on one transport mode often leads to congestion, detrimental to the overall quality of transport and sustainability (Givoni and Banister 2010).

**Figure 1.1:** Annual Number of Passengers by Transport Mode per Year



Source: People's Republic of China. 2013. *National Statistical Yearbook*.

The emerging need for a more integrated transport network creates an opportunity for the development of interchange hub facilities, which can serve as the gateway to the city, facilitating efficient interchange from one mode of transport to another. The interchange hub can become the fulcrum of intermodality and provide seamless journeys, efficient interchanges, and accessibility for all, and further promote the appeal of public transport.

The PRC government has clearly recognized the need for large capacity interchange hubs wherein the Urban Priority Development of Public Transport Guidance, issued by the State Council, emphasized the need to “develop various forms of large capacity public transport, construct transport hubs, and optimize the functionality and layout of transfer center...” In 2010, the PRC Transport Society also established an interchange hub branch. At present, the Ministry of Construction is preparing the urban passenger transport hub construction standards and urban passenger transport hub design specifications.

At present, however, a clear and systematic guidance for the planning and design of interchange hubs is yet to be established. First, urban planning, including comprehensive transport plans, need to be linked with the site selection process for high-speed railway (HSR) stations. Second, there has been no general regulation with regard to interchange hub size and standards.<sup>1</sup> More in-depth studies are needed to strengthen the body of knowledge on interchange hub development. Third, there are relatively few planning layout models of the core areas of the interchange hub. Fourth, more attention is needed on the passenger-oriented features and services of interchange hubs to make the travel more convenient and enjoyable. Fifth, most interchange hubs focus more on being mere transport stations, but not enough attention has been given to how hubs can be more integrated with the overall urban fabric (i.e., transport system and mixed-use development). Finally, since multiple government agencies are involved in interchange hub development, efficient coordination is essential to ensure successful construction and the eventual operation of the hub. Streamlining of roles and harmonization of different development plans should also be considered.

The growth of the modern HSR in the PRC has led to a second railway era. It has surpassed the rest of the world in the past 10 years, with a network of up to 12,183 kilometers in 2013, and has recorded a growth in traffic from 128 million in 2008 to 672 million in 2013 (Ollivier et al. 2014).<sup>2</sup> According to the Twelfth Five-Year Plan, the railway system (including all heavy rail) will accelerate the transformation of its development model, enhance the level of modernization, and construct a railway network that matches economic and social development. By 2020, the network is expected to connect many of the largest cities in the PRC (Zhang et al. 2010). New urban districts are planned around many HSR stations, and these districts are becoming major elements of the urbanization process (Chen, Hickman, and Saxena 2014). These developments highlight the potential of HSR stations to emerge as interchange hubs that can serve as the gateway to the city, while facilitating an efficient and convenient journey experience.

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<sup>1</sup> The examples provided in this report can only be used as reference but are not necessarily enforceable standards.

<sup>2</sup> The passenger traffic growth accounted for 39% of the annual growth from 2008 to 2013.

The shift toward more people-oriented transport planning has paved the way for wide public attention and acceptance of developing interchange hubs. Transportation is no longer as simple as moving from one point to another. Factors such as (i) enjoyable and convenient travel experience, (ii) integrated transport networks that facilitate efficient interchanges, (iii) sustainable and low-energy infrastructure design, and (iv) transport-oriented development have become more important. The growing and evolving needs in transport planning have laid a good foundation for future development.

## Objectives and Scope

At present, there is no standardized guidance that can be used when constructing interchange hubs (including those based around railway stations). The various facilities within an interchange hub (railway stations, coach stations, car parks, etc.) are developed by different government agencies, with each having a unique set of standards and regulations. Therefore, there is a need to establish a more integrated approach to hub planning and design. This report strengthens the existing knowledge on interchange hub planning aimed at a more systematic, comprehensive, and standardized interchange hub development in the PRC.

This report aims to

- (i) discuss urban transport planning concepts concerning interchange hub development,
- (ii) address general planning and design problems,
- (iii) draw lessons from local and international best practices to resolve interchange hub planning issues, and
- (iv) provide basic elements of interchange hub planning and design.

The report focuses mainly on general planning and design concepts in interchange hub development and does not set out detailed methods and techniques, such as actual passenger flow forecasting and modeling, detailed engineering design, and so on. Therefore, it is more suitable for use in interchange hub project proposals, feasibility studies, and other preliminary phases.

## What Are Interchange Hubs

An interchange hub is a transport-transfer nexus created to gather and distribute passengers as efficiently as possible by linking outward-bound urban passenger transport facilities, such as railway stations, airports, coach stations, or port terminals, as well as various inner-city transport systems, such as subways, buses, taxis, and cars. Modern interchange hubs also feature people-oriented amenities and services (e.g., restaurants, cafes, barrier free facilities, entertainment, Internet connectivity, and others) to make the travel experience more enjoyable. This report specifically focused on interchange hubs with railway stations as the central structure (Image 1.1).

**Image 1.1:** Wuchang, People's Republic of China. High-speed rail connects cities, shaping urban and regional development patterns.



## Characteristics of Interchange Hubs

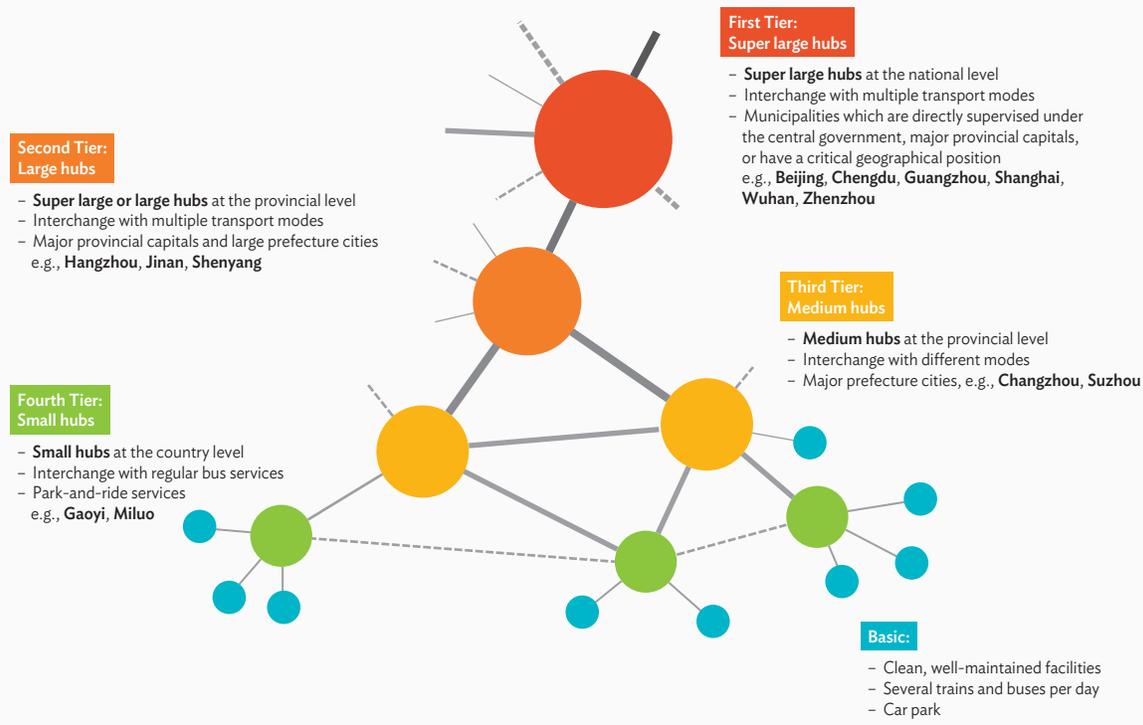
### ► Size Differences of Interchange Hubs

The size of the interchange hub is dependent on the volume of passenger flow, the types of transport modes that need to be catered to, and the role it plays in a local and regional context. In the PRC, rail stations can be classified into super large, large, medium, small, and basic hubs (Figure 1.2). Rail stations that are combined with a subway are classified as large scale, and those without subways are small scale. From a city perspective, rail stations located in large municipal areas (e.g., Beijing, Shanghai, Tianjin, and Chongqing), and managed by the central government, can be considered large-scale interchange hubs. On the contrary, those comprising railway stations in small and medium-sized cities are considered small-scale interchange hubs.

### ► Gateway to the City

An interchange hub is the gateway to the city. It serves both as an access point and as a driver of mixed-use development. The hub functions as a major element of the city's urbanization process rather than merely as a place or station for passengers. The hub can be used as an effective strategy to help solve urban congestion problems, by providing which has positive impacts on surrounding areas, particularly in terms of urban regeneration and development.

**Figure 1.2: Hierarchy of Rail Hubs in the People's Republic of China**



Source: C. L. Chen, R. Hickman, and S. Saxena. 2014. *Improving Interchanges: Toward Better Multimodal Railway Hubs in the PRC*. Manila: Asian Development Bank. p. 9.

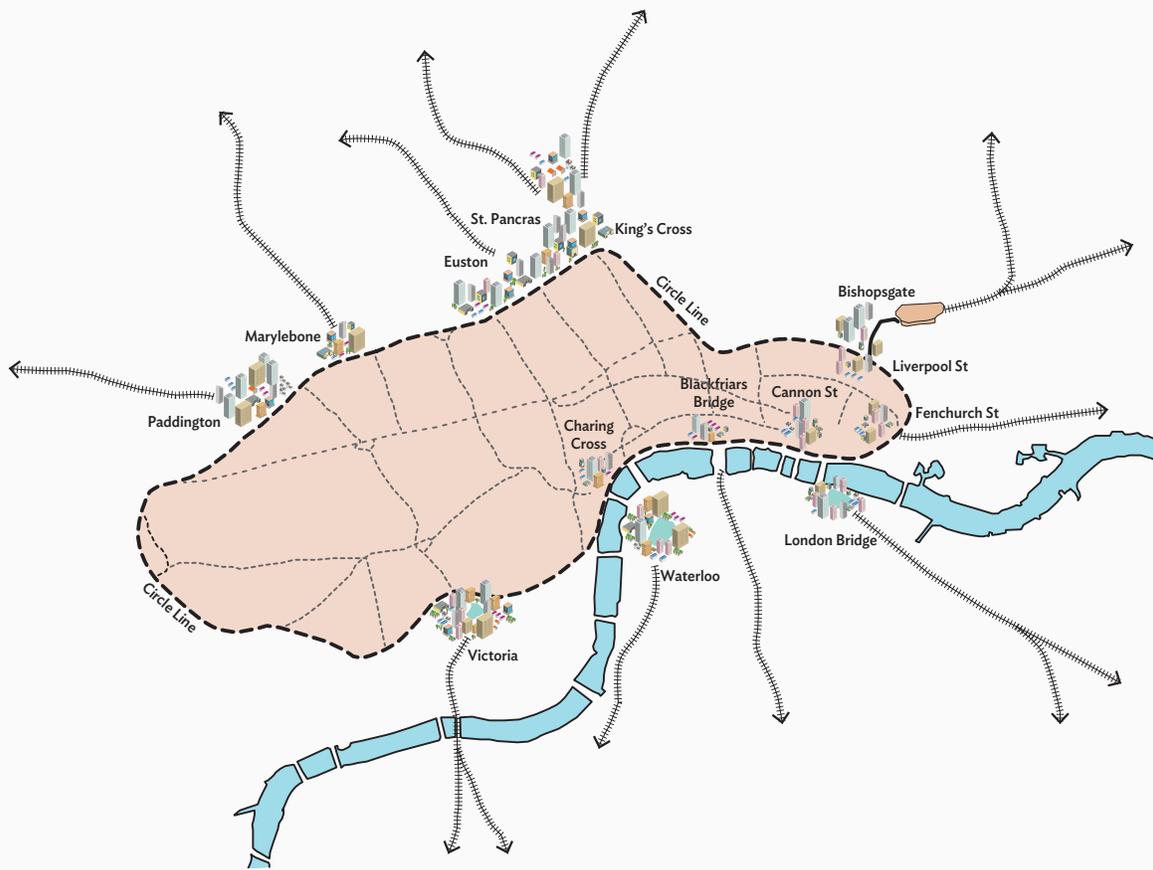
## ► Transport Integration and High-Density Development

Modern interchange hubs have become highly efficient and convenient. The interchange hub links different transport modes in one location, while also improving the efficiency of land use and other resources. Each transport mode supports the other by helping to redistribute passenger overloads among them and caters to passenger commuting requirements and demand. Thus, the diverse needs and features of each transport mode should be considered during the planning and design stage to develop a sustainable and viable design, particularly in terms of construction and operation.

Apart from transport network integration, the interchange hub can also feature commercial and retail facilities and be linked with surrounding mixed-use development. This feature maximizes land use through resource sharing, minimizes travel requirements, and makes the journey more convenient.

This type of high-density development is evident in some European cities as well, where public transport network routes are developed across urban areas and surrounding regions. In London, public transport routes connect many urban areas within a 60-minute commute from the central area (Figure 1.3). Interchange hubs serve as the focal point of transport integration, and the density of development increases markedly around the major interchange hubs (Chen, Hickman, and Saxena 2014).

**Figure 1.3:** Interchange Hubs and Higher Density in London



Source: Terry Farrell and Partners. 2010. *Interchange Hubs and Higher Density in London*.

### ► Driver of Regional Economic Development

The rapid process of urbanization in the PRC necessitates the regeneration of a growing number of older urban districts. Clearly, an interchange hub can be seen as one of the most significant drivers of change for urban development as it brings about wide-ranging economic benefits to the surrounding areas. A good example is the Jinan West Station Site Plan which has had a positive impact on the surrounding areas and, on a wider scale, has facilitated the development of the entire western area of Jinan.

### ► Time Frame of Interchange Hub Development

The development of an interchange hub requires a relatively long time frame from planning stage to construction, until fully operational. The lengthy time scale of hub development can have a significant impact on the overall transport system (e.g., travel preferences, traffic congestion, and others), particularly for residents who live in the areas near the interchange hub or within the city. Thus, the development of an interchange hub should be undertaken in segments, based on the different time frames required. Generally, these can be divided into

three main stages: short term (3–5 years), medium term (5–10 years), and long term (10–20 years),<sup>3</sup> since different transport modes need different construction conditions and operational characteristics. For example, a medium-term plan for railways or urban trams usually takes 10 years, while a long-term plan can take 20 years with large-scale investment. Also, in a long-term plan, the decision making is relatively complicated, particularly compared with a plan involving small-scale investment. In addition, compared with railways or trams, highway- and bus-based interchange hubs are more flexible. In general, in relation to short-term planning, the planners can evaluate the short-term development conditions required for an interchange hub and then carry out specific detailed planning and design. In the longer term, planners can focus more on the sustainability of hub operations given evolving transport demands, clean energy challenges, and climate change risks.

### ► Spatial Range of Influence

The interchange hub has both direct and indirect areas of influence on the neighborhood where it is located. An area of direct influence of an interchange hub refers to that which is directly covered by transport services. This means that travel can be completed using the transport network of the interchange hub, resulting in convenient traffic conditions.<sup>4</sup> The area of indirect influence scale covers a wider area that is typically not directly connected with the transport network of the interchange hub. The hub can have an impact on the communities located in the peripheries of the transport network.

The study of interchange hub planning scales could help to resolve connection and matching issues between an interchange hub and its surrounding road network, by ensuring that the access points to and from the interchange hub are located appropriately, the surrounding road network capacity is sufficient, and the strategies to meet traffic demand are feasible. However, it should be noted that passenger transfer behaviors often take place inside an interchange hub, which means that stations and platforms for different modes of transport within an interchange hub are the main areas for the gathering, transfer, and distribution of passengers. Thus, the efficiency of an interchange hub also relies on the internal traffic flow within an interchange hub, and its organization.

Figure 1.4 shows an example of spatial range of the Jinan West Station.

## Factors to Consider in Interchange Hub Planning and Design

### ► Conforming and Contributing to City Planning

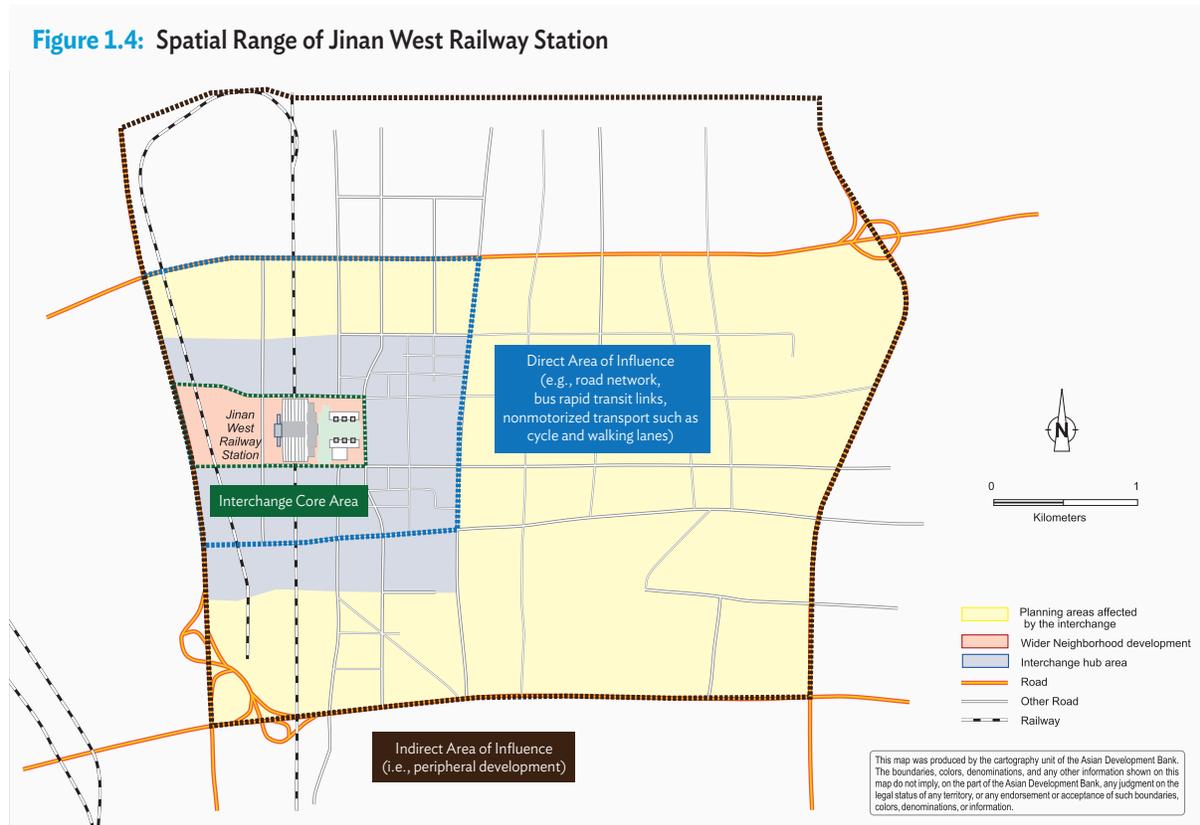
Being the gateway of a city and the focal point of transportation networks, an interchange hub has great potential for development and can be the most vibrant part of a city. Therefore, the scale and location of an interchange hub should be harmonized with the overall development plans of a city. In addition, since the primary purpose

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<sup>3</sup> W. Wang. 2007. *Transport Planning*. Beijing: China Communication Press. pp. 7–8; Y. Zhou. 2011. *Highway Cargo Transport Hub Layout and Planning in Jinzhou Municipality*. Master thesis collection, Jilin University.

<sup>4</sup> Common indicators of convenient traffic conditions include the (i) duration of travel (i.e., generally within 2 hours), (ii) distance covered (i.e., generally within 1 kilometer), and (iii) number of transfers (i.e., generally no more than two, including connections with trams).

of developing interchange hubs is to improve transport efficiency, the layout and land use of an interchange hub should be planned to be as high density as possible to avoid unnecessary waste of space and mobility requirement. When it involves the use of urban squares or public green spaces, the scale and size of the land should also be considered to provide to passengers an exterior environment that is as pleasant and comfortable as possible. In addition, the interchange hub should be designed to support both transport and commercial facilities to enhance the rational use of land surrounding the hub.



Source: Third Railway Survey and Design Institute Group Corporation 2014.

### ► Efficient, Convenient, and Optimal Overall Design

Interchange hubs integrate a variety of transport facilities, and it is essential for all components to run efficiently to ensure overall integrity of day-to-day operations. It is important to follow the guiding principles of the urban master plan during the process of planning and design of an interchange hub to avoid inconsistencies as well as fragmented approach during construction. This type of comprehensive approach will help to achieve optimal overall design. Innovative solutions should also be explored.

### ▶ Promoting the Use of Public Transport

The interchange hub has great potential to promote the use of public transport as it facilitates improved mobility and overall passenger journey experience. The multimodal connectivity needs of commuters must be prioritized. Walkability within the interchange hub, especially on the drop-off and pick-up points between different transport modes, is essential. Hub facilities such as wide walkways, travel-oriented retailers (e.g., coffee shops, baggage stores, entertainment facilities, shopping stalls, spa and massage shops, wireless connectivity, and others), passenger waiting areas, and information centers are all essential features that must be incorporated in the design of the interchange hub. The goal is for the hub to become a destination in its own right, and for the travel to be something that the users look forward to as an enjoyable activity rather than a waste of time. In the long term, the interchange hub can encourage a shift in the commuting culture where convenient and efficient public transport system is preferred over private vehicles.

### ▶ Green Interchange Hub Design

An interchange hub should feature an environmentally responsible and resource-efficient design. Alternative and clean energy should be considered to power interchange hub facilities to improve sustainability and reduce carbon footprint. Green designs such as in-house water treatment facilities, smart building technologies, waste reduction and recycling practices and facilities, and other similar features should also be incorporated in the design. Linkages with green transport modes can also make the interchange hub more ecofriendly. For example, in the PRC, solar paneling has been installed on the platform canopies at the Shanghai Hongqiao interchange station, which can generate an amount of electricity equal to that of a small power plant. In addition, other ways of lowering energy use have also been implemented, such as using ground source heat pumps and soil heat pumps, which benefit the construction and development of the hub. This illustrates that the PRC government has acknowledged the use of sustainable environmental features in developing interchange hubs. There is also a “green evaluation standard” guidebook to refer to when designing interchange hubs, which sets out the sustainable environmental requirements for interchange hubs.

### ▶ Efficient Use of Space

The interchange hub should promote high density development and reduce unnecessary movement within and outside the interchange facility. The efficient use of space must be considered when allocating urban squares or public green spaces. Excessive use of open space without any transport-oriented facilities can reduce the walkability of the interchange hub. Grouping similar facilities and services within the interchange hub is also important to ensure efficient passenger mobility.

### ▶ Sustainable Urban Development and Renewal

As the gateway to the city, the interchange hub can be a major element of urban development and renewal. A busy interchange hub can catalyze mixed-use development and generate a multitude of economic

opportunities. It is essential for the design to be integrated with existing land use regulations and future development plans to ensure that the interchange hub can remain useful in the future years.

### ► Feasibility Study and Detailed Project Design

Careful planning is required, especially for large-sized interchange hubs, given that multiple components are rarely constructed and put into operation simultaneously. Phased implementation may be considered as an option. Feasibility study and detailed engineering design are critical elements to ensure project readiness, especially for interchange hubs with technically challenging requirements. To ensure that the design of the hub is in line with prescribed industry standards, the China Railway Corporation (CRC) leads the review of preliminary design of rail stations, while local construction departments provide support in reviewing local project components (subway stations, municipal transport facilities, etc.). Interchange hub planners must also consider design standards for different transport regulations, professional design standards, as well as local laws and regulations (Table 1.1). Thus, multiple entities involved in hub development should be well coordinated to ensure synergy and successful project implementation.

**Table 1.1: Local Laws and Regulations**

Transport Regulations	Professional Design Standards	Local Laws and Regulations
<ul style="list-style-type: none"> <li>Railway Station Building Design Specifications and Railway Station Yard Design Specifications</li> <li>Coach Station Design Specifications</li> <li>Metro Design Specifications</li> <li>Urban Road Design Specifications and Parking Lot Design Specifications</li> </ul>	<ul style="list-style-type: none"> <li>Civil Architecture Design Principles and Civil Architecture</li> <li>Design Fire Protection Specifications for Architectural Design</li> <li>Architectural Structure Design Specifications</li> <li>Bridge Structure Design Specifications</li> <li>Underground Structure Design Specifications for Structural Design</li> <li>Specifications and Standards Related to High-Voltage Alternating Current, Electrical Information, Roads and Bridges, and Other Facilities</li> </ul>	<ul style="list-style-type: none"> <li>Zoning restrictions, local planning requirements specific to certain areas (e.g., such as in the case where a hub is also a subway station, the design shall also meet the requirements of a subway line), environmental conservation and resettlement regulations, and other local laws and regulations</li> </ul>

Source: China Friendship Development International Engineering Design & Consultation Corporation 2014.

### ► Harmonized Policy Perspective and Stakeholder Participation

Implementing large projects such as interchange hubs requires complementary policies from all levels of the government. At the national level, policies on sustainable transport should provide the broad policy framework that can guide local government units. In addition, coordination among local government units is also important since addressing issues on improving mobility and integrated transport can cut across multiple provinces or localities. It is also equally important to conduct user surveys to identify commuter and operator needs, and incorporate these with the features and amenities of the interchange hub.

## ► Interchange Hub Management and Operations

In the PRC, different types of transport terminals are financed and owned by various government agencies. For example, railway stations in the PRC are planned and financed by the CRC;<sup>5</sup> construction of coach stations is financed by the Ministry of Transportation and managed by local operational departments; and construction of municipal transport facilities is financed by local government and managed by other local authorities. Investment in subway construction is financed and managed by local subway companies, while construction of other facilities, including bus stations, car parks, taxi ranks, and all other public areas, is financed by investment companies, which are set up by the government and managed by other departments. Consequently, various institutions and agencies involved in transport planning and construction needs to be coordinated and united within a larger, holistic organization to facilitate efficient interchange hub design. In this report, the CRC is considered as a coordinating agency, because the central feature of the interchange hub design is a railway station.

In addition, interchange hub planning should also consider the restrictions and standards imposed by technical specifications and the rationality of engineering design, as well as carrying out in-depth research during the planning stage. There are numerous lengthy underground and structural engineering projects involved in interchange hub construction, and the difficulties and restrictions of civil works associated with these will have an impact on construction. Multiple management departments will be involved in the construction, and many construction units will participate in the implementation stage. Interchange hub design and planning should facilitate efficient management during the implementation stage.

## Major Working Stages of Interchange Hub Planning and Design

There are four main stages of interchange hub planning and design (Figure 1.5):

- (i) **Site selection.** This stage refers to the practice of evaluating site options and selecting the best location for the interchange hub. Key factors to consider during site selection include mobility needs, potential for an integrated transport network, land use plan and zoning restrictions, environmental and climate change risks, resettlement issues, proximity to urban centers, availability of basic services, land development patterns, and others. Ideally, interchange hubs should be located in prime areas where connectivity with different transport modes and the facilities within the urban center is maximized, while minimizing environmental and climate change risks as well as the displacement of communities.

**Figure 1.5: Stages of Interchange Hub Planning**



Source: East Asia Department, Asian Development Bank (2015).

<sup>5</sup> The Ministry of Railways formerly had this responsibility.

- (ii) **Transport planning.** This stage involves studies on traffic demand forecasts, public transport flows, and the integration of multimodal transport networks. A traffic flow survey is typically undertaken at this stage. It also defines the scope of transport studies and offers specific recommendations for, and analysis of, the surrounding road traffic system, characteristics of passenger flow, passenger flow forecasting, as well as the size, standard, grade, and comprehensive adjustment process of the main station. Transport planning is important to ensure the proper functioning of the transport network both inside and outside of an interchange hub.
- (iii) **Core area layout planning.** This stage determines the core area layout that enables the hub to facilitate seamless traffic movement and sustainable land development. The core area layout directly reflects the intended functional uses, technical rationality of planning and design, and the spatial influence of the interchange hub. Hub planners analyze ways on how to integrate the hub within the local urban environment as well as the surrounding urban spaces. Different engineering and technical designs are also determined during this stage. Planning for the core area layout ensures that the hub can positively influence future urban development without causing excessive disruption on existing urban structures.
- (iv) **Ancillary service planning.** This stage identifies people-oriented facilities and amenities within the hub to provide a more convenient and enjoyable travel experience for passengers. Well planned ancillary facilities enable the interchange hub to fulfill travel related requirements such as easy transfer between different transport modes, sufficient and comfortable waiting facilities, clean washrooms, barrier free facilities, and the like. In addition, planning for ancillary facilities also includes modern amenities that can make the hub a place for social activities and a destination in itself. These amenities include various commercial, retail, and entertainment facilities (e.g., restaurants, boutiques, cafes, cinema, etc.). Provision of wireless Internet connection and computer stations have also become key elements of the modern hub as these facilities can make the waiting time more productive. Interior design is also part of ancillary service planning.

## KEY GUIDING PRINCIPLES

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An interchange hub can facilitate efficient urban mobility by integrating existing transport networks. It can also enhance the journey experience through people-oriented facilities and features. Beyond improving urban mobility, the interchange hub can also function as a major element of urban development and renewal. In the PRC, new urban districts are being built around modern HSR stations. The huge potential of interchange hubs highlights the need for a guide that can be used by planners, government agencies, and other experts to learn from the good practice that is being developed. This report presents four major stages for developing interchange hubs: site selection, transport planning, core area planning, and ancillary service planning. Each stage requires effective collaboration between different agencies, such as national and local planning agencies, private companies, and the public authorities. Implementing multiple projects at the same time could be problematic and hence needs careful planning. The potential feasibility and rationality of engineering solutions need to be considered, particularly in terms of the overall layout and planning of the interchange hub.

# INTERCHANGE HUB SITE SELECTION

It is essential that the location of the interchange hub is harmonized with urban and transport planning, that is, it should be linked with the urban center, integrated with existing transport networks, and strategically designed in accordance with future development plans. This chapter looks into the site selection criteria and a number of factors affecting the site selection for interchange hubs.

## Site Selection and Positioning of Railway Stations

### ► Railway Route and Station Site Selection Criteria in the People's Republic of China

In the People's Republic of China (PRC), the criteria for site selection for an interchange hub depend on the location of the railway line as a whole, comprehensive development plan of a city, zoning and land use regulations, and various technological and social factors. Among others, the cost of demolition also needs to be considered and regional areas suitable for use need to be identified. All these factors can affect the site selection for an interchange hub. The construction of the railway line should avoid segmenting cities into pieces of land as this approach can result to fragmented land development. It is critical that the site selection for an interchange hub is in accordance with the development goals of the city.

An example of good site selection practice is the Shanghai–Wuhan section of the Shanghai–Wuhan–Chengdu HSR. During the planning stage, there were two route options: northern and southern routes. In terms of engineering investment, the southern route program was estimated to cost less (CNY45.2 billion) than the northern route program (CNY47 billion). However, the travel time was estimated to be less in the northern route (4.6 hours) than in the southern route (7.1 hours), and it would have passed through more provincial capital cities, proving greater potential to enhance regional connectivity.<sup>6</sup> Hence, the northern route program was selected due to its more comprehensive social and economic benefits.

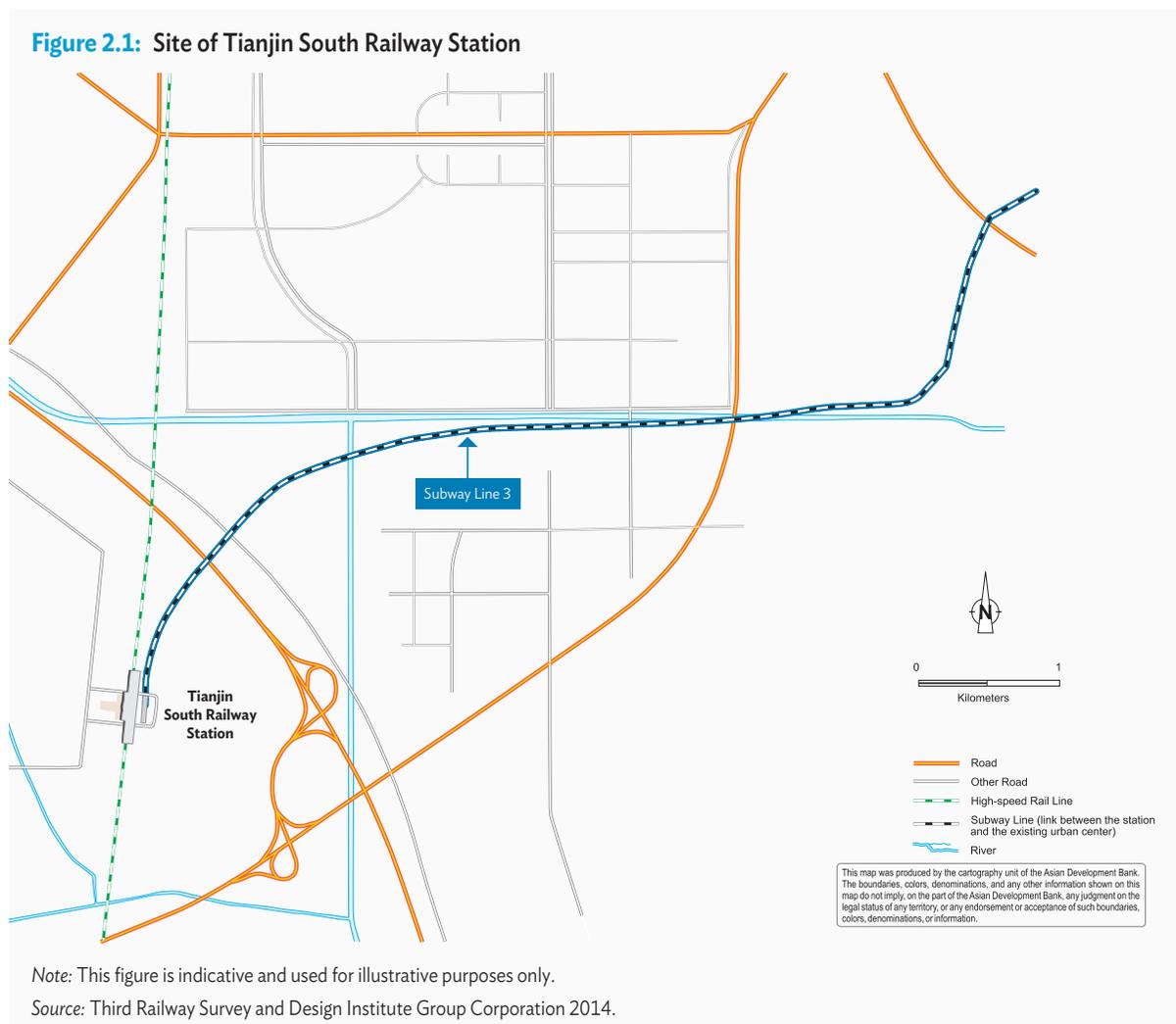
Shanghai Hongqiao station, on the contrary, illustrates how strategic site selection can improve regional connectivity. The station is located at the intersection of three HSR lines: Shanghai–Hangzhou, Shanghai–Nanjing, and Beijing–Shanghai. It functions as a mega transport hub of nationwide significance, and serves the Yangtze River Delta. It has an important role in the integration of regional transport resources, and has great influence in the construction of the urban passenger transportation network in Shanghai.

<sup>6</sup> Shanghai–Wuhan–Chengdu High-Speed Railway. <http://baike.baidu.com/view/620031.htm> (accessed 10 March 2015).

Until the early 1990s, site selection for new interchange hubs was based on the location of existing stations in the PRC. However, with the rapid development of the HSR in the PRC, most HSR-related interchange hubs have been built outside the city center. There are instances of stations within the urban center having adverse impacts on existing development and traffic volume, mainly because of two reasons:

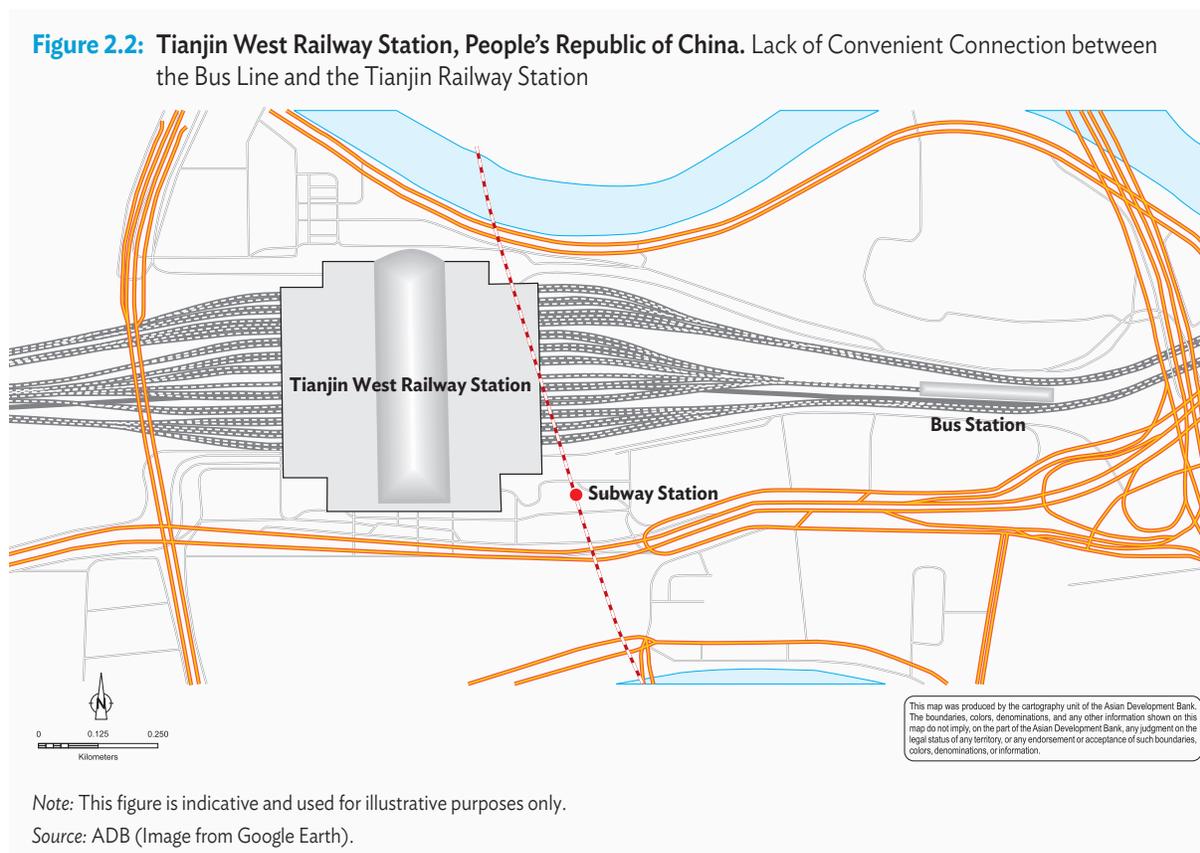
- (i) It is generally impractical to build interchange hubs in the heart of the city because of the large amount of demolition work involved in creating space for an interchange hub. This is one of the main reasons why interchange hubs have to be constructed some distance away from the downtown.
- (ii) If railway lines go through the central zone of the city, the constant noise can be a nuisance for local residents.

For example, the site of the Tianjin South railway station, an intermediate station on the Beijing–Shanghai HSR line, was originally intended to be located in the existing urban center. However, due to the adverse impact this would have had on inner urban planning, the station was relocated to an area farther away from the city center. To ensure easy access between the station and the urban area, Subway Line 3 was built (Figure 2.1).



Another example that illustrates the potential problems of locating an interchange hub within the city is the Beijing–Tianjin HSR railway station. It is believed that one of the most important causes of traffic congestion in Beijing is the location of large interchange hubs in the city centers. Some passengers, who live in the outlying or rural areas of Beijing, have to make their way to the downtown first, regardless of their eventual destinations, to take trains to the other side of the city or to other cities, as some of the main interchange hubs are located at the center of Beijing. These passengers may therefore have to spend extra time commuting from the outskirts of the city to the central zone and then travel back to the outskirts again. There are few orbital public transport links; hence, many passengers end up spending non-value-added time on their journeys.

Locating interchange hubs outside the urban center can also raise transport connectivity concerns, as there can be poor quality of public transport in suburban areas. For example, when Tianjin South railway station was first opened to the public, there were limited bus services and no other means of public transport. Therefore, some passengers had to take taxis or use private cars to and from the interchange hub. Another issue is that planners who design or plan for an interchange hub can overlook the long distances between bus stations and railway stations, such as in the case of Tianjin West railway station. The lack of multimodal connectivity ultimately results in passengers having to walk more than 1 kilometer (km) between the train and bus stations just to transfer from one mode to the other (Figure 2.2). It should be noted, however, that given the large population and high number of passenger transfers in the city, the link between stations can become overcrowded if the train and bus stations are constructed too close together. Therefore, the right combination of multimodal facilities and site planning should be determined. The interchange hub can be constructed on the outskirts of the city, but a multimodal linkage between the hub and the urban center should be established.



### ► Linking Interchange Hub Site Selection with Urban Planning

Site selection for the interchange hub should be harmonized with the urban planning in the city. At present, many interchange hubs are located on the outskirts of cities in the PRC. The goal is to promote outward expansion and develop the areas surrounding the urban centers using railway interchange hubs as focal point. As a result, new interchange hubs in the PRC are usually constructed outside the urban centers where lands are not yet fully developed. Once the surrounding areas develop, the location then becomes the subcenter of the city. However, the interchange hub should serve as the link between the new subcenter and the existing city center to ensure that urban development is not fragmented.

The intercity link between the Beijing South railway station and the Tianjin railway station can be cited as an example, as both are located in the central areas of the respective cities. The locations were selected based on the comprehensive urban development plan for both cities. However, complications can arise in instances where urban planning and interchange hub site selection are not harmonized. When development plans are not put into practice, or they are not applicable, the growth of areas on the outskirts of the city can become fragmented. This has negative implications for interchange hubs constructed outside the existing urban center. In such a condition, even if the city continues to develop over the next 5–8 years, the distance between the city center and the interchange hub would still be too far. Thus, the hub cannot fulfill its function to integrate the transport networks in the city. The hub's range of influence would also be negligible, and it will not be able to affect existing and future land development.

Therefore, urban planners, interchange hub operators, and transport planners should carefully consider harmonizing while also balancing potential conflicts between urban planning and hub site selection. It is necessary to develop interchange hubs based on existing urban planning, while also being aware of the transport requirements.

### ► Polycentric-Based Interchange Hubs

In the PRC, some cities are planned on a polycentric basis with interchange hubs and new city quarters added around the public transport nodes (Figure 2.3). With very large cities, multiple centers are required to spread the central facilities and people spatially. For example, due to the high population density in some megacities in the PRC (e.g., Beijing, Shanghai, and Tianjin), a single link between each interchange hub gradually becomes too congested. The HSR from Beijing to Tianjin was opened to the public in 2008, and just 6 years later, in 2014, it had become saturated with traffic. Consequently, the municipal transport authority was forced to plan for a second HSR line. However, even with the addition of a second HSR line, it will still be difficult to prevent the HSR from becoming saturated in the long term. The ideal solution would be to create multiline links, such as “ring railway lines,” in interchange hubs (Figure 2.4). This method would retain the original links between the lines, while adding an additional loop line outside the city. Multiline links can reduce the overcrowding caused by an influx of rural residents into the city center. Moreover, interchange hubs can attract commerce and consumption to a developing zone, thereby boosting economic development in these areas. This can be illustrated by the HSR line from Beijing South railway station to Tianjin railway station, which passes through

Wuqing (one of the districts in Tianjin). Although the HSR only stops at Wuqing relatively infrequently, Wuqing has become the fastest-growing district (excluding Binhai District) in Tianjin, in economic terms, because having the HSR passing through it during 2008–2014 has enabled business to thrive.

Figure 2.3: Polycentric Urban Development and Interchange Hubs

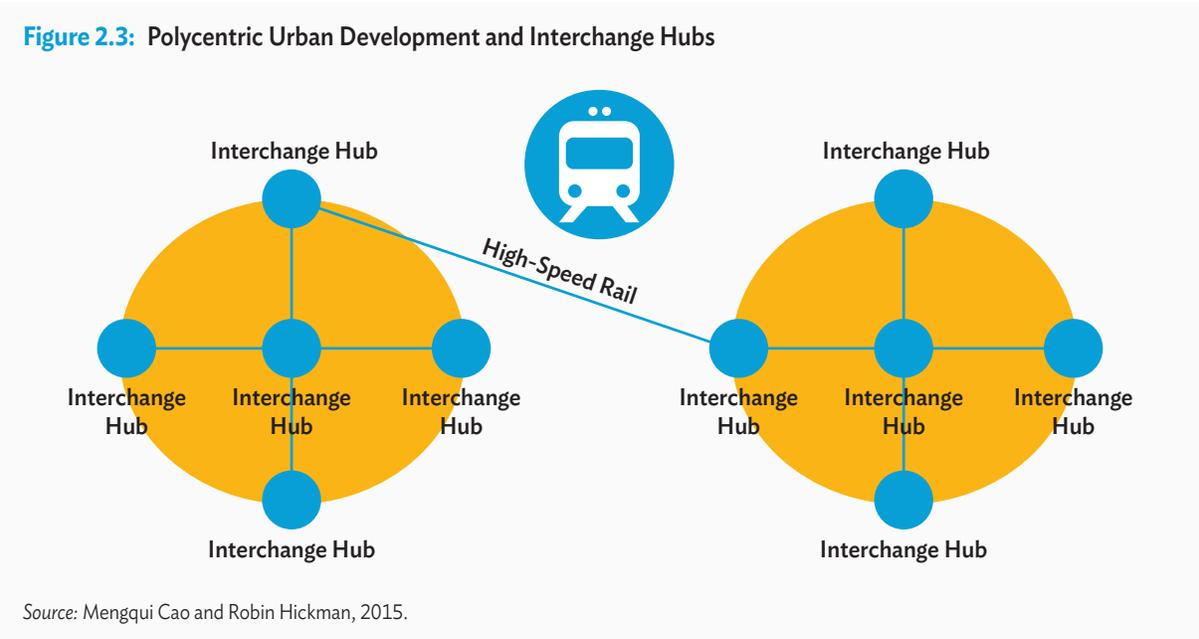
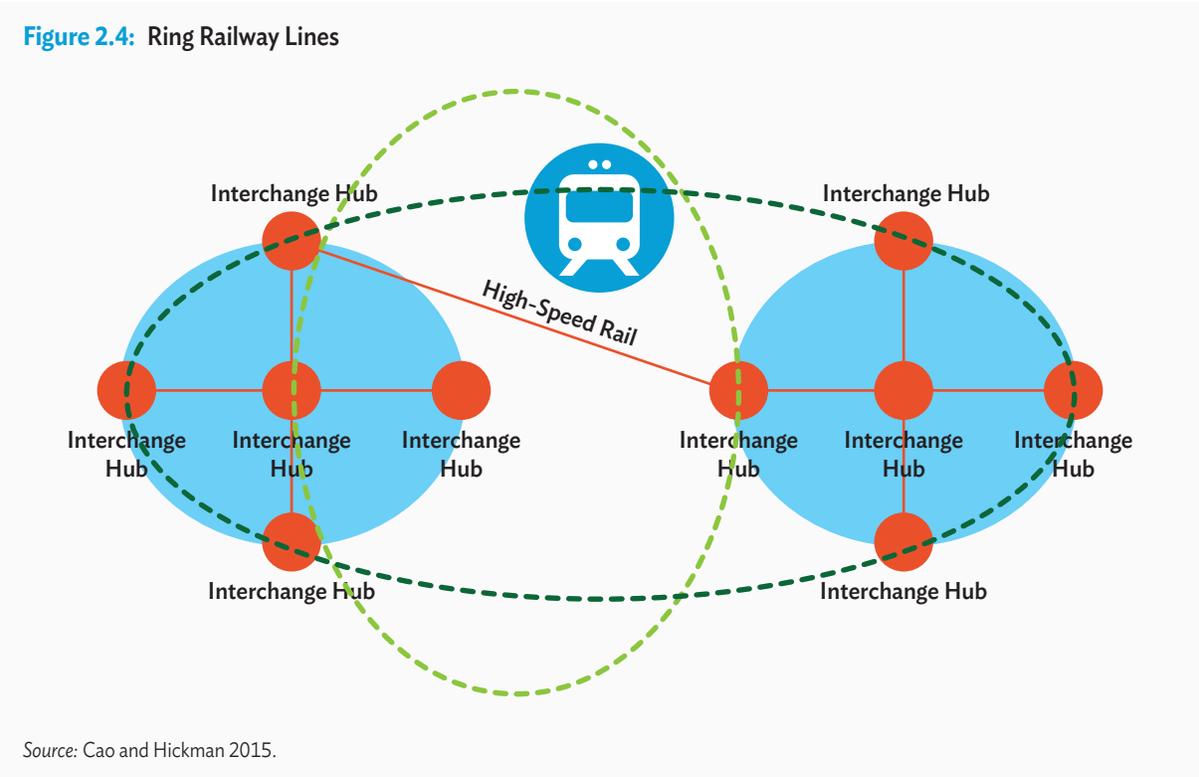


Figure 2.4: Ring Railway Lines



## Factors to Consider during Interchange Hub Site Selection

### ► Harmonizing Site Selection with Different Levels of Urban Planning

The location of a railway station must be closely related to the structure and layout of a city. The site selection for railway stations should be harmonized with both national- and city-level urban planning because land use regulations for railway projects are managed by the macro control schemes in a city. While the construction of railway route is designed as accurately as possible, the site selection for railway stations are often adjusted and refined based on existing urban development plans and actual land utilization. Conversely, urban planning can also be affected by the construction of a railway route. In such cases, the existing urban structure around the station may need to be repositioned, and land use controls (zoning restrictions, types of allowed land use, etc.) may also be changed accordingly.

### ► Interactive Planning for Transport Stations

A railway station developed as an interchange hub can result in more efficient land utilization. In a large-scale interchange hub, transport-oriented development should be streamlined to minimize land wastage and enhance the appeal of using public transport facilities in a city. Proximity to other transport stations (e.g., airports and bus stations) should also be taken into account, and ways to integrate and link different modes of transport through the hub should be planned. For example, the interchange hub can be built and incorporated with large airport sites. In the case of small interchange hubs, railway stations are usually connected to bus stations. The interchange hub should also be linked with nonmotorized transport modes, such as cycle and walking facilities. A number of interchange hubs in northern PRC have links with coach stations (Table 2.1).

For example, when the plan for Tianjin West railway station was proposed, as one of the railway station stops on the HSR line between Beijing and Shanghai, the regeneration plan for Tianjin West railway station was given high priority by the municipal government of Tianjin. A comprehensive regeneration plan was then drawn with the aim of developing the areas surrounding the station. Now, there is much new development happening around the station, and the peripheral areas are still being developed and regenerated. Thus, the Tianjin West railway station has facilitated the urban regeneration of its surrounding areas. Planning is usually regarded as a major component of a mega transport infrastructure project such as the interchange hub. A proposal for an interchange hub should encompass future plans for the surrounding areas.

### ► Transport Positioning in Cities and Transport Planning Support

The site selection for railway stations affects the location of transport facilities for future interchange hubs in a city. Railway stations located in the central areas may evolve and become interchange hubs for the city. In turn, the rail-based interchange hub can integrate transport modes and help manage railway passenger flows optimally and create more convenient conditions for passenger transfer. In addition, the main factors that influence the site selection of an interchange hub are closely connected to its position and function within the city. The interchange hub can improve the level of service offered by public transport and reduce

**Table 2.1: Distance of Selected Interchange Hubs from Coach Stations in Northern People's Republic of China**

Station Name	Construction Site	With Coach Terminal	Coach Terminal Conditions
Langfang	Within city	Yes	Located on the other side of the high-speed rail station, 3.5 km by car
Tianjin South	Tianjin, 20 km	Yes	It is 14 km from the existing coach station
Cangzhou West	Cangzhou City, Hebei Province, 7 km	Yes	The coach terminal and station were constructed together, with the coach terminal located on the side of the station building; the square is located next to the coach parking lot, which is opposite to the bus parking lot
Dezhou East	15 km	No	17 km from railway station to coach station
Tai'an West	Tai'an City, Shandong Province, 6.5 km	No	8.5 km from railway station to coach station
Qufu East	7 km	Yes	Located on the other side of the square, connected by corridors with the railway station
Tengzhou East	6 km	Yes	It is 33 km from the existing coach station
Zaozhuang West	5 km	Yes	It is 33 km from the existing coach station

km = kilometer.

Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Image 2.1: Tianjin Railway Station and Its Surrounding Areas**



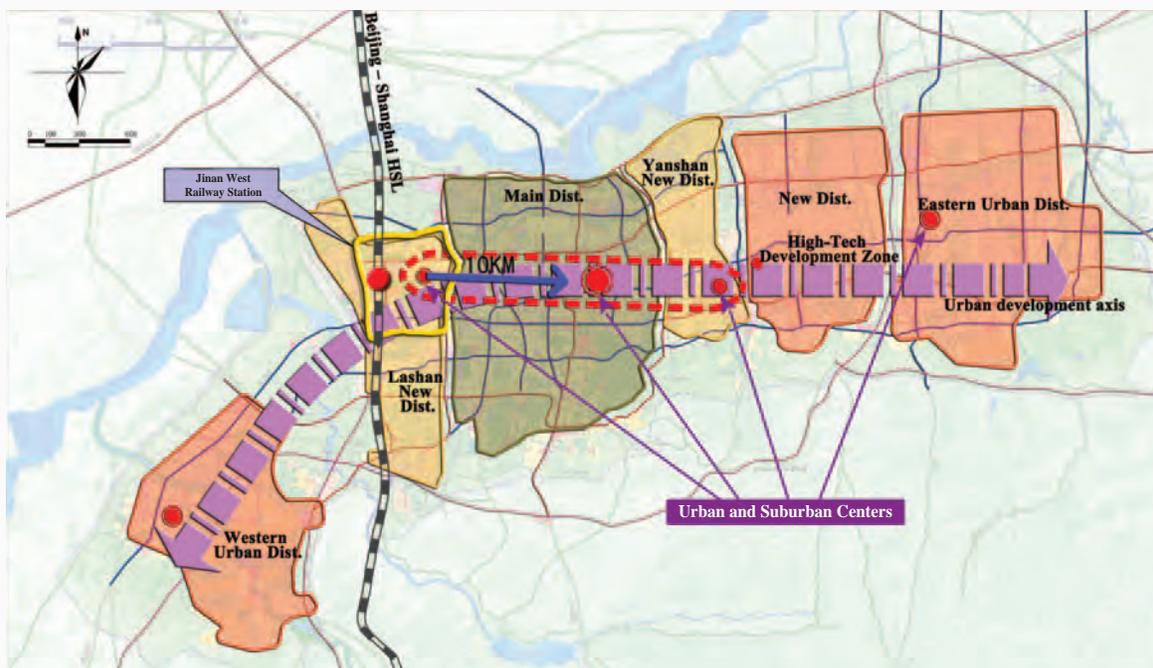
dependence on private cars. A good example is the link between the Tianjin coach terminal and the railway station (Image 2.1). The coach terminal is located on one side of the North Square at Tianjin railway station, which means that the railway station has become a transfer interchange hub for the surrounding districts.

### ► Development Orientation in Urban Areas

An interchange hub can trigger development in the surrounding areas, and can eventually become a supplementary urban center, affecting the future development of the city. The hub also plays a crucial role in connecting the urban center with public transport facilities. Many large cities (e.g., Hong Kong, China; Tokyo; and Singapore) have interchange hubs that serve as the focal point of transfer. This type of transit-oriented development has created a more sustainable development approach for both public transport and urban land use. Jinan West railway station illustrates this type of development. The station is located in the Lashan District, within the main urban planning area in Jinan. The overall planning area is 26 square kilometers and it is 10 km away from the city center. The HSR station has facilitated the development of the whole of the western area of Jinan (Figure 2.5).

The development of Jinan West Station has promoted planning and construction to the west of the passenger station, forming a business and cultural center with an HSR station as its center. Land surrounding the station is used for mixed use development such as commercial, entertainment, and other cultural activities (Figure 2.6).

**Figure 2.5: Jinan West Railway Station Site Plan and Urban Development**



Dist. = district, HSL = high-speed line.

Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Figure 2.6:** Land Use around Jinan West Railway Station



Source: Third Railway Survey and Design Institute Group Corporation 2014.

## ► Land Acquisition and Land Use Conditions

Land acquisition and resettlement costs are important factors in site selection for interchange hub. The construction of interchange hubs may require resettlement that can have adverse effects on existing communities and businesses. The market value of real properties (which includes land and structures) should be the basis of fair and appropriate compensation to be provided to affected communities. Strategies may be explored to minimize the cost of resettlement such as land swapping, land donations, and others. Stakeholder participation is very important to facilitate efficient land acquisition and community resettlement. Table 2.2 shows the cost of land acquisition and resettlement pertinent to some urban railway lines in the PRC, which can vary from 7.6% to 30% of the total cost of investment.

**Table 2.2: Resettlement Costs of Some Urban Railway Lines in the People's Republic of China**

City	Railway Line	Starting Year	Resettlement Costs (CNY million)	Per kilometer (CNY million)	Total Investment (CNY billion)	Proportion (%)
Beijing	Line No. 5	2002	1,289	47	13.497	9.6
	Line No. 10	2003	1,064	43	13.400	7.6
Guangzhou	Line No. 2	1999	883	48	16.272	10.0
	Line No. 3	2003	1,313	37	8.848	8.8
	Line No. 4	2003	571	40	14.996	4.4
	Line No. 5	2004	1,148	36	13.078	7.1
Tianjin	Binhai Line	2001	672	14	7.523	8.9
	Line No. 1	2002	860	33	9.200	9.3
	Line No. 2	2007	743	32	10.751	6.9
	Line No. 3	2007	1,023	34	12.132	8.4
Shanghai	Line No. 2	1997	2,099	111	12.393	16.9
	Line No. 3	1997	2,805	112	9.268	30.3
	Line No. 5	2000	778	45	3.586	21.7
	Line No. 4	2002	4,027	183	14.036	28.7
Nanjing	Line No. 1	2000	673	40	7.018	9.59

CNY = yuan.

Source: Z. Wang and F. Chen. 2008. Reduction on the Cost of Resettlement for Subway Construction. *Urban Subway Transport*. 1. pp. 17–20.

Land in the PRC is owned by the state. There is some real estate development, but people are only given the right to use the land for a limited time rather than outright real property ownership. The lease term for transport land use is determined according to urban planning regulations, and is regarded as urban transport land use. The government will purchase the land to build interchange hubs once the site has been decided. Moreover, investment is taken into account in the construction of the interchange hub as a whole. Thus, if acquiring the land involves compulsory purchase, the government will appropriately compensate the residents of the area.

When the land has been designated for transport use, the residents have to relocate. Often, local authorities have to resolve the grievances of “nail householders” (residents who refuse to be relocated).

### ► **Regeneration of Old Cities and New City Development**

Renovating and expanding existing railway stations to become interchange hubs can affect development patterns of surrounding areas, especially when located within the urban center. Thus, due diligence is critical to ensure that the design of the interchange hub is in line with existing development restrictions (e.g., zoning control, allowed types of land development, construction standards, traffic volume, and others) and environment conditions. In general, the interchange hub layout is relatively compact, because land is both limited and costly in city centers.

There are also a number of railway stations that have been located outside urban centers such as the Hengyang railway station of the Wuhan-Guangzhou passenger line. During the planning stage, there were six site plans, including renovation of the existing station and building of new stations. Although the existing station attracted passengers and was convenient for transfers, it had longer route times, lower technical standards, and would not have met the specifications of the new passenger-dedicated line. Thus, authorities decided to build a new station rather than renovate the existing station. After comparing station building conditions, issues related to project implementation, urban planning and related facilities, passenger travel conditions, attractiveness to passengers, land acquisition and resettlement costs, and other factors associated with the passenger-dedicated line, Hengyang Station on the Wuhan-Guangzhou HSR was eventually chosen. The new station was located 8 km east of the existing Hengyang Station. Although, at the time, the station site was surrounded by a small village, there are plans to move the entire city center eastward in the future. The new station is expected to catalyze development of the city.

Locating railway stations in relatively undeveloped areas are considered to be less restrictive, particularly in terms of land acquisition and resettlement. Therefore, a number of newly built interchange hubs are located in undeveloped or regenerated areas. However, it is worth noting that locating the interchange hubs in relatively undeveloped areas can cause inconvenience for passengers specifically in the early years of operation. Issues such as increased travel costs, lack of mixed-use development (such as retail and commercial shops), transport links that are yet to be fully developed, and others can reduce the appeal of the interchange hub among passengers. It is critical to ensure that the hub is linked with the existing urban center through different transport modes namely subway, buses, walkways and cycle paths.

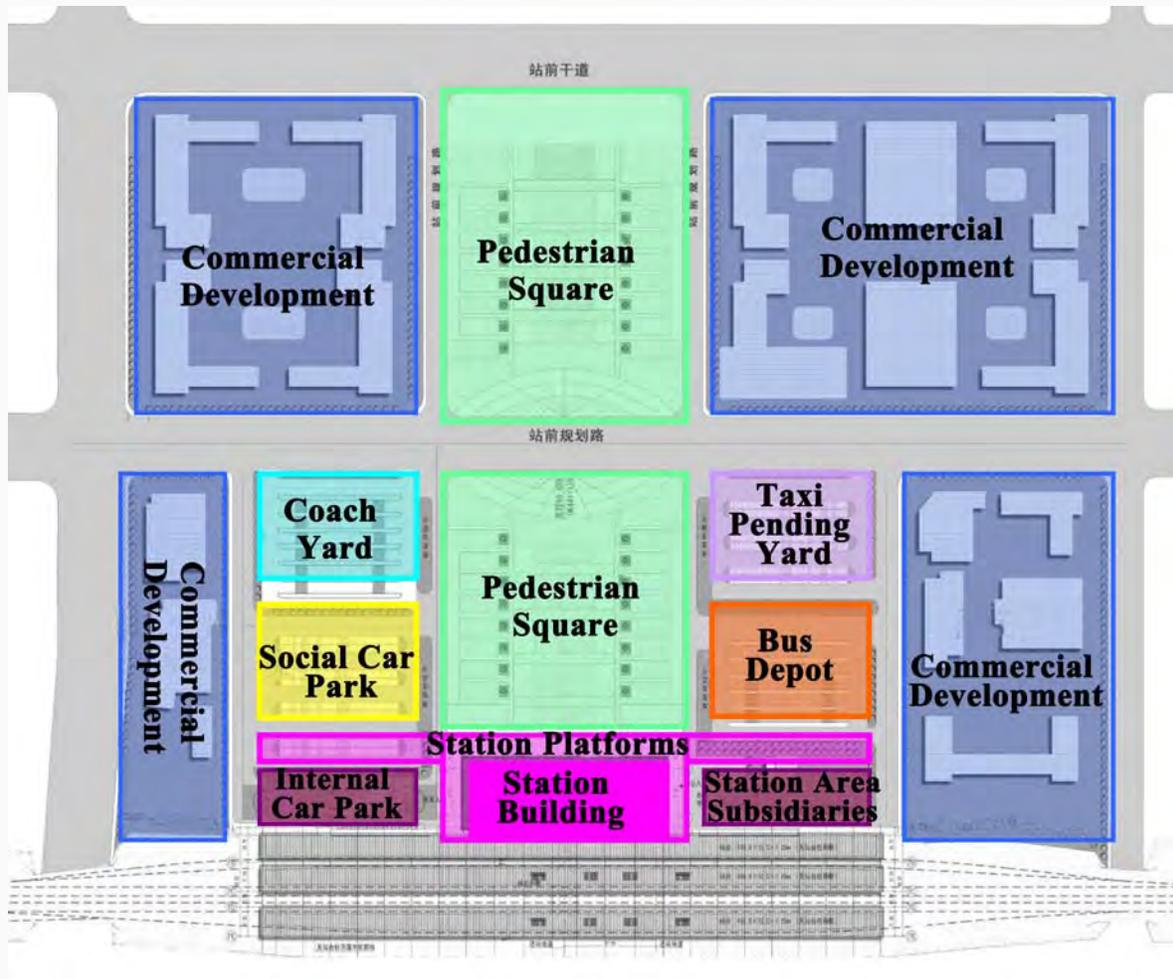
## **Interchange Hub Size and Land Use Analysis**

### ► **Composition of Interchange Hub Land Use**

The composition of land used for interchange hubs may include a railway station, a coach terminal, a bus station, a car park, taxi pick-up points, other distribution stations, pedestrian areas, roads, and undeveloped land. The interior part of an interchange hub should also include ancillary facilities (e.g., operational service rooms and

staff accommodation). Figure 2.7 shows an example of the composition of land used for an interchange hub. Cycle facilities, including cycle routes and parking, are often poor in new interchange hubs in the PRC, and should be improved to a great extent. For example, there are excellent examples in the Netherlands, where small stations relative to standards in the PRC, often have 10,000 or more cycle parking spaces within the interchange hub.

**Figure 2.7:** Interchange Hub Land Use Diagram



Source: Third Railway Survey and Design Institute Group Corporation 2014.

### ► Interchange Hub Station Size

The characteristics of each mode of transport indicate that the corresponding size of each terminal and control over land use have to conform to national standards. The coach station architectural design specifications, classifications and building requirements of coach stations, the code for design of railway station buildings, and the railway engineering design technical manual for terminals and hubs constitute the guidelines and specifications that have been widely used to control the size and use of land during the planning and design stages of various transport stations (Chen, Qian, and Xu 2012; Wu 2011).

As the interchange hub is expected to spur growth in the surrounding areas, space for development expansion should be considered during the site selection process. In general, an interchange hub can directly influence mixed-use development within a 500-meter radius. The influence of the interchange hub beyond this radius can only be regarded as indirect influences, where planning and format distribution will be variable (Wang and Ren 2014).

In addition, it should be noted that, in the PRC, there are currently no specific criteria or design approaches relating to the size or capacity of interchange hubs. However, there are specific regulations for determining the size of railway stations, underground stations, and coach stations. The regulations clearly set out how passenger flow should be integrated with the scale of the stations. Thus, these regulations can be used as guide in determining the size or capacity of interchange hubs. It should be noted that the size of an interchange hub cannot be calculated by adding up the size of each of the facilities involved. The actual size may be larger, because the connections between each station take up more space. Thus, after designing an interchange hub, planners need to check whether the size is suitable. In addition, many railway stations that can also be regarded as interchange hubs have already been built in the PRC; therefore, data from existing railway interchange hubs can also be used to assess the suitability of proposed future hubs.

Some of the early designers were inclined to produce oversized interchange hubs due to overestimation of passenger demand. Hub planners should be able to account for potential changes in passenger behavior as well as technology updates to ensure that the size and scale of hubs are adequate. For instance, most passengers now prefer to buy tickets online or from automated ticket machines rather than buying them from service counters in the booking hall. Furthermore, most passengers prefer to book tickets online in advance instead of having to queue up and buy tickets when they arrive at interchange hubs. The booking hall at Tianjin West railway station can now be seen as an example of wasted space, as most passengers buy tickets online or use automated ticket machines.

### ► Interchange Hub Land Use Control

Capacity control of interchange hub land use has advantages in terms of integration. Preliminary land use control at the site selection stage can involve overlapping of various functions of station land and facility land, while comparison with projects of similar sizes can be useful in understanding which conditions are suitable for future interchange hub commercial development and improvement (Li 2010; Wang and Ren 2014) (Table 2.3). At the planning and design stages of an interchange hub, land use is strictly controlled to ensure greater productivity and efficiency.

**Table 2.3: Interchange Hub Station Characteristics of Selected Interchange Hub Stations**

Station Name	Binhai Station	Hangzhou South	Shenyang North	Jinan West	
Area of Interchange Hub Station <sup>a</sup> (m <sup>2</sup> )	Approximate combined area of North and South squares is 78,000 m <sup>2</sup>	Total area of East and West squares is 92,800 m <sup>2</sup> , gross floor area of approximately 200,000 m <sup>2</sup>	Approximate combined area of North and South squares is 115,000 m <sup>2</sup>	Approximate combined area of North and South squares is 209,800 m <sup>2</sup>	
Underground Space	Underground engineering construction area of 206,000 m <sup>2</sup>	Total area of East and West squares is 66,600 m <sup>2</sup>	Approximate combined area of North and South squares is 71,500 m <sup>2</sup>	West Square underground works of 1,700 m <sup>2</sup>	
Land Nature	Coach Yard	North Square: 5 arrival lots, 20 departure lots	Provided	Not provided	Provided
	Subway	Metro Line B2, B3, Z2	Metro Line Nos. 5 and 11, Hangzhou Shaoxing Line	Metro Line Nos. 2, 4, and 6	Future Metro Line Nos. 1 and 6
	Bus Depot	8 bus lines in South Square, 4 bus lines in North Square	East Square Bus covering 12,800 m <sup>2</sup>	16 bus lines in South Square, 6 bus lines in North Square	Provided
	Car Yard	228 underground car parking lots in South Square and 120 in North Plaza	Total area of East and West squares is 20,900 m <sup>2</sup>	360 underground car parking lots in South Square and 290 in North Plaza	305 car parking lots in West Square
	Taxi Yard	234 underground taxi depot lots in South Square, and 50 in North Square	Total area of East and West squares is 11,500 m <sup>2</sup>	96 underground parking lots in South Square and 60 in North Plaza	West Square parking lot area of 6,900 m <sup>2</sup> (including green belt)

m<sup>2</sup> = square meter.

<sup>a</sup> Excludes rail yard.

Source: Third Railway Survey and Design Institute Group Corporation 2014.

## KEY GUIDING PRINCIPLES

Although a railway interchange hub ultimately follows the methods used in railway route selection, the site selection for an interchange hub should still be harmonized with the existing urban regeneration and development plans as well as transport planning. There are different factors that could affect hub site selection. The location of the hub should be well integrated with the existing transport network to efficiently facilitate large passenger flow volume. Beyond its transport function, the hub should also be linked with the overall urban fabric and become the driver of sustainable urbanization.

# TRANSPORT PLANNING

Transport planning is essential to organize and manage traffic flow to and from the interchange hub. This chapter discusses different transport planning study areas such as surrounding road traffic system, the scale and level of major stations, characteristics of passenger flow in interchange hubs, and concepts and methods for passenger flow forecasting in the context of hub development.

Passenger flow forecasting was also discussed as a tool to predict and manage the volume of traffic for different transport systems. Forecasting passenger flow for interchange hubs plays an important role in determining the site selection and layout of interchange hubs and the scale of various interior facilities.<sup>7</sup> It can also help to support interchange hub organization and improve services between each transport mode. Transport demand forecasting is important for identifying and analyzing traffic conditions to ensure that facilities are of adequate size to cope with existing and future demand.

## Analysis of Impact Factors

An interchange hub is one of the most important components of urban transport. It is created and evolves with socioeconomic and transport development in an urban area, while simultaneously having aggregation and scale effects on the area. Factors that have an impact include regional socioeconomic development, urban structure, regional transport conditions, and the need for sustainable development.<sup>8</sup>

### ► Patterns of Growth and Economic Activities

Patterns of growth and economic activities, both at the city and regional level, affect the overall transport demand within the range of influence of an interchange hub. The derivative demand for an interchange hub is sensitive to socio-economic aspects such as per capita income, consumption level, population density, migration patterns, and the overall pace of urbanization. In addition, the layout and structure of the hub is also shaped by the changes in land development patterns such as the construction and/or regeneration of commercial and industrial centers and other similar activities. For example, the generation and development of passenger demand in the Chengdu East railway interchange station can be regarded as the result of an increasing need for transport caused by steadily improving socioeconomic conditions in Chengdu, Sichuan Province, in the southwest of the PRC.

<sup>7</sup> D. Hu. 2008. *Highway Transport Hub Design*. Beijing: China Communication Press. pp. 1–5; X. Li, W. Liu, and Y. Zhou. 2009. Transport Demand Forecast of Xiamen Transport Hub. *Traffic and Transportation*. pp. 39–42.

<sup>8</sup> S. Zhang and Z. Yao. 2007. *Planning and Design of Highway Transport Hub*. Beijing: China Communication Press. pp. 19–23.

### ► Urban Structure

Harmonizing transport networks with the existing urban structure is fundamental for a well-designed interchange hub. The system of urban land use in the PRC is currently undergoing reform. Differences on land values have resulted to central urban residential areas being transformed to mixed use development. An increasing number of industries formerly located in urban centers have also been relocated to suburban areas. As further urbanization is expected to happen in the PRC, interchange hubs will have to be constructed outside existing urban centers due to inadequate land resources within existing city centers.

Therefore, it is necessary to evaluate the existing and future trends of the urban structure, and consider the impact of the interchange hub on the overall urban layout. The hub should provide locational advantage—the opportunity to reach places efficiently—to the community where it is located. As it has become common in the PRC to construct hubs outside the city center, planners should ensure that the connecting points between regional and in-city transport are established. This will enable the hub to cater to the varying transportation needs of the city and create a truly multimodal system. This enhanced accessibility can be the driving force of more sustainable urban development.

### ► Regional Transport Conditions

The impacts of the existing regional transport situation on an interchange hub can be divided into two categories: (i) the current development situation of various transport modes and (ii) the capacity for transport transfer. On the one hand, improving the accessibility of regional transport will widen the choice of areas for locating an interchange hub, and extend the reach of transport channels, thus expanding the scope of the layout of a station. This, in turn, will generally help to improve interchange hub layout structure. On the other hand, the limitations of urban transport may also mean that an interchange hub has to move outside a city to find a suitable location. Adjusting regional transport conditions appropriately can improve the accessibility of an interchange hub, while satisfying the demand for travel and passenger transfer.

For example, Chengdu North Railway Station is located in the northern part of the North 2nd Section of the 2nd ring road in Chengdu and has a railway as its backbone, while also taking into account the needs of long-distance passenger transport, and connecting many urban trunk roads. There are 22 regular bus lines, 1 rapid transit bus line, and 1 subway line, which are very convenient for passenger transfer. These excellent transport facilities have generated a large amount of passenger transfer activity in the North Station, while making the interchange hub one of the largest in terms of passenger flow in the western part of the PRC.

### ► Effects of Sustainable Development

The dynamic trend toward special agglomeration or diffusion of interchange hubs and the transformation of their unique structure will have an immediate effect on the urban and regional environment. Optimizing the special layout structure of an interchange hub is not only an important part of sustainable development within the transport system but is also vital for the sustainable development of the urban and regional economy.

When planners are considering potential new areas for locating an interchange hub. Therefore, sustainable development will have a very significant impact on the layout and development of comprehensive interchange hubs in the future.

Xipu Station on the Chengdu–Dujiangyan intercity railway illustrates the economic effect of an interchange hub. During the planning and building stages of the station, passenger flow demand was relatively low. However, when the subway lines and the interchange station became operational, commuting became more convenient for urban and suburban residents, while urban construction and the comprehensive development of surrounding areas were also boosted. At present, a transport network with public transport as its main feature, and coordinated development with other transport modes, has been created in the areas surrounding the Xipu Station. Transport links, commuting for urban residents, business travel, and real estate development have thus been improved in this region due to the establishment of an interchange hub.

## Integration of Existing Transport Systems Around the Hub

### ► Influence of an Interchange Hub on the Nearby Road Network

An interchange hub will draw in large passenger flows in a short time, particularly during the rush hour when a large number of trains and long-distance passenger transport coaches arrive. During the period immediately after trains or coaches have arrived, passengers need to be distributed to their various destinations by different modes of transport, such as subways, buses, taxis, private vehicles, nonmotorized vehicles, walking or cycling, a process which will be supported by the surrounding road network. The surrounding road network needs to cope with the large flows of passengers and vehicles from the interchange hub to minimize congestion that can hamper the normal operation of the urban traffic network. Therefore, during the planning stage of an interchange hub, the demand for gathering and distributing passengers should be taken into consideration.

Figure 3.1 shows the Beijing South Railway Station surrounded by an existing road network, which forms a ring road network by connecting surrounding roads with interchanges, and the South and North Zhanqian roads. The ring road has four access points, which help reduce traffic congestion due to large passenger flows on the surrounding road network.

### ► Transit Mode Share Targets

Transit mode share refers to the percentage of passengers using a particular type of transportation (e.g., bus, coach, subway, train, taxi, car, or nonmotorized transport). It may also refer to the number of trips that passengers take in relation to their preferred mode of transport. Evaluating transit mode share enables planners and hub operators to get an overview of passenger demand, develop strategies (i.e., in terms of structure and layout, policies, and marketing) to create a more balanced mode share, and identify the best way to integrate various transportation modes. For instance, in the case of the Beijing South railway station, initial estimates predicted that the subway would accommodate 40% of the total number of passengers, while the remaining 60% would use taxis, buses, coaches, and private vehicles. However, according to this proportional ratio,

**Figure 3.1:** Diagram of Road Network Surrounding the Beijing South Railway Station



Source: Third Railway Survey and Design Institute Group Corporation 2014.

it was found that the surrounding roads did not have sufficient capacity to cope with such a huge volume of passengers. Therefore, another subway line was built to pass through the Beijing South railway station, to accommodate and shift the 60% of the total number of passengers towards the use of the line. This has resulted to a corresponding decrease in road traffic.

**Image 3.1:** Cycle Parking under the Central Station in Malmö, Sweden



Establishing transit mode share targets can enhance the sustainability of the overall transport network. Hub operators can develop strategies and design hub facilities that encourage passengers to shift from the use of private vehicles toward greater use of public transport, especially nonmotorized modes. Recent trends show that mode share targets are aimed toward greater use of walkways and bike lanes, and more interchange hubs are being built with these facilities. Walkways are often linked with nearby commercial areas reducing the need to use motorized vehicles. Bike lanes can also be conveniently linked with bus, train, and subway lines. In Sweden, cycles are allowed in specific train coaches, and extensive cycle parking is also provided (Images 3.2 and 3.3). In other countries, bike racks installed in buses allows for a full multimodal experience (Image 3.4). Thus, analyzing transit mode share within the range of influence of the hub enables planners to manage traffic demand as well as passenger behavior.

It should be noted that nonmotorized transport (i.e., cycling, walking, and other similar variants) has not been taken into account when calculating the transit mode share for railway interchange stations in the PRC. In fact, several railway stations that were built around a decade ago, such as Tianjin West and Tianjin East, did contain parking areas for bicycles. However, these bicycle parking areas were subsequently reduced for the following reasons: (i) cycling has gradually been replaced by perceived “more convenient” methods of transport, such as private cars, underground, trains, and buses; (ii) the volume of private vehicles is increasing, and private vehicles have proven to be more popular than bicycles; (iii) cycle parking provision should be improved, as there is a high risk of bicycles getting stolen if passengers leave them in interchange hubs overnight.

**Image 3.2:** Coaches for Cycle Users in Malmö, Sweden



■ Crotilde Imbert, [www.copenhagengize.com](http://www.copenhagengize.com)

**Image 3.3:** Bike Racks in Buses—Ontario, Canada



■ Mikey G. Ottawa, [www.flickr.com/photos/mikeygottawa/](http://www.flickr.com/photos/mikeygottawa/)

### ► Major Road Standards and Factors to Be Considered in Creating Interchange Hubs

A major function of the road network surrounding an interchange hub is to facilitate traffic gathering and distribution, and to meet the commuting needs of nearby residents. Major roads directly or indirectly leading into an interchange hub from a nearby road network should satisfy two basic conditions: (i) the capacity of the external road network should be greater than the roads within the interchange hub to ensure quick and efficient traffic distribution to and from the hub; and (ii) the road capacity going into the interchange hub can be moderately less than the outbound road capacity, because passenger arrivals do not cause as much congestion, due to the fact that people spend more time waiting for scheduled train departures. However, the pressure caused by passenger distribution is greater at specific times when trains arrive at the interchange hub. When major inbound and outbound roads serving an interchange hub are being developed, it is necessary to consider the accessibility of public transport modes. Public transport should be the major means of transportation for gathering and distributing passengers departing from and arriving at an interchange hub.

## Scale, Standard, and Level of Major Traffic Facilities (Stations)

### ► Determining Size and Standards according to Passenger Flow

The main facilities associated with interchange hubs include railway stations, coach terminals, subway (light-rail) stations, bus stations, taxi stands, general parking lots, and non-automobile parking lots. State regulations, standards, and specifications for planning and design, as well as passenger demand forecasting need to be taken into consideration, when the scale of an interchange hub is determined. Furthermore, the decision process should draw on comparisons with other completed projects, and should fully consider the future development of an interchange hub. Integration and coordination with other means of transport is integral in setting reasonable standards for the scale of an interchange hub and its various transport facilities.

In the PRC, the operation and development of different modes of transport has been administered separately, resulting in the segmentation of regulations and technical specifications by different industries within the transport sector. During the ministry reform that took place in 2013, the Ministry of Railways was abolished and its administrative functions were repackaged and incorporated into the Ministry of Transport, thus creating the opportunity for coherent and unified transport planning and management. However, the current practice in planning and designing of interchange hubs follows consolidated, but varying, specifications. Tables 3.1–3.4 list and describe the different standards and codes used in planning and designing interchange hubs in the PRC. These various codes are also used in forecasting passenger demand.

### ► Adjusting Layout According to Planned Functions

An interchange hub integrates a variety of transport facilities, while bringing together and connecting the spaces used by various types of transport to form a coherent whole. Consequently, the varying standards that apply to different transport sectors should be harmonized to ensure coherence. In this case, planners should ensure that existing norms and standards are adhered to while taking the necessary technical measures to achieve the

**Table 3.1: Specifications and Standards Used for Passenger Demand Forecasting in the People’s Republic of China**

Categories	Regulations	Specification Overview
Railway specifications	Railway Stations and Hub Design Specifications	Specifies the basic regulations for designing a railway station, which include crossing stations, overtaking stations, intermediate stations, district stations, marshaling yards, humps, passenger stations, passenger facilities and passenger traffic equipment, passenger car servicing depots, freight stations, goods yards and cargo equipment, industrial stations, harbor station, hub, and station track rails.
	Passenger Station Construction and Design Specifications	Specifies basic regulations in site selection and the general layout of railway station, station square, station building design, passenger terminal building, fire and evacuation procedures, construction equipment, and others.
	Administrative Regulations of Railway Land Use	Specifies regulations relating to railway land use, including the responsibilities for regulatory organization, construction, land use planning, environmental protection, incentives, and penalties.
	The Railway Transport Safety Protection Regulations	Specifies basic regulations for the overall safety, inspection, and maintenance of railway operations which include railway track and infrastructure systems as well as public awareness campaigns.
Subway	Subway Transport Protection Design Specifications	Specifies the professional design requirements for constructing, structures, ventilation, water supply and drainage, electric systems for air-raid shelters; it also provides specifications for the protective design features of the project area, selection of air-raid shelters, and protective sealing measures for trans-wall pipelines.
	Design Specifications of Subway Transport	Focuses on the safety aspect of urban mass transit, technical requirements for health, environmental protection, resource conservation and safety; it specifies the requirements for the operation, vehicles, speed limits, civil engineering, machinery and electrical equipment associated with urban mass transit.
	Urban Railway Engineering Construction Standard	Specifies the regulations for the construction scale and project components, general layout and railway line engineering, vehicles and speed limits, operational organization and management, station building and structural engineering, mechanical and electrical systems and equipment, vehicles base and associated works, safety protection, environmental protection and energy saving, and the main technical and economic indicators.
Road specifications	Code for Transport Planning on Urban Roads	Provides specifications for urban road planning, construction, maintenance, repair, and management.
	Urban Road Engineering Design Specifications	Provides guidance and specifications for urban road design, including traffic capacity and service level, cross section, plane and vertical sections, intersections between roads, intersections between roads and rail transit lines, pedestrian and nonvehicle traffic, public transport facilities, public parking lots and city squares, roadbeds and pavements, bridges and tunnels, traffic safety and management facilities, pipelines, drainage and lighting, greenery and landscape.
	Environmental Influence Assessment Standard for Highway Construction Projects (Trial)	To ensure the quality of environmental assessment, it specifies the regulations on assessment scope, evaluation standards, contents and methods for assessing the environmental impact of road construction projects.
	Technical Rules for Road Traffic Management Facilities	Specifies the regulations related to road signs, markings, and the settings and design of signal lights.

*continued next page*

**Table 3.1: continued**

Categories	Regulations	Specification Overview
Transport facilities and other specifications	Urban Public Transport Stations, Lot, and Plant Design Specifications	Sets out the regulations for first and last stations on bus route, stop stations, taxi stands, ferry stations, parking lots, maintenance shop, repair shops, and other features related to the operation and maintenance of urban mass transit.
	Outdoor Parking Lot Design Specifications	A design guide for planning outdoor parking lots in large and medium-sized cities as well as key tourist areas, but smaller cities may also find it useful to refer to for implementation.
	Bus Passenger Station Architectural Design Specifications	Sets regulations for site selection and general layout, station squares, station building design, parking lots, fire prevention, and construction equipment, and so on, for railway stations.
	Urban Parking Planning Regulations	Specifies the scale and layout of parking lots, urban public parking lots for public buildings, urban public parking lots, as well as parking lot traffic organization and planning.
	Urban Underground Space Development and Utilization Regulations	Specifies the exploitation and utilization process of urban underground space, which mainly covers the current situation and predictions for future development of underground space, underground space development strategy, development level, content, duration, size and layout, as well as steps in the development and implementation process of underground space.
	Parking Lot Planning and Designing Rules	Specifies the scale, layout, traffic organization, and design of signs and markings for outdoor parking and associated parking lots for public buildings.
	Provisional Rules of Construction and Management of Parking Lots	Specifies the operational management of the construction and postconstruction phases of car parking lots (including new construction, renovation, and expansion).
	Standards for Constructive Traffic Design and Parking Garage/Lot	Specifies the regulations for traffic organization, and design of signs and markings for new and expanded parking garages (lots).
	Large Bus Terminal Layout Planning	Provides detailed specifications for construction standards, layout principles, layout planning, and corresponding measures for large-scale bus stations.
	Mechanical Parking Garage Design Specification	Sets out regulations regarding architectural design, structural design, transportation design, facility equipment settings, and safety design of mechanical parking garages.

Source: Data is from a 2014 interview with experts from Southwest Jiaotong University.

**Table 3.2: Railway Station Design Specification**

Scale of Railway Stations	Maximum Passengers in Waiting Room <sup>a</sup>
Mega stations	More than 10,000
Large-scale stations	2,000–10,000
Medium-scale stations	400–2,000
Small-scale stations	50–400

<sup>a</sup> Maximum passengers in waiting room means the average number of waiting passengers at any time period (for 8–10 minutes) on any day in peak month during a year.

Source: Data is from unpublished official records by the Ministry of Transport, 2007.

**Table 3.3: Road Transport Passenger Station Design Specifications**

Classification	Average Number of Departing Passengers Per Day	Number of Bus Departing Lots	Land Use (m <sup>2</sup> per 100 people)	Parking Lot Requirements
I	More than 10,000	20–24	360	Required number of parking lots is determined by number of departing buses.
II	5,000–9,999	13–19	400	
III	2,000–4,999	6–12	500	
IV	300–1,999	Less than 6	500	
V	Less than 300	Determined by actual usage	500	

m<sup>2</sup> = square meter.

Source: Data is from unpublished official records by the Ministry of Transport, 2004.

optimal overall results. For example, the platform width of subway stations constructed underneath railway stations should conform to the specifications set out in national rail stations' column grid, and be appropriately widened to meet the needs of the overall adjusted structure. Similarly, a railway-based interchange hub design needs to comply with the rules governing the rail area inside the station and those relating to urban roads. The standards adopted for railway station departure tunnels when constructing pedestrian corridors to connect both sides of an interchange hub form part of a new requirement, which is reflected in the large number of interchange hubs currently being planned.

**Table 3.4: Public Transport Hub Design Specification**

Type	Classification	Number of Buses	Land Use	Parking Lots Land Use
Terminus	Large scale	More than 50	90–100 m <sup>2</sup> per bus	For night parking, parking area is determined by the aggregated parking area for all operating buses.
	Medium scale	25–50		

m<sup>2</sup> = square meter.

Source: Data is from unpublished official records by the Ministry of Transport, 2004.

## Characteristics of Passenger Flow in Interchange Hubs

### ► Uncertainty of Long-Term Passenger Flow

The emergence and formation of passenger flows are influenced by many factors, while changing socioeconomic and traffic conditions may also affect the impacts of these various factors. Sufficient data are available to forecast passenger flow accurately in the short term under measurable conditions. However, long-term passenger flow forecasting is more difficult, as the development of long-term social and economic conditions is uncertain and unpredictable, and the factors underlying this uncertainty are relatively complicated.

In the PRC, significant changes in urban development and means of travel, followed by rapid urbanization and motorization, have had varied effects on passenger flow. Moreover, the highly unpredictable decision-making process in various administrative departments has affected infrastructure construction and urban development. Furthermore, the lack of updated information and communication between different government agencies also causes inefficiency, hampering efforts to obtain essential data which are required to forecast passenger flow within an interchange hub.

In addition, different types of passenger travel behaviors, traffic characteristics, and other elements might also cause inaccuracies in passenger flow forecasting. Therefore, attempts to predict passenger flows for interchange hubs tend to rely mainly on short and medium-term forecasting, while applying a gradual progressive approach in relation to the long term forecasts.

### ► **Imbalance of Passenger Flow**

Provinces and cities have varying levels of development and transport system efficiency and accessibility. Such differences are reflected on the imbalance of commuting direction flowing to and from the interchange hub. Furthermore, timing can also cause imbalance in interchange hub passenger flows, due to the effects of holidays, number of journeys, and arrival and departure times. In the PRC, interchange hub passenger flow becomes drastically overloaded during traditional festivals and at times when special holiday arrangements apply (shifting working days and weekends to form longer holidays ranging from 3 to 7 days, Spring Festival, and Dragon Boat Festival, etc.). Furthermore, the morning and evening rush hours in an interchange hub are due to the overlapping functions of inbound interchange hub transport (or urban internal transport). These influence the morning and evening rush hour passenger traffic in the interchange hub as well as on nearby road networks.

### ► **Matching Passenger Flow with the Development Phases of the Interchange Hub**

Interchange hub development is a gradual and dynamic process, which is affected by the regional economy and the transport situation in that region. The effective development and operation of an interchange hub cannot be achieved overnight, and interchange hub passenger flows might be lower during the early stages when it is difficult to attract the expected volume of passenger traffic. Thus, it may not be necessary to open all the planned railway platforms at once, but they can rather be developed and operated in different phases. For example, Chengdu East Railway Station initially opened only nine platforms, but there are now 26 platforms in the interchange hub. Subsequently, more platforms were opened to adapt to the gradually increasing passenger flow and to further improve the efficiency of the interchange hub.

### ► **Attracting Passenger Flow Surrounding the Hub**

Interchange hubs can catalyze passenger flow and urban development. The influence of the hub on passenger flow depends on its role in the local as well as regional transport network. Ideally, the transport network of the hub should connect not only urban centers, but also link other various spaces such as residential, institutional, and

other types of spaces. This can tremendously improve accessibility and connectivity. Consequently, improving connectivity can also create derived transport needs which can catalyze different types of development (e.g., residential, commercial, and other social service facilities). It is important for planners to anticipate the effects of increased passenger flow within the hub. Facilities (i.e., structures, vehicles, commercial and other ancillary facilities) should cope well with the changing role of the hub in the long term.

## Concepts and Methods for Passenger Flow Forecasting

### ► Concepts for Passenger Flow Forecasting

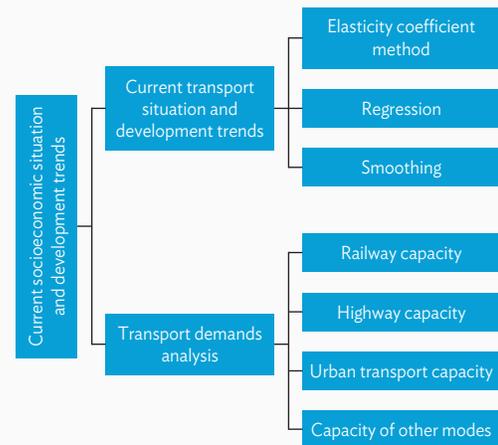
Forecasting passenger flow in interchange hubs is mainly based on the social economy, land utilization, the current development situation of transport, and featured analysis. These data comprise the variables of the forecasting model. In turn, the results of passenger flow forecasts are used as input in determining the scale and layout of the interchange hub. The concepts for passenger flow forecasting in interchange hubs are illustrated in Figure 3.2.

### ► Methods for Passenger Flow Forecasting

The wide variety of passenger flow demand prediction methods can be divided into three types of approaches: qualitative forecasting, quantitative forecasting, and a combination of qualitative and quantitative forecasting.

Qualitative forecasting mainly includes user survey method, expert forecasting method, analogy method, and so on.<sup>9</sup> The user survey method refers to the interview of transport service-oriented customers. The purpose of this method is to determine the plan and intention, means, frequency, and destination of the trip of the traveler in a certain period of time in the future. The expert forecasting method can be seen as a strategy that depends on the knowledge, experience, as well as the analysis and judgment of the expert. The analogy method, on the other hand, is based on typical cases, and compares the similarities between the internal conditions and environment. It obtains similarities in the socioeconomic and transport development patterns to predict passenger flows. This analogy method is particularly useful to cases where other approaches have insufficient data (including historical and real time), or there are complex factors involved in developing an interchange hub, but with very few precedents.

**Figure 3.2: Concepts for Passenger Flow Forecast of Interchange Hub**



Source: Data is from a 2014 interview with experts from Southwest Jiaotong University.

<sup>9</sup> A. Zhou. 2013. *Design and Planning of Transport Hubs*. Beijing: China Communication Press. pp. 58–67.

Quantitative forecasting includes time series analysis, regression analysis, elastic coefficient methods, the growth rate method, and so on. Time series analysis includes exponential smoothing, trend extrapolation, gray forecasting method, and so on.<sup>10</sup> Regression analysis consists of simple regression, multiple regression, and stepwise regression. It is necessary to choose the appropriate method according to the specific statistical sample during the process of passenger flow prediction. Quantitative forecasting methods tend to rely more on historical statistics rather than subjective or value-based factors. This approach can be used in the engineering project feasibility study and the engineering design phase of the interchange hub.

The combination of qualitative and quantitative methods can be reciprocal rather than being mutually exclusive in the forecasting process. For instance, the Delphi method (i.e., an interactive, comprehensive, and analytical forecasting technique based on expert knowledge) can be seen as one of the main approaches to help future decision making.

## Forecasting Passenger Distribution and Transfer Flows

An interchange hub links the inbound and outbound transport of a city and is a major place where distribution and transfer of urban transport takes place. Its passenger flow forecast also includes two aspects: passenger distribution flow and transfer flow.

### ► Passenger Distribution Flow Forecasting

Passenger distribution flow can be divided into outbound transport and inbound transport.

#### *Outbound Traffic Demand Forecasting*

Outbound traffic demand forecasting refers to determining the traffic exchange between cities, and covers railways, highways, and air transport.

**Railway passenger transport demand forecasting.** Commonly used method include multiple regression analysis, gray forecasting method, and combination forecasting. For example, the East Chengdu passenger transport interchange hub currently has about 60,000 passengers per day, reaching about 20,000 passengers per hour during peak hours, with arrival and departures reaching 33 rounds, 5 trains, and 9 lines being used (a total of 14 trains and 26 lines). Transport forecast results indicate that the passengers will reach 200,000 per day and about 50,000 per hour during rush hours by 2030.

- (i) **Highway passenger transport demand forecasting.** The method for highway passenger transport demand forecasting mainly includes multiple regression, time series regression, and auto regression, which separately represent the forecasting models of associated type, successive type, and recursive

<sup>10</sup> Y. Hu and F. Huang. 2012. *Design of Transport Stations and Hubs*. Beijing: China Communication Press. pp. 24–29; S. He. 2012. *Theories and Methodologies of Transport Hub Planning*. Beijing: China Communication Press. pp. 65–68.

type. Highway traffic in the East Chengdu Station mainly provides distribution services for railway traffic, thus highway traffic demand is closely related to railway passenger transport demand. Under current conditions, daily departures average 73 train times, covering nearby districts and counties in Chengdu as well as neighboring cities. In the planned year, there will be greater coverage to better provide evacuation and feeding services for highway traffic, and a reasonable link to other inbound transport means.

### ***Inbound Transport Demand Forecasting***

Passenger transport demand is mainly predicted using railway passenger demand forecasting methods, combined with the effects of city planning and land utilization, especially taking into consideration the passenger distribution in the regular transport modes in other cities.

- (i) **Urban rail transit passenger demand forecasting.** Railway passenger transport demand forecasting method is used, while simultaneously taking into account the effects of city planning and land utilization.
- (ii) **Urban conventional public traffic demand forecasting.** Forecast is based on trip matrix of urban public traffic, where a four-stage transport demand forecasting model is adopted.<sup>11</sup>
- (iii) **Taxi passenger demand forecasting.** Forecast is based on the number of taxis in a city and the regional network connectivity in an interchange hub. Common methods used are time series method, neural network method, and combination forecasting can be adopted for taxi passenger transport demand forecast.
- (iv) **Social vehicle passenger demand forecasting.** Social vehicles facilitates transfer inside the interchange hub. Passenger demand is based on the transfer rate and parking rate in lots, and the common methods used are multiple regression, gray forecasting, or a combination of both.
- (v) **Nonmotorized vehicles and pedestrian passenger transport demand forecasting.** The suitable traveling distance and range of nonmotorized vehicles and pedestrians movement are analyzed by combining the current development situation of the regional social economy, land utilization, public traffic service quality, and the number of vehicles. Consequently, multiple regression or gray forecasting is used to predict passenger transport demand.

### **► Passenger Transfer Flow Forecasting**

There are mainly two purposes for passenger transport interchange hub demand forecasting. First is to take the results as the basis for determining the size of interchange hub facilities, and the other is to analyze future earnings of interchange hub operations, and base the interchange hub transport organization and service system design on the results. Effective forecasting can help ensure the financial viability of operating the interchange hub. In addition, forecasting passenger transfer flow can help determine the overall economic returns and social benefits of the project. Transfer demand analysis should include two aspects, that is, transfer to different means and transfer through the same means to different routes.<sup>12</sup>

<sup>11</sup> W. Wang, X. Yang, and X. Chen. 2002. *Planning and Management of Urban Public Transport System*. Beijing: Science Press. pp. 40–56.

<sup>12</sup> Y. Wen, K. Yan, and F. Cheng. 2005. Interchange Demand Forecast Model of Urban Transport Hubs Based on Travel Chains. *Traffic and Transportation*. July.

Forecasting transfer demand to different transport means typically adopts the Logit model, which is a mature disaggregated analysis. It assumes, in its basic theory, that traveler choice of transport means are normal distribution. Factors such as convenience, speed, economy, reliability, accessibility, and preference are all taken into consideration during forecasting, and in comparison with the variables and processes in the four-stage transport forecasting, a multinomial Logit model can be established that reflects realistic interchange demand.

As for the forecast of transfer demand and transfer capacity, another feasible method is to analyze the transport distribution and the allocation techniques of the four-stage transport demand forecast. A typical method is the gravity model, one of the aggregated data analysis methods, which forecasts demands based on characteristics of modes and interchanges between them, rather than on passenger behaviors. Aggregated analysis can be combined with disaggregated analysis to achieve a more effective demand forecast.

### ► Study on Passenger Flow Allocation

The interchange hub will expectedly accumulate a large number of passenger transfers (arrival and departure) for each transport mode by which it is linked. The proportion of passenger transfer for each transport mode is then reflected on the passenger flow capacity of the hub. Thus, differences in the scale of accumulated passenger transfer (for each transport mode) can result in a different interchange hub location, layout, and scope of services. For interchange hubs where the railway is the major transport means and various means coexist, the direction and source of railway passenger flow (railway terminal, departure, and transfer) determines the scale and layout of the squares on both sides of the railway station as well as the entrances and exits.

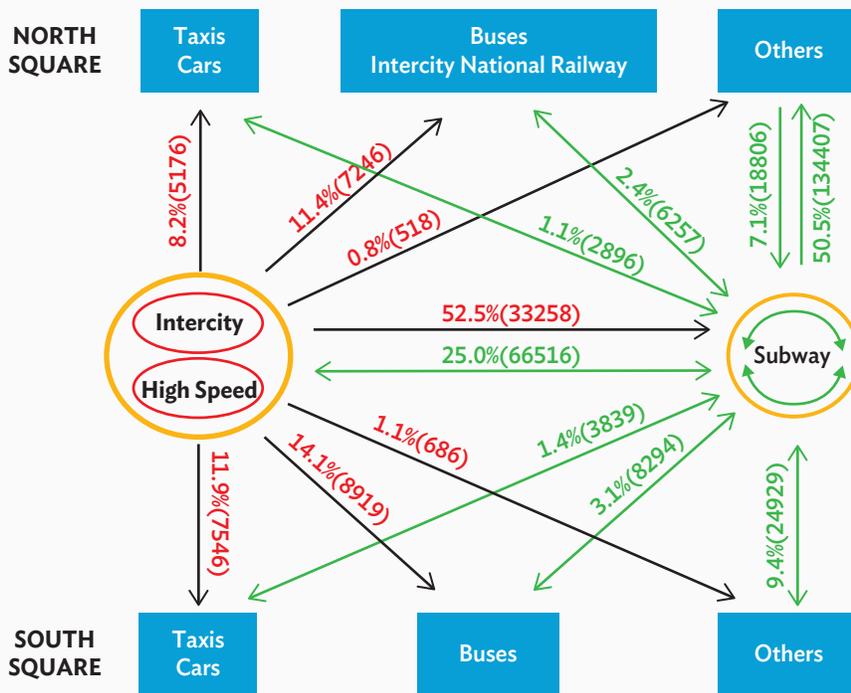
If there is massive reconstruction or a new district is to be built, instructive design can be adopted. The transport links (i.e., various station facilities and route layouts) will be based on the most efficient passenger transfer route. Subways, buses, taxis, and nonmotorized modes of transport can quickly gather and transport passengers in major nodes and relieve road traffic pressure. Therefore, these should be closely linked with the interchange hub. Figures 3.3–3.5 show examples of typical transfer passenger flows in Tianjin railway station. The patterns in day to day commuting behavior illustrate the importance of seamless multimodal connectivity.

## Introduction of Subway

### ► Mutual Dependence between Interchange Hubs and Urban Railway Transport

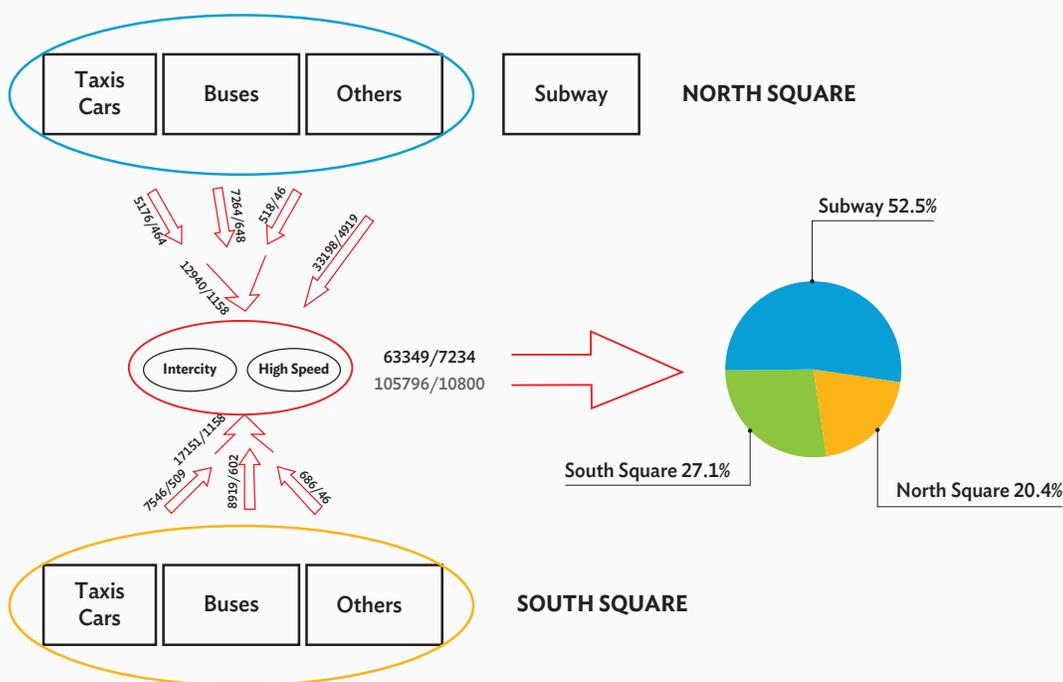
The connection to subway lines is vital to large transport hubs. The presence of subway stations is a key indicator to measure the scale of interchange hubs. At present, all large cities and metropolises are building subway systems. Connecting subway systems to railway stations has now become a common practice and has led to the emergence of large transport hubs. Essentially, large-scale railway stations need to use the subway as the main method and the most effective way for passenger transfer. This is decided by the features of large railway stations, such as large carrying capacity and punctuality. For example, since the ground-level road traffic at the Beijing South Railway Station had already reached saturation during the planning stages, passenger congestion was difficult to solve. The subway alone transports more than 50% of the passenger flow in the station. In other

**Figure 3.3:** Tianjin Railway Station Interchange Hub Passenger Flow Analysis Chart



Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Figure 3.4:** Tianjin Railway Station Interchange Hub National Railway Passenger Flow Analysis Chart

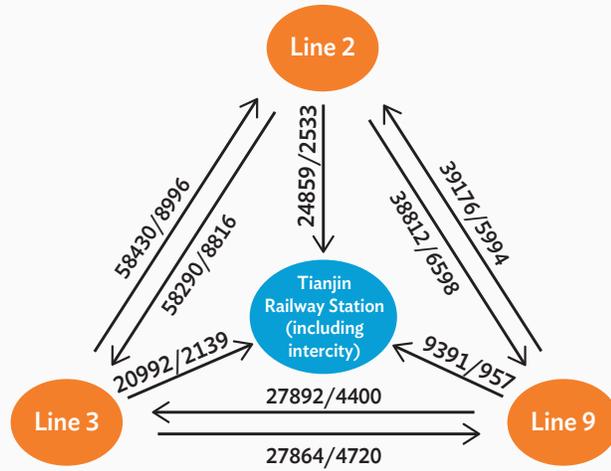


Source: Third Railway Survey and Design Institute Group Corporation 2014.

interchange hubs, subways generally transport more than 30% of the passengers. The calculations for passenger flow distribution can be seen as an example. For instance, if transport planners have to forecast the Beijing South Railway Station daily passenger flow for 2030, daily number of passengers needs to be calculated first (e.g., 286,500 passengers per day in total, which include 121,000 from Beijing–Shanghai high-speed railway, 95,000 from Beijing–Tianjin intercity railway, 1,300 from normal railway, and 69,200 from suburb railway). Furthermore, it is supposed that if there is passenger transfer among Beijing–Shanghai high-speed railway, Beijing–Tianjin intercity railway, and suburb railway at the Beijing South railway station, the transfer number accounts for 5% of the total transport volume, whereas the daily arrival number at the Beijing South Railway Station can be calculated as  $(121,000 + 95,000 + 1,300 + 69,200) \times (1 - 0.05) = 272,175$ . In addition, if passenger flow forecasting is based on the analysis of departure of passengers in 2030, total daily passengers can be calculated as  $(121,000 + 95,000 + 1,300) \times (1 + 0.2) + 69,200 \times (1 - 0.05) = 326,500$  (note that the extra 20% of volume can be attributed to those who are seeing-off and picking-up). Therefore, through analysis and study of the Beijing South railway station passenger flow distribution ratio, it is found that the subway can accommodate approximately 50% of passenger inflow into the interchange hub (Figure 3.6, Image 3.4).

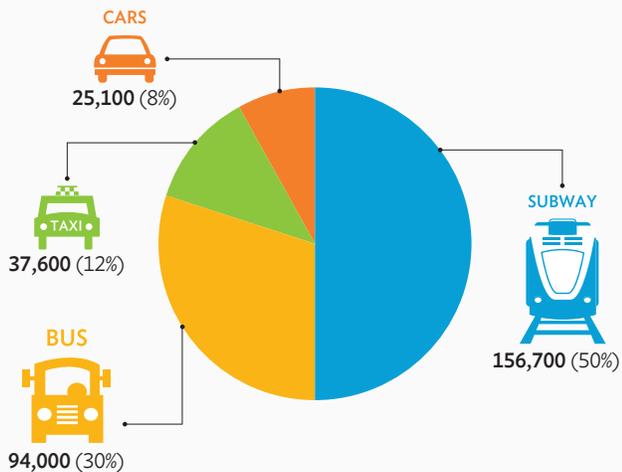
Interchange hubs formed by railway stations play very important roles in urban rail transit networks, as they serve as transportation joints. This is because railway stations can accommodate very large passenger flow, specifically large instantaneous flows. Therefore, it is advantageous to have two or more subway lines linked to the interchange hub to manage passenger congestion. Generally, more subway lines can help diversify passenger flow and increase travel efficiency.

**Figure 3.5:** Analysis Chart of Transfer Passenger Flow between Subway and Railway and Subways in Tianjin Railway Station Interchange Hub



Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Figure 3.6:** Beijing South Railway Station Passenger Flow Distribution Ratio Diagram



Note: Walking, cycling, and others are not counted in.  
Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Image 3.4:** Subway Station—Beijing South Railway Station



China Friendship Development International Engineering Design & Consultation Corporation

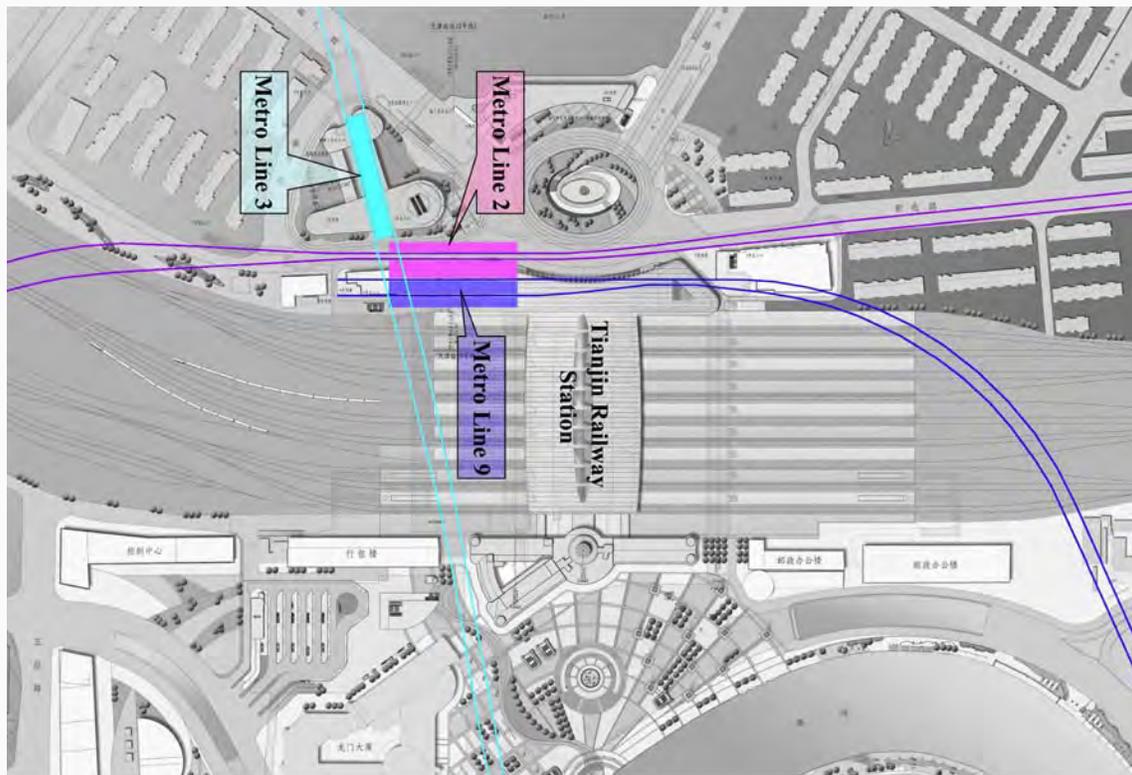
## Forms of Subway Stations

### ► Factors to Be Considered for Setup of Subway Stations

To introduce a subway into a railway station, the interchange hub has to be large and comprehensive. The position and role of a subway line in the interchange hub are important; therefore, the following factors should be taken into account in the planning of the subway station (Figure 3.7):

- (i) **Close combination with railway station.** The subway can efficiently distribute passengers around the urban center. It generally accounts for 30%–50% of the passenger flow at a railway station. Convenient transfer and proximity to the railway station are priorities in the setup of a subway station. The relational position between the subway station and the railway station has various combination modes but is restricted due to various conditions. The most basic mode is to ensure that the transfer is carried out in the internal continuous space and that it is not affected by wind, rain, or snow.
- (ii) **Convenient transfer with public bus, coach, and other traffic.** Subway stations are set up inside a railway station predominantly for relief from railway passenger flow, but if the interchange hub is located in the urban central area, it is generally regarded as the transfer interchange hub within the city; therefore,

Figure 3.7: Diagram of Tianjin Station Subway Transfer Nodes



Source: Third Railway Survey and Design Institute Group Corporation 2014.

convenient transfer by the conventional public bus should be prioritized, and the above two factors should be comprehensively considered while designing a subway station.

- (iii) **Passenger flow service of peripheral areas.** While planning for the layout of a subway station in an interchange hub, the service of peripheral areas should also be considered. During the formation of a large interchange hub, the large-scale commercial development areas are also formed in peripheral areas to balance the transfer with the railway station. The transfer function of the railway station still prevails and is a solution to the problem of linking together the peripheral areas of the subway station through the underground space. Another possible solution is to shorten the distance between the front and the rear stations of the subway station in the interchange hub so that access to the hub from the peripheral areas (vice versa) more convenient.
- (iv) **Utilization of underground space.** Subway stations generally have large underground space. The effective use of this underground space is also a factor to be considered during the research on the planning layout of subway stations.
- (v) **Time sequence of construction.** This is with regard to the underground space between the subway station and the railway station, which will affect the construction duration of the railway station. The comprehensive passenger transport hub has the railway station at the center and the construction of the subway and other auxiliary traffic facilities will affect the progress in the construction of the railway station; in such a case, the adoption of appropriate planning layout and construction methods can reduce the mutual impact during implementation.

### ► Combination with Railway Station

There are four different modes of combining railway station with subway stations namely: (i) complete overlap mode, (ii) semi-overlap mode, (iii) separation mode, and (iv) complete separation mode.

- (i) **Complete overlap mode.** The subway station (underground) and the railway station buildings (above ground) completely overlap with each other. The subway station is located below the railway station, and the platform floor of the subway station is located under the outbound floor of the railway station; the structures of the two systems are combined as a whole, and, therefore, the transfer distance of passengers is the shortest. This type of subway station serves the railway station, and its combination is the closest. It applies to the interchange hub with a coach station but has no strong contact with peripheral areas. The complete overlap mode is very convenient (e.g., Beijing South Interchange Hub), as passengers can get straight onto the railway platforms as they exit the underground station.
- (ii) **Semi-overlap mode.** To accommodate the needs of a square and railway station, the subway station may be arranged at one end of the railway station rather than underneath, and some subway stations are located under the square space. This mode is so one in which the subway station is under the railway station and the transfer is more direct and convenient. At the other end of the station is the square which is more conveniently located near coach stations.
- (iii) **Separation mode.** The subway station is located around the railway station but arranged adjacently. In addition, the transfer takes into account the railway station and other traffic facilities and commercial development in the square. The distance between the subway station and railway station should be as short as possible to ensure efficiency in passenger transfer. Ideally, the transfer distance should not

exceed 80–100 meters (m). This distance is commonly implemented in large interchange hubs that have been built recently. This layout mode has two cases: parallel arrangement in the platform direction of railway station and vertical arrangement in the platform direction of railway station. If there are two mutually vertical subway lines, the T-type transfer form is generally adopted to get much closer to the railway station.

- (iv) **Complete separation mode.** The location of the subway station is separate from the railway station. This situation arises when the railway station and the subway station are constructed as separate projects (without well-defined planning coordination), or when one of the subway stations and the railway station have been built in advance. This mode may result to inefficient and inconvenient transfer. Thus, underground space and tunnel systems that link the stations should be equipped with good lighting, ventilation, and user friendly wayfinding and information systems. Facilities such as escalators, lifts, and moving walkways, and other barrier free facilities should be considered during the planning of the layout to facilitate faster transfer between stations.

## Vertical Planning of Subway Station in an Interchange Hub

The arrangement of vertical planning of a subway station in an interchange hub is generally determined by the design of a railway station. The basic principle in subway station vertical planning is to minimize the number of floors and the depth of the underground project. This reduces investment requirements, and the lifting height of transfers. During the vertical planning of an interchange hub, there are different types of railway stations that can be considered, while the elevation introduced by the subway is limited; therefore, there are various possible solutions depending on the difference in the plane position. However, the following factors generally need to be considered:

- (i) The floor height of the subway station is generally about 8 m, and the height of the floor that passes through the section is generally about 6 m.
- (ii) In the case of two subway stations, the station opened in advance is generally placed on the upper floor.
- (iii) In the case of more than three subway stations, the station with the largest capacity is placed on the upper floor.
- (iv) When the elevation of the subway station has been determined, the construction method and other factors associated with the section and station shall be considered.
- (v) If the open-excavation construction method is adopted, the utilization of the upper space should be considered.

### ► Layout Form of Subway Station in an Interchange Hub

There is a close relationship between the type of layout of a subway station in an interchange hub and a railway station, as explained above, but the relation between plane position and vertical direction should also be considered. At the same time, this is also related to other traffic facilities, especially in terms of the layout of underground space. Each interchange hub is different and, therefore, there are various layout modes and solutions available, but their points of emphasis are different. In the process of research, planners should

therefore be allowed a free rein with regard to their creativity and should not be limited by prescribed methods, enabling them to solve the problem and find the best layout mode through the comparison of various solutions.

During the consideration of the station layout, the overall functional organization of the interchange hub should be considered and the following factors observed:

- (i) The subway payment and ticketing area on the station hall floor is not allowed to occupy too large an area, block the passenger flow, or hinder the smooth operation of the underground transfer hall. In the subway design, it is required that the payment areas of subway stations on different lines shall be connected, the station hall floor of the subway must be located on the transfer hall floor of the interchange hub, and the transfer hall is often divided by the payment area of the subway due to its large size. In general, the payment area is located on one side or another floor is added to the subway station hall.
- (ii) The platform width of the subway station is determined by the calculation of passenger flow; however, the structural column grid of the subway station within the interchange hub is generally consistent with the column grid of the interchange hub; therefore, the platform width of the subway station in the interchange hub should be adapted to the column grid dimension of the interchange hub, and it generally has to be widened to meet the requirements of the relatively central passenger flow of the interchange hub subway station.
- (iii) When a side platform is used in the subway station, the conditions for changing sides should be observed.
- (iv) The entrance and exit points of the subway payment area should be arranged in multiple directions to meet passenger transfer requirements; however, passengers who are circumambient must not be allowed outside the payment area.
- (v) In general, in an interchange hub, the subway station is relatively large in scale and consequently the scale of the equipment room is also large. The scale of the equipment room should be controlled within reasonable limits, as its setup cannot occupy an excessive amount of the effective spatial location of the interchange hub.
- (vi) When the underground space occupied by a railway station, subway station hall floor, and interchange hub transfer space are connected, it should be noted that the use standards for heaters or air-conditioning differ depending on the type of space; according to the premise of openness and transparency of space, the space occupied by each part should either be effectively separated or the design standard for each part should be unified.
- (vii) The subway station in an interchange hub should match the overall spatial design of the interchange hub to create rich spatial form and effects. For instance, the use of shared space, the introduction of natural light, and so on, can form part of the overall identity of an interchange hub station.

### ► Consideration of Project Technology

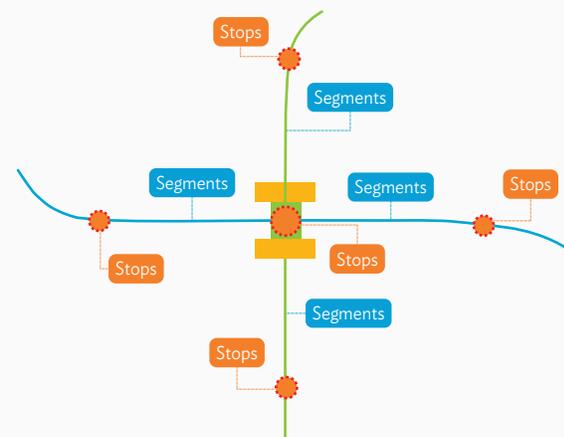
During the research stage of the planning layout of an interchange hub subway station, research into its feasibility and financial viability should be carried out from the perspective of project technology. The rationality of the planning layout can only be determined through the schematic demonstration and comparison of project technology, which mainly refers to the structural design and also includes the construction method used for the main structures and the professional design of ventilation and air-conditioning.

- (i) **Feasibility and rationality of line alignment.** The design of the subway station is closely related to the line alignment of the front and rear sections and is restricted by it. Therefore, research into the rationality of the subway line position should be carried out during the planning layout stage.
- (ii) **Minimize the foundation pit excavation depth of the underground project.** The excavation depth of the foundation pit has a huge impact on investment in the construction of an interchange hub; the subway station platform in an interchange hub is generally located on the bottom floor of the underground space; therefore, reducing the number of underground floors and compressing the floor height have special significance for the rationality of the design of the interchange hub.
- (iii) **Efficient construction of underground facilities.** Underground projects generally require huge investment costs. Given that the subway station within an interchange hub is usually implemented as a reserved project, it is strategic to, as much as possible, minimize the one-off investment required during the long-term reservation period. Therefore, effective measures to ensure the most efficient scope of the reserved project should be considered during the planning layout phase.
- (iv) **Underground ventilation systems.** During the planning layout stage, setting up of a comprehensive and environmentally controlled air shaft for the subway should be considered. Setting up piston wind outlet of this section is an important feature to be considered as it makes the overall volume larger. It is important to determine the position of the wind outlet as early as the planning stage as this will affect the functional layout and landscape of the interchange hub.

### ► Direction and Routing of Subway Lines in an Interchange Hub

To connect subways to an interchange hub, it is necessary to study the location of the subway lines and stops. Usually, planners can consider the stops before and after the interchange hub, which means that one study section will include three stops and two segments, or if it involves a point where two lines cross over, then one study section will include five stops and four segments (Figure 3.8). Since the route planning of subway lines is subject to construction and demolition laws, when the plans for connecting subways are being drawn up, they will need to take into account a significant level of engineering even if the project is still in the planning stages to meet the requirements of feasibility and reasonability.

**Figure 3.8:** Illustration of a “5-Stop 4 Segments” Layout



Source: Third Railway Survey and Design Institute Group Corporation 2014.

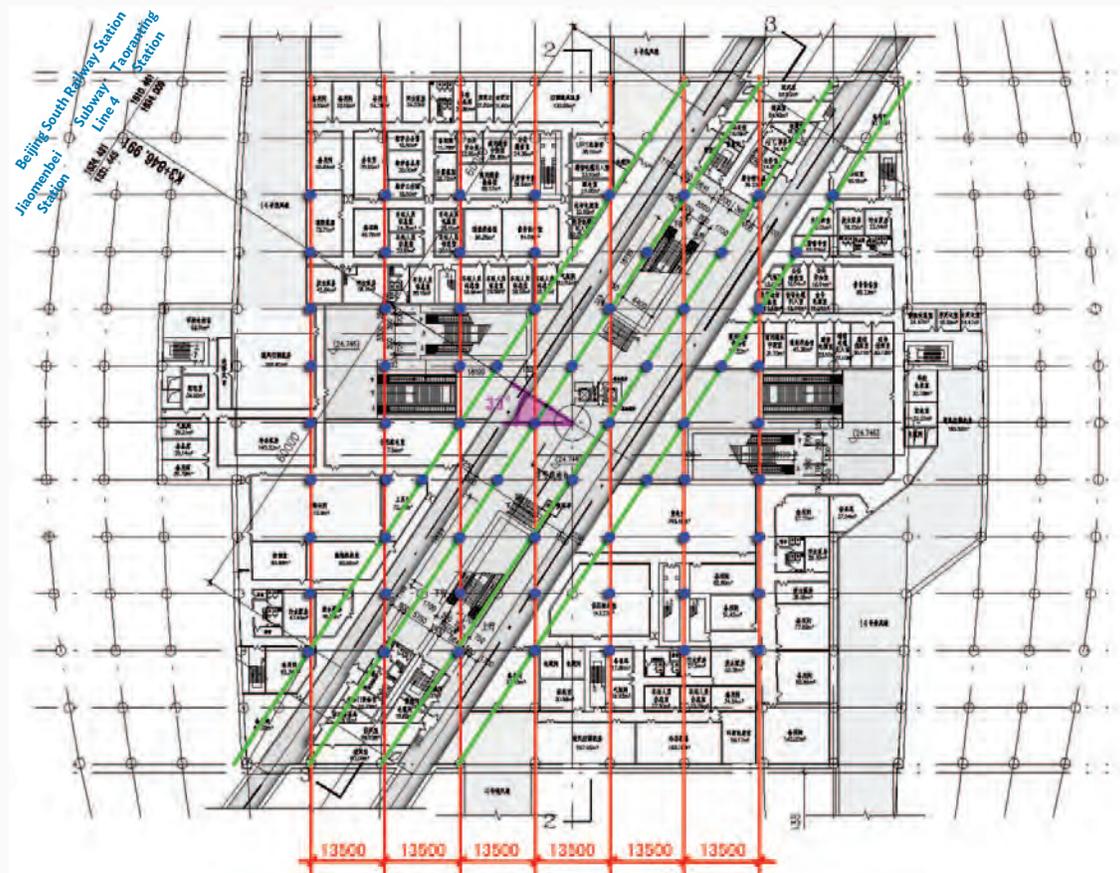
The connection of a subway to a train station takes two main forms: it can run parallel with the railway or it can be vertical to the railway. In order that it can be adapted to the column grid of the train station in an interchange hub, a subway line follows the same trend as the city subway system. However, under special circumstances, the subway line may follow a diagonal route across the railway station. Corresponding measures should be taken in relation to the construction works, and is likely to incur a higher cost.

It is relatively less complicated to construct railway stations in areas where development is still ongoing. Since there are few existing buildings, the connection of the subway can take a more structured form. However, there are manifold constraints in building subways in central urban areas. The surrounding environment and conditions, extending to an area incorporating three stops, may affect the way that subways are connected to railway stations and the overall planning of interchange hubs.

### ► Introduction of a Subway and Interchange Hub Project Construction Sequence

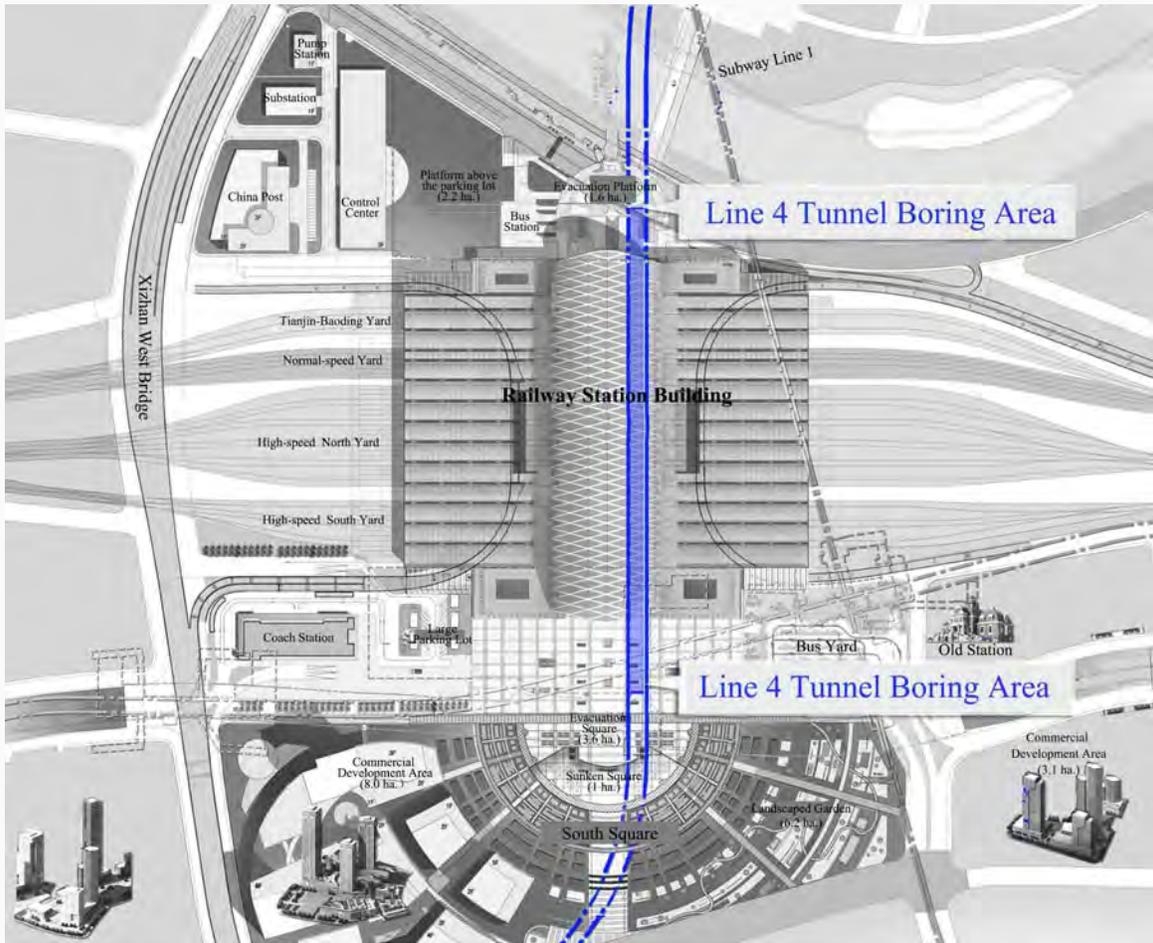
The construction and planning of interchange hubs are part of the long-term development plans of a city. The planning of the subway line network in a city is reviewed annually. Careful consideration should be given to introducing a reserve long-term subway project into an interchange hub during its transportation planning phase. It is generally believed that the integrity of the planning functions of an interchange hub must be guaranteed; the lower the reservation costs, the better. The current reality is that most underground works are reserved for long-term projects to ensure the long-term functions of an interchange hub, which represents a step forward in interchange hub planning. However, through the use of planning studies, particularly those that apply engineering methods to study underground works, ways can still be found to reduce initial investment (Figures 3.9–3.11).

**Figure 3.9:** Diagram of Tianjin West Railway Station Metro Line 4 Shield Tunnel Station



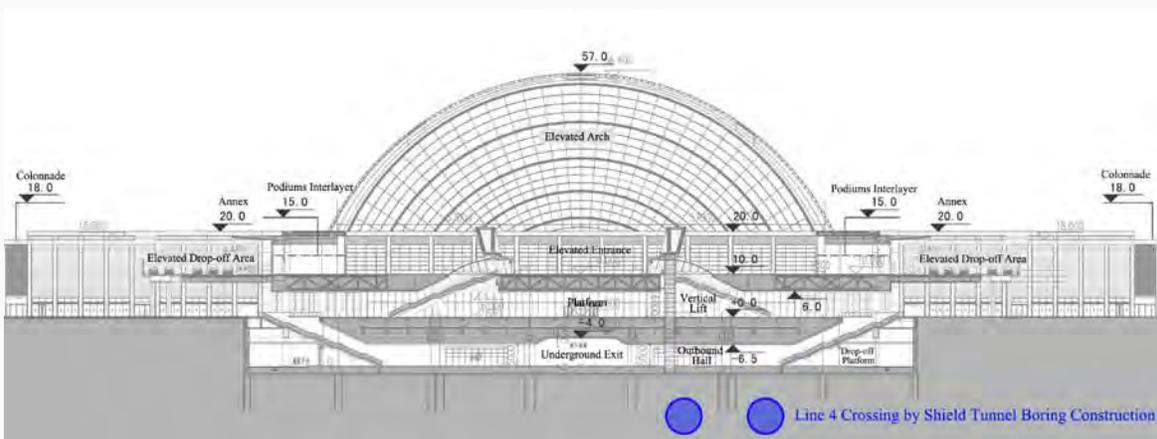
Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Figure 3.10:** Tianjin West Railway Station Metro Line 4 Shield Tunnel Station Schematic Plan



Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Figure 3.11:** Tianjin West Railway Station Metro Line 4 Shield Tunnel Station Sectional Schematic Diagram



Source: Third Railway Survey and Design Institute Group Corporation 2014.

## KEY GUIDING PRINCIPLES

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Transport planning is important to ensure that surrounding transport networks are efficiently linked with the interchange hub. The advantages of different transport modes should be considered to create the optimum conditions and to provide a basis for a viable planning layout. The size, scale, and level of an interchange hub depend on passenger flow. Reliable data should be used when conducting passenger flow forecast studies. The results of such studies should also take the long-term development perspective into account to lay the foundation for a more integrated approach in interchange hub planning. Transport planning should also incorporate passenger perspective for a more balanced approach in managing passenger flows. Ultimately, the interchange hub layout and design should facilitate seamless multimodal integration.

# CORE AREA LAYOUT PLANNING

Core area layout planning reflects the intended functional uses, technical rationality of planning and design, and spatial influence of the interchange hub. Although this part of the project is an aspect of the planning stage, it also falls under architectural design, since most interchange hubs comprise multiple layers of three-dimensional objects. Furthermore, it also involves the spatial layout of each component. Interchange hub planning combines various subtransport facilities and stations, as it has to take into account the entire plan of the interchange hub core area layout. The regional urban planning, the layout of a railway yard, the type of railway station that will be used, the introduction of different modes of rail transport, the rationality and feasibility of engineering sequence implementation and arrangements, commercial development, and other factors are all part of the core area layout plan of the interchange hub. This chapter identifies the main design principles and issues that need to be taken into account when determining the overall layout of the interchange hub. It emphasizes the need to integrate the hub within the local urban environment and more widely within the surrounding city, and discusses different engineering and technology designs.

## Major Factors that Affect the Interchange Hub Layout

### ► The Relationship between the Direction of the Railway Station Yard and Urban Structure

The direction and location of the railway yard is partly affected by the direction of the railway routes but more importantly by technical limitations. In general, it replicates the urban road network structure, whereby the passenger station building and the main roads of the city are linked. However, such link is often limited by various technical conditions. Moreover, since railway yards do not conform to the same specifications or standards as urban roads, effective core area layout planning is essential. An interchange hub, with a railway station as its central structure should be well integrated with the city. There are many examples of interchange hubs where this has been achieved, including Shanghai South Railway Station, Beijing South Railway Station (Image 4.1), and Tianjin Binhai Railway Station (Figure 4.1). All of these examples adopted different approaches, yet their ultimate goals of conforming to the existing city patterns to enable interchange hubs to become effective transition points between cities and railways were the same.

## Feasibility Study of Symmetrical Stations on Both Sides

During the planning and construction stages of interchange hubs, where site selection of railway stations at the center of the city is conducted, planners and project managers decide whether to construct stations on both sides or only one side of the railway line, in accordance with the overall regional planning strategy of the city (Figures 4.2 and 4.3). Various planning options will have a significant impact on urban development and regional

**Image 4.1:** Beijing South Railway Station

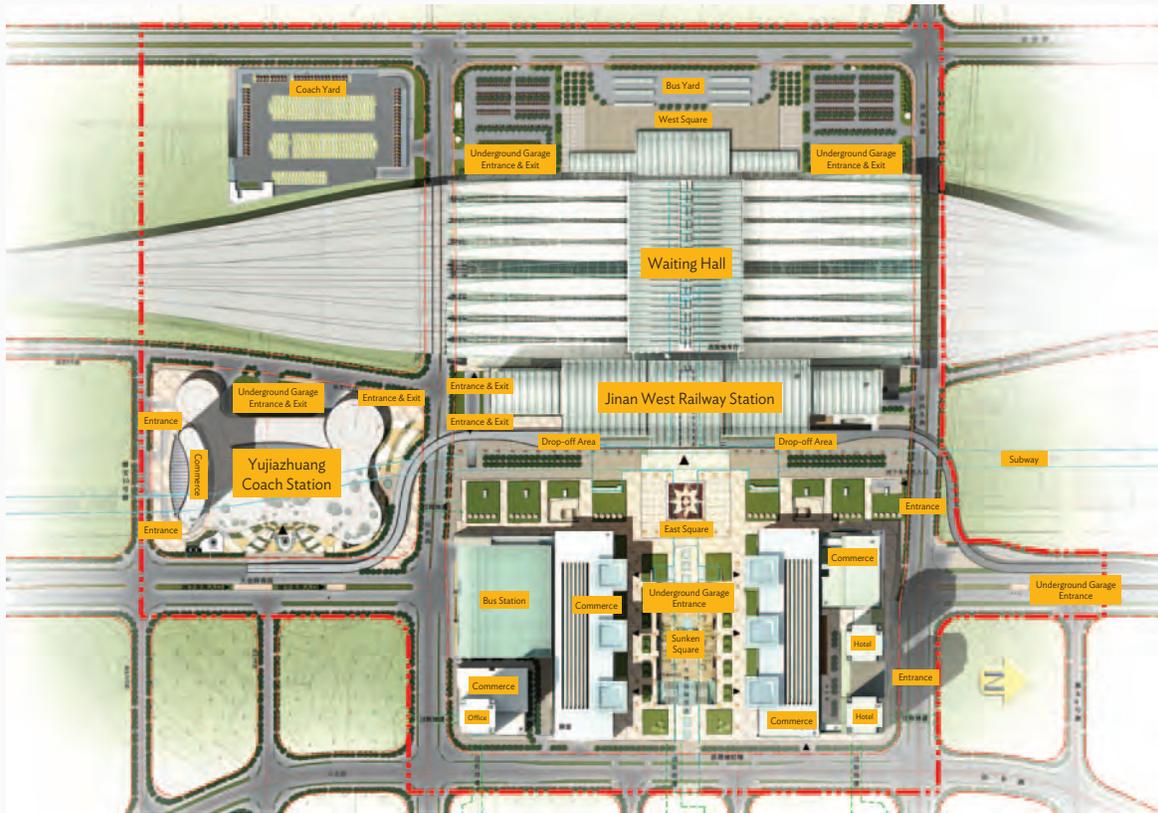


**Figure 4.1:** Tianjin Binhai Railway Station



Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Figure 4.2: Jinan West Railway Station**



Source: Third Railway Survey and Design Institute Group Corporation 2014.

**Figure 4.3: Laiyang Railway Station**



Source: Third Railway Survey and Design Institute Group Corporation 2014.

patterns. In general, when large railway stations are built in the central area of a city, they are usually designed with stations on both sides of the railway line to make it more convenient for passengers arriving from different directions. Moreover, this type of plan will also encourage commercial development around the interchange hub, thereby increasing commercial activity in the region as well as improving the service level of the urban economy.

A design with stations on opposite sides of a railway line should also be accompanied by squares on both sides. Trestles or tunnels should be used to connect the two station buildings together to make transfers more convenient for passengers. The trestles or tunnels should also be easily accessible for vehicles, and thus they play an important role in cities that are divided by railway lines. The connectivity of a city is another important requirement, as stations are the core part of the interchange hub in terms of urban planning. Furthermore, they promote commercial activity within the area and drive regional economic development. Building stations on both sides of a railway line, where applicable, will not only make traveling more convenient for passengers but also promote urban development.

In general, a design with stations on both sides of a railway line will generally include a main square and a subsidiary square. However, each square has different functions and, therefore, the position of the squares are different, as illustrated by the Tianjin Binhai Railway Station and the Jinan West Railway Station. A design with stations on both sides of a railway line also tends to focus more on the importance of connectivity for passengers and vehicle users on both sides of the line, unlike designs with a station on only one side. Passenger walkways are generally located in the middle of the interchange hub, while the passageways for vehicles are arranged around the interchange hub.

For models with a station on only one side of a railway line, the stations are usually small or medium-sized with a front plaza. This kind of station requires all the transport facilities to be integrated into the station or located in front of the station building. The common reasons for choosing to build a station only on one side include (i) station location is far away from the city, (ii) station access on the other side of the railway is not needed, and (iii) requires less investment and is easier to manage.

Considering the continuing trend of rapid urbanization in the People's Republic of China (PRC), it is generally more advisable to build stations on both sides of the railway line. Railway stations within small interchange hubs are often constrained by limited investment, and, therefore, it is not usually possible to provide station space on both sides of the railway line. In this case, it is recommended that connecting corridors should be made available to make access more convenient for passengers.

### ► Railway Station Design

The railway station design is typically a function of the relationship between the designed elevations across the railway station and the planned elevations around the construction area. This relationship presents a choice of different forms of stations, constructed on different planes, using a three-dimensional configuration. The most common forms include the side type, the end type, the low-lying type, and the high-lying type. According to the terrain heights of the station and the square, these four common forms can be further subdivided into other types. Different forms of stations will affect the overall functional layout of an interchange

hub, access to other transport facilities, and the organization of traffic routes. In terms of construction of station-based interchange hubs, the station form, to some extent, determines the layout of the surrounding traffic facilities and routes. Thus, the station form constitutes a core part of the overall planning and design of an interchange hub.

### ► Peripheral Traffic Planning

Interchange hubs are a core part of the urban traffic system, as they connect a variety of functional road networks to services and ensure that they operate effectively. Railways and subways carry a large number of passengers to an interchange hub, following the distribution and transportation of passengers to their destinations via urban road networks. Therefore, traffic planning has an impact on the layout of an interchange hub.

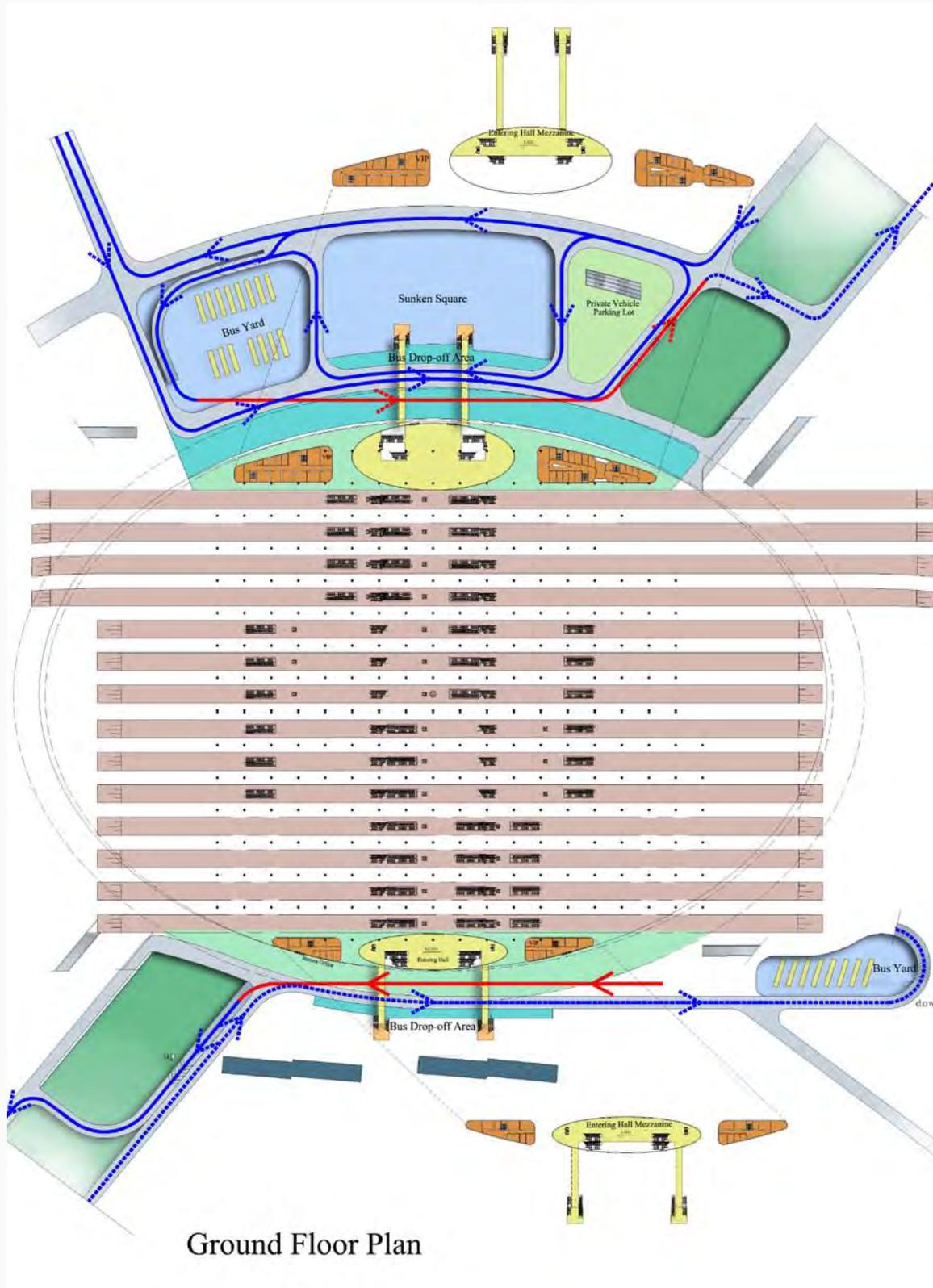
Large interchange hubs are closely linked to surrounding roads and they are able to rapidly distribute and organize traffic in all directions. In most cases, there are surface roads, underground roads, elevated city-level roads, and expressways around an interchange hub, which are in turn linked to urban trunk roads. Roads from small and medium-sized station interchange hubs tend to be relatively simple and only go in one direction. In addition to easing traffic congestion, the effects of the interchange hub on the landscape of the city should also be taken into account. Figure 4.4 shows the different types of roads that are connected to the Beijing South Railway Station. There are two underground bus depots at the north and the south sides of the station. The ground level is designed to deal primarily with the delivery and pick-up demands of large-scale forms of urban public transport. The road layout facilitates an efficient urban road traffic system. The interchange largely meets the delivery and pick-up demands of small vehicles. The Beijing South Railway Station also has entrances and exits on four different directions to facilitate links with the urban trunk roads.

### ► Subway Connection and Station Design

Interchange hubs that are connected to subways usually incorporate relatively developed urban rail transport systems, which carry a large number of passengers and have large-scale stations. Various traffic facilities around the construction area contribute to the formation of a large interchange hub. However, interchange hubs without subways are generally smaller, and they can be assumed to have fewer passengers.

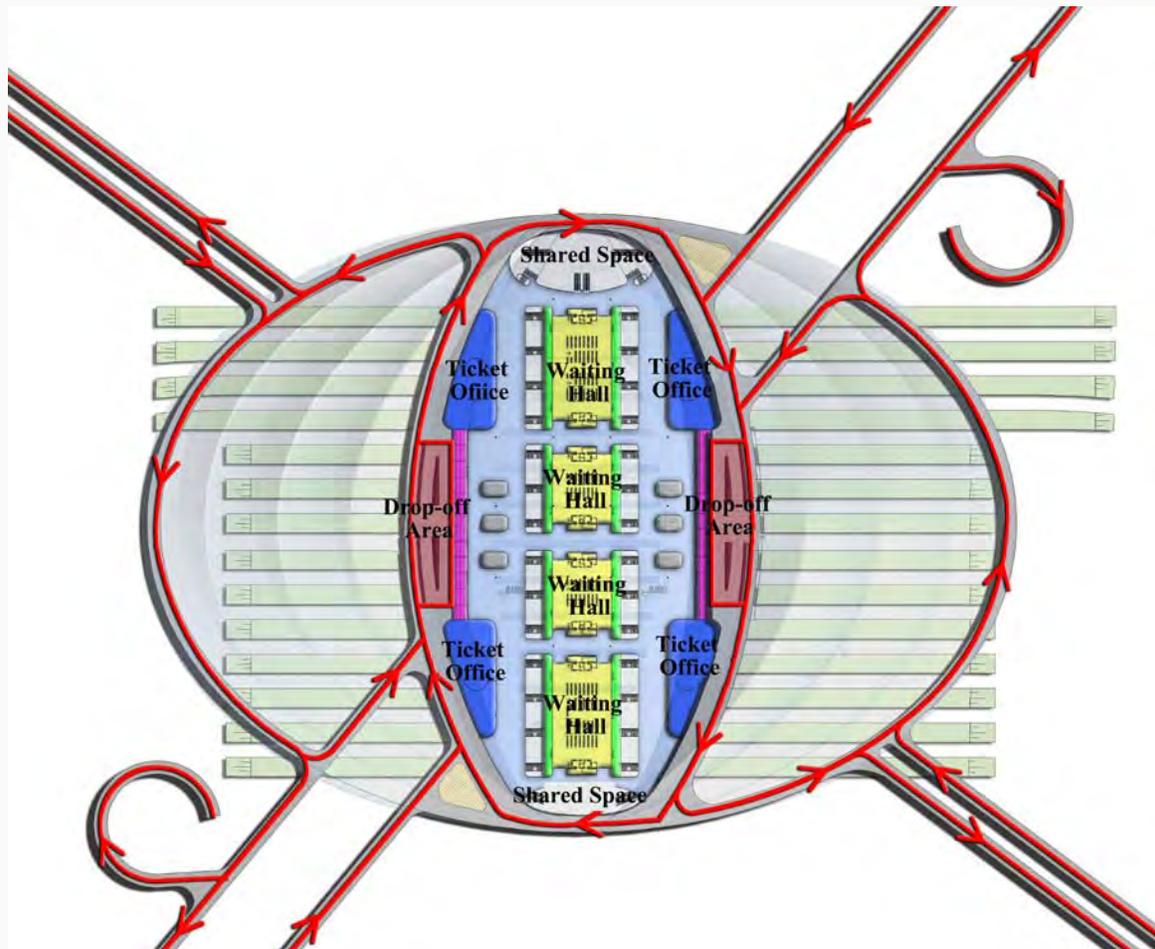
Commonly, an interchange hub will have one or more subway lines with a centralized station. Some hubs will be able to combine existing subway stations at the planning and design stage. As a major means of passenger flow for an interchange hub, the subway will typically account for over 30% of passenger flow at a railway station. Passengers will usually opt to use rail transport as their preferred means of travel, due to its large capacity, efficiency, and punctuality. As the most important component of an interchange hub, different methods of transfer involving a railway station and subways will affect the overall interchange hub layout. Furthermore, connecting an interchange hub to a subway station generally entails large-scale construction work, which accounts for the bulk of the investment. Therefore, the means by which a subway station can be integrated with an interchange hub should be considered as a key factor at the layout planning stage.

**Figure 4.4:** Beijing South Railway Station, Elevated Levels of Traffic



Source: Third Railway Survey and Design Institute Group Corporation 2014.

Figure 4.4: continued



Source: Third Railway Survey and Design Institute Group Corporation 2014.

### ► Commercial Development around the Hub

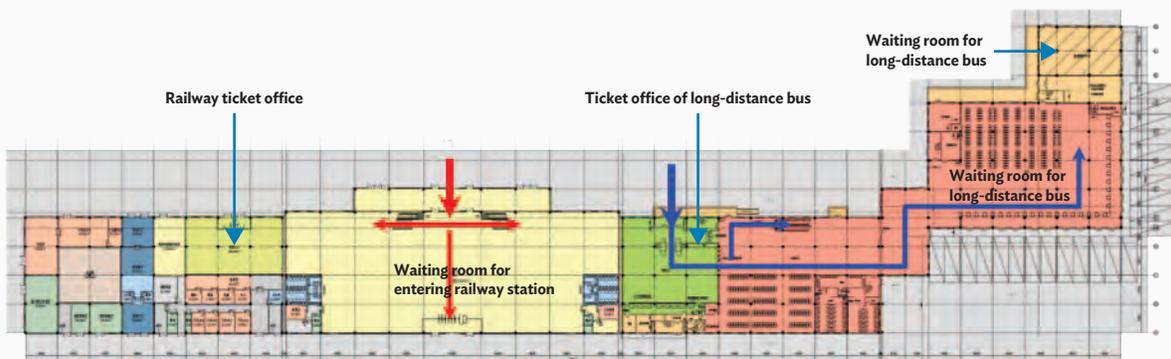
People movement is inextricably linked with commercial activities. As the interchange hub facilitates the travel of large volumes of people, its core layout plan should be responsive to the present and future commercial development. Hubs located within urban centers should be conveniently linked with existing commercial centers. In Singapore, for example, the metro rail is linked with shopping malls, and people can walk to these areas. Thus, the link between the hub and the commercial areas can potentially lessen the high volume of traffic generated around these areas. On the contrary, hubs located outside the urban center should provide ample space for future commercial development, since hubs can catalyze real estate development in their surroundings. In addition, hubs outside the urban center should also be well integrated to the existing development within the center to avoid fragmented urbanization. A good layout of the commercial centers should also be considered to ensure the efficient movement of people and traffic within and outside the hub.

## Functional Layout of Railway Stations

### ► Operational Pattern

The functional layout of railway stations is determined by operational patterns (Figure 4.5). The various operational patterns have corresponding functional layouts. Passengers entering the station are segregated from those exiting the station to have an orderly passenger flow and to prevent inbound and outbound passengers getting in each other's way.

**Figure 4.5:** Functional Layout of Railway Stations



Source: Third Railway Survey and Design Institute Group Corporation 2014.

Identity verification was introduced in railway stations in 2012, which meant that the verification process had to be taken into account in the operational and functional layout. The implementation of an online booking system and the installation of large numbers of ticket machines in 2011 have all changed the ticket booking and purchasing habits of passengers, and this has also had an effect on the operational model of the station, which has been adjusted accordingly. These changes and adjustments have helped improve railway stations and make them more efficient.

Under the current operational pattern, inbound passengers are separated from outbound passengers at the railway stations in the PRC, regardless of the station size (large scale, medium scale, or small scale).

Currently, there are various ways to purchase tickets, such as online booking, buying tickets from designated ticket agencies, or buying from the railway station either before the departure date or on the same day that the passenger is traveling. Passengers can choose the most convenient way to purchase a ticket according to their specific needs. Different methods of booking tickets correspond to different types of operational pattern and services for passengers.

### ***For passengers who purchase a ticket prior to the date of departure***

Passengers entering the station building have to go through an identity and security check (note that stations operate differently: at some stations, identity checks are carried out while the ticket of a passenger is being checked), there is then a wait for the train (at which point they can purchase food, etc.), then the passengers go to the platform, they then board the train at the platform (for some through trains, passengers will first need to wait at the platform).

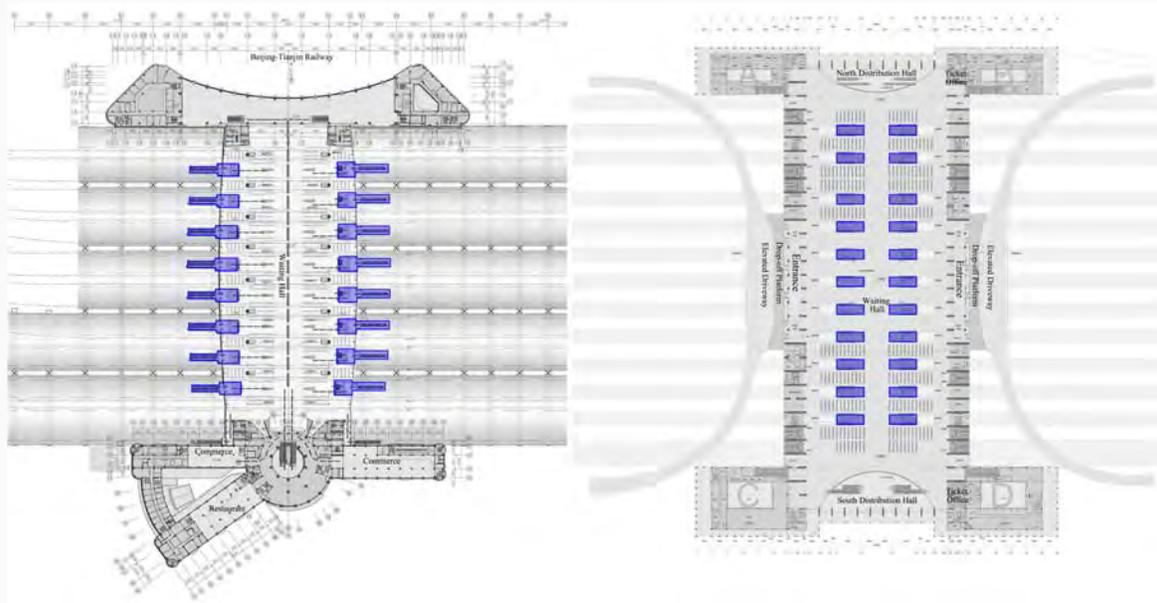
### ***For passengers who purchase a ticket online on the date of departure***

- (i) Purchase (and receive) the ticket at the booking office (Image 4.2), enter the station building, go through the identity and security check, wait for the train (at which point passengers can purchase food, etc.), enter the platform after the ticket has been checked, board the train at the platform.
- (ii) Enter the station building, go through security, purchase (and receive) the ticket, wait for the train (at which point passengers can buy food, etc.), go to the platform after the ticket has been checked (the identity check is carried out at the same time), board the train at the platform.

**Image 4.2:** Automated Ticketing Stations



**Figure 4.6: Boarding Ticket Gate Location Diagram**



Source: Third Railway Survey and Design Institute Group Corporation 2014.

Deciding where identity checks will be carried out depends on the location of the booking office (Figure 4.6). Booking offices are located within the waiting areas to ensure that the identity check is conducted before passengers purchase their tickets. In some large stations that do not have booking offices within the waiting areas, the identity check is completed in conjunction with the security check before the passengers arrive at the platform; that is, it must be completed in conjunction with the ticket check (the ID card must bear the same name as the one on the ticket). At small and medium-sized stations, the booking offices are not connected to the station building, so the identity check is carried out before the security check.

Intercity trains differ from other passenger trains with regard to the waiting procedure. Intercity trains, with their unique frequency and operating patterns, can distribute passengers more effectively. Passengers board the trains soon after entering the station. Therefore, waiting times for intercity trains are short, and a large waiting area is not required. However, passengers who use standard railway lines to travel will need more space when waiting for trains. They often arrive at the waiting area half an hour or more before the departure time and also place a high demand on the service facilities in the waiting area.

### ► Requirements for Service Counters and Ticket Machines

In the past, deciding on how many face-to-face service counters (Image 4.3) were required was based on the volume of passengers using an interchange hub at peak time. However, service counters are increasingly being replaced by automated ticket machines (Image 4.4) due to the advances in technology. Therefore, it is now easier for passengers to book their tickets online in advance and then collect them at an interchange hub using the automated ticket machines.

**Image 4.3:** Ticket Office—Service Counters in Beijing South Interchange Hub



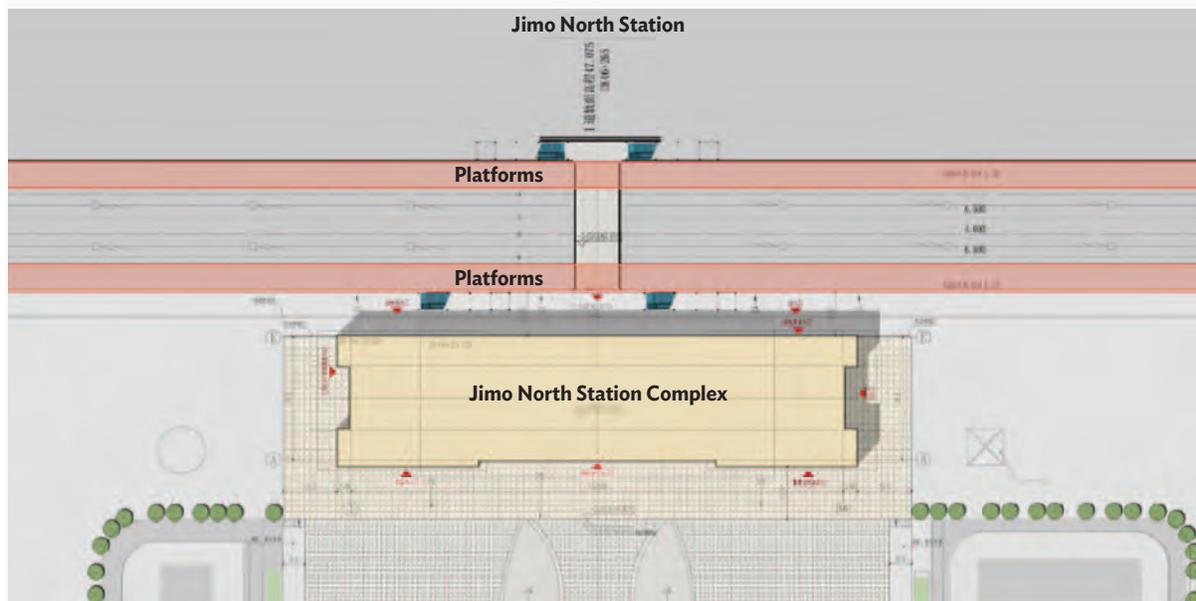
**Image 4.4:** Automated Ticket Machines in Beijing South Interchange Hub



### ► Station Yards and Types of Railway Stations

Station yards located within railway stations comprise mainly of platforms and different lines or routes (Figure 4.7). These lines or routes are divided into main tracks and departure tracks. Main tracks are used to allow trains to pass each other, while departure tracks are located near platforms to allow trains to stop. Passenger-dedicated lines currently use symmetrical layouts. Most small and medium-sized passenger station yards have one rail line, with a relatively fixed layout; if there are four or six routes, it is essential to have two platforms. Large passenger stations generally have several railway yards with more platforms. If these are normal speed yards, the entire station layout will be more complicated.

**Figure 4.7:** Qingdao-Yong Chen Intercity Railway Jimo North Station Yard Layout



Source: Third Railway Survey and Design Institute Group Corporation 2014.

Depending on the relationship between the elevations of the railway lines and the planning of the urban area under construction, railway stations take various forms, with different arrival and departure patterns. Consequently, the choice of the station layout is also closely related to the supporting municipal facilities of the city, the scale of the station building, and the condition of the station facilities. The most common forms include side type, end type, belowground level type, and the aboveground level type. Small and medium-sized station buildings often take one of the above forms depending on the conditions of the construction site. In the case of stations with fewer platforms, an overpass or underground tunnel is often used to connect the main building of the passenger station to the various platforms. In large stations with a considerable number of platforms, the station type must be designed to minimize the distance between the waiting area and the platform for passengers. Consequently, the waiting area and the departure area will usually be located close to the corresponding platform. Therefore, the more complex form of a station building purposively combines various patterns or layouts.

(i) **Line side station building.** A line side station building is often located on one side of the station. In design terms, due to the differences in elevation between the station and the square, side-type station buildings can be divided into three types: parallel, above ground, and below ground (Figure 4.8).

(a) The first floor of a parallel station building is often located near the platform. Small and medium-sized parallel station buildings often use an overpass for passengers arriving at the station and an underpass for passengers to depart. The ticket checkpoints for arrival and departure are located correspondingly. The Beijing South Railway Station is an example of this type. If a station is used by a high volume of passengers, there will be a high-lying waiting area and an underpass exit.

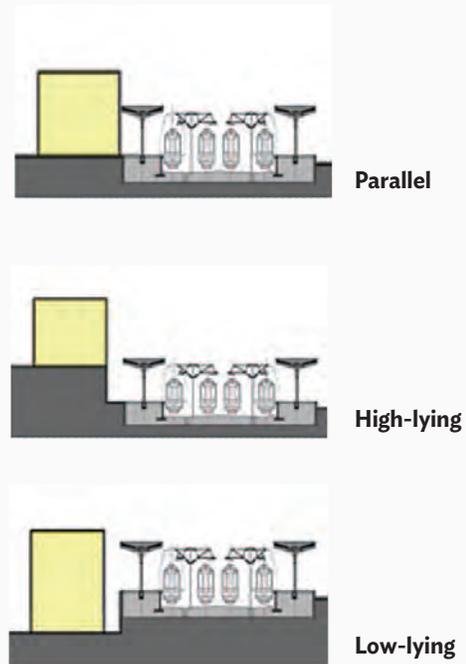
(b) The first floor of a high-lying line side station building is higher than the platform. Overpasses are used for entering and leaving the station. The Chongqing North Railway Station is an example of this type of station.

(c) The first floor of a low-lying line side station building is lower than the platform. Underground tunnels are used to enter and leave the station. The Changsha Railway Station and the Yan'an Railway Station are two examples of this type of station.

(ii) **End-type station building.** End-type station buildings are located at the end of a station. They are commonly known as level end-type stations, such as the Beijing South Railway Station. End-type station buildings are different from terminus stations. In the PRC, even in the case of terminus stations, the station buildings are line side or high lying. End-type station buildings are rarely seen in the PRC. The Nanjing South Station and the Beijing South Railway Station are two of the few examples of this type. However, in European countries, end-type station buildings are much more common (Figure 4.9).

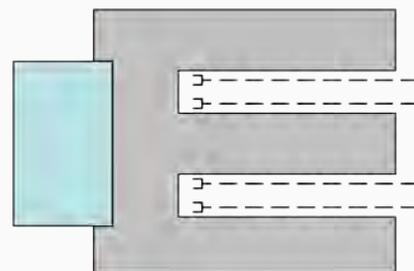
(iii) **Belowground station building.** This type of passenger station is designed with railway track height above the station areas. Major entrances and exits to the railway stations are set on one side or both sides of tracks (Figure 4.10). Belowground station buildings use bridges to connect railway tracks and platforms, with station buildings located under bridges, while passengers access the platforms via escalators. Depending on the structural type of a bridge, bridge station buildings can be divided into two categories: station-bridge separation and station-bridge combination. Station-bridge separation means that the

**Figure 4.8: Line Side Station Buildings**



Source: Third Railway Survey and Design Institute Group Corporation 2014.

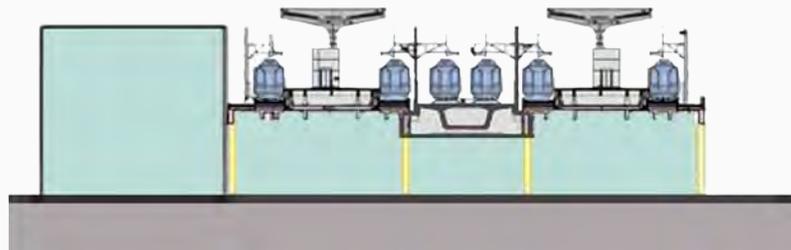
**Figure 4.9: End-Type Stations**



Source: Third Railway Survey and Design Institute Group Corporation 2014.

railway route bridge structures are separated from the new passenger station building structures. This type is suitable for railway tracks with an elevation of more than 10 meters (m) or stations with an interior elevation. The advantages of using this method are that it promotes less structural stress and minimizes noise. The station-bridge combination model combines railway track bridge structures with passenger station building structures. It considers the difference between the track elevation and a station building interior elevation of less than 10 m. This type can also be used for larger stations.

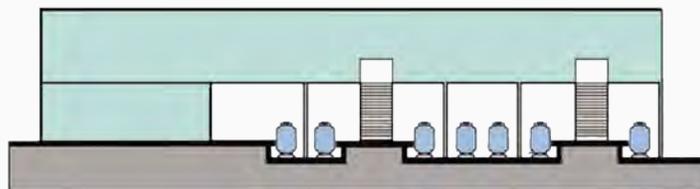
**Figure 4.10: Belowground Station Buildings**



Source: Third Railway Survey and Design Institute Group Corporation 2014.

- (iv) **Aboveground station building.** The main functional space of an aboveground station building is located within the platforms and above the railway tracks, usually incorporating an elevated waiting room (Figure 4.11).

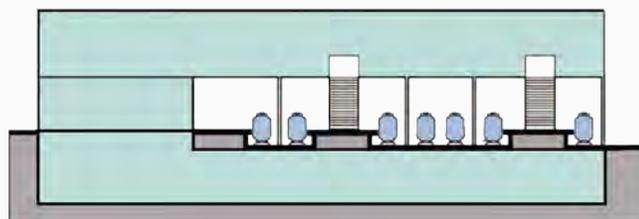
**Figure 4.11: Aboveground Station Buildings**



Source: Third Railway Survey and Design Institute Group Corporation 2014.

- (v) **Mixed type station building.** Depending on the interchange hub layout and its function, various types of station buildings are integrated to form a new mixed type of station building. This type is mainly used for large passenger stations (Figure 4.12).

**Figure 4.12: Complex Station Buildings**



Source: Third Railway Survey and Design Institute Group Corporation 2014.

## ► Selection and Determination of Station Type

Deciding on which railway station type to select depends on the rationality of its functional use and the surrounding transport network. It is an important part of planning an interchange hub, as the railway station is at the center of the interchange hub. On the one hand, the railway station must meet the technical requirements of professional railway design. On the other hand, it must also comply with urban planning regulations to achieve the best overall outcome for the interchange hub.

- (i) **Large passenger stations.** Large railway stations are more complex with regard to external conditions. The station design should be adapted to the external conditions as far as possible. There are more railway routes and platforms in large passenger station yards. To make the boarding and exit points more convenient, as well to comply with the principles of boarding and exit diversion, these stations generally use “board above/exit below” models within an elevated waiting room. Thus, the waiting and boarding spaces are located above the platforms. Underground exit passages are linked to all the platforms, the main square of the interchange hub, and the transfer hall. Passengers enter the station hall at the ground level or via the elevated platform, and then wait at the elevated waiting room. Finally, they are directed past the ticket gate machines of the corresponding platforms to board the trains. This approach reduces the traveling distance and the waiting time for the passengers to board the trains. To make it more convenient for passengers coming in from the subway and other modes of underground transport, some large passenger stations also use underground waiting and boarding spaces, but doing so will increase the costs of boarding management.

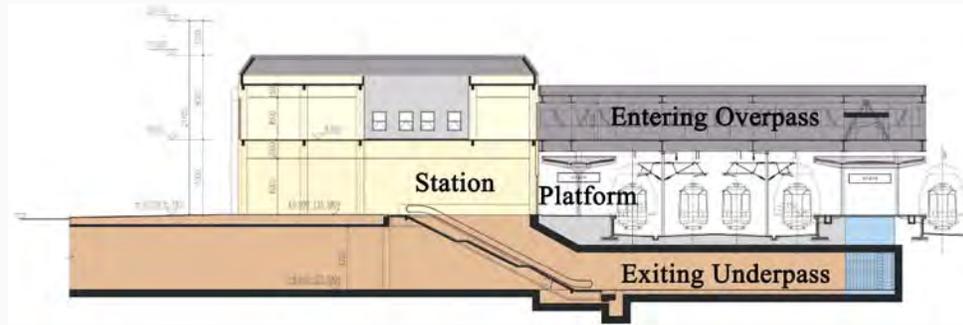
There are two kinds of elevated waiting room layouts, which are combined with different passenger boarding locations: the first has boarding ticket gates located on both sides of the elevated waiting room, with the middle part serving as the waiting area, such as the Harbin West Railway Station or the Tianjin Railway Station. The second type involves locating boarding ticket gates inside the elevated waiting room, with the middle part being used as the waiting area and the areas just outside the entrances being used as boarding passages. This layout generally results in passengers using boarding routes above the platforms and the boarding hall being located on both sides of the elevated waiting room. This method makes boarding more direct and convenient for passengers. Examples of this type are the Beijing South Railway Station and the Tianjin West Railway Station.

The combined station type which includes an elevated waiting room, underground station exits are generally used. Passengers arriving at the station can access the exit passage or underground station exit hall from the tunnel exits on the platform and complete their transfer using the underground, subways, or other means of municipal transportation. Currently, underground station exit halls in railway stations are generally merged with corridors that link the station squares on both sides to form a unified space.

- (ii) **Small and medium-sized passenger stations.** Presently, belowground station buildings, ground level station buildings, and aboveground station buildings are used in the design of small and medium-sized station buildings. The aim is to minimize the terrain elevation difference between the yard and the square. In the design process, the elevations of the ground floor in the station building and the square are basically the same. The square design also helps to keep the building level same as the elevation of the surrounding urban planning.
- (a) **Ground level station structure.** The ground floor elevation and the station platform are basically at the same level. The elevation difference between the urban planning elevation and the station

platform design is no more than 3 m, and the elevation difference is overcome by following a square design. Ground level station buildings are divided into with and without basic platforms (Figure 4.13).

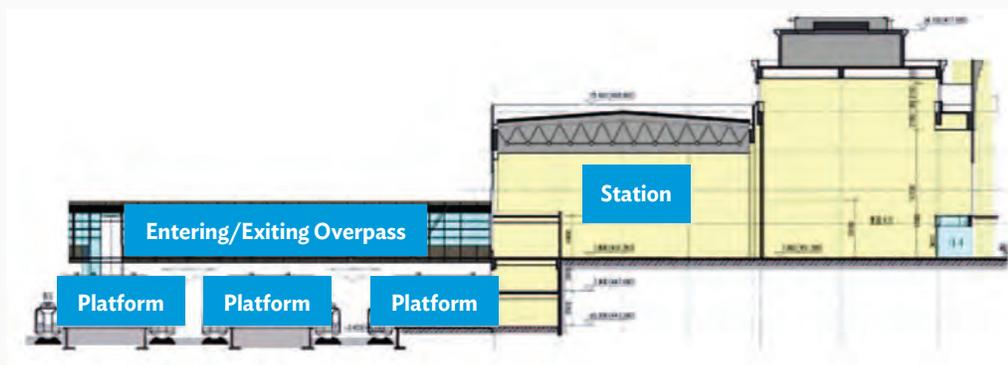
**Figure 4.13:** Ground Level Station Structure—With Main Platform



Source: Third Railway Survey and Design Institute Group Corporation 2014.

- (1) **With basic platforms.** For a standard yard comprising two platforms with four routes, the station building is located near the basic platform. Some larger station buildings may use bridges for entrances and tunnels for exits; station buildings also use two floors as waiting areas. Smaller station buildings may adopt the model of using tunnels or bridges for entrances and exits. The use of bridges or tunnels depends on the yard planning conditions of the station buildings. Basic platforms can follow the pattern of level entrances and exits.
  - (2) **Without basic platforms.** A standard yard of two platforms with six routes, and railways lines near station buildings, will use the model of tunnel entrances and exits. The station building usually has just one floor. Centralized boarding and exit ticket gates are not used for each platform.
- (b) **Aboveground station structure.** The ground floor elevation is 5–8 m higher than the station platform. Bridges are used for boarding and exiting. One side of the basic platform can be used as an area for passenger services (Figure 4.14).

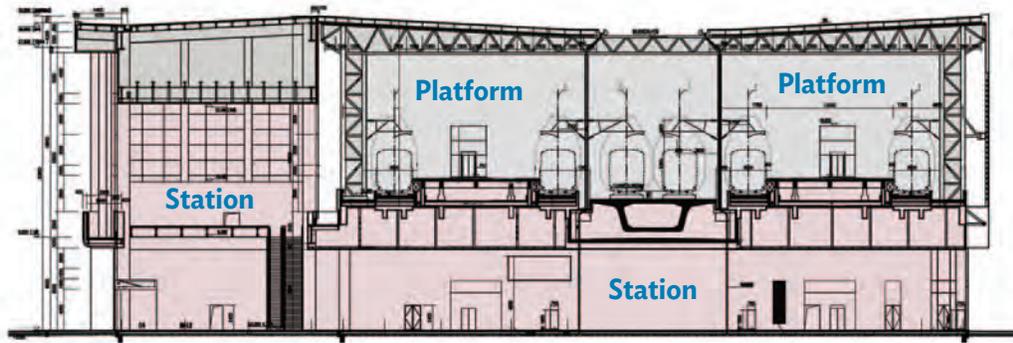
**Figure 4.14:** Aboveground Station Structure



Source: Third Railway Survey and Design Institute Group Corporation 2014.

- (c) **Belowground station structure.** The ground floor elevation is 5–8 m lower than the station platform. Most tunnels have entrances and exits. For larger station buildings, bridge entrances can also be set into the basic platform. For station buildings consisting of two floors, both the floors are used as waiting areas. The second floor is mainly used as a waiting room for the basic platform. For smaller station buildings, all entrances and exits are used (Figure 4.15).

**Figure 4.15:** Belowground Station Structure



Source: Third Railway Survey and Design Institute Group Corporation 2014.

A single-floor station building is unique and is associated with belowground station buildings: bridge station building. Railways can be built across cities using bridges. Platform elevation is about 14 m higher than square elevation. Besides constructing station buildings on the side of a station yard, they can also be set into layers below a railway, which can provide waiting room for passengers as well.

If the elevation difference between the proposed design of the square and the actual station platform is between 3 m and 5 m, it must then be decided which type of station building should be constructed, taking into account regional planning, yard layout, and the investment involved.

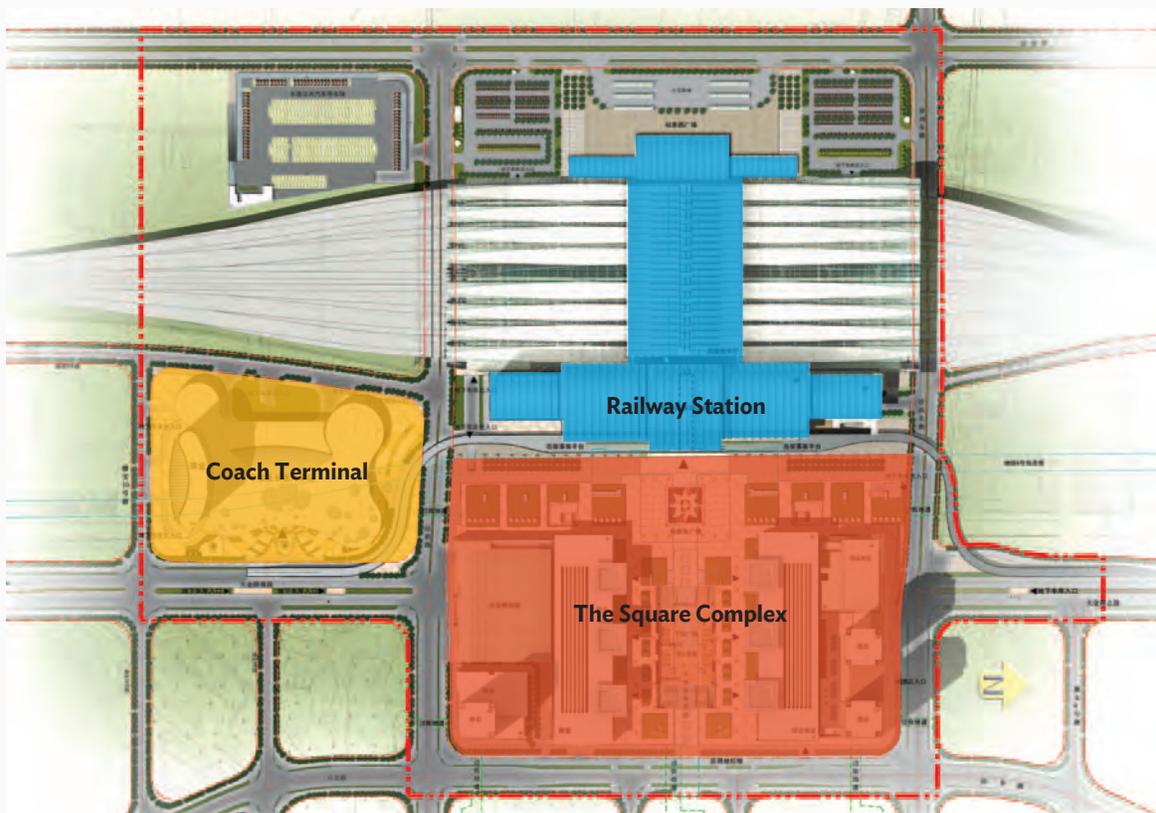
A railway station has a significant influence on its surrounding environment. Its surrounding conditions and elevation can influence passenger flow to use mixed type station buildings for large passenger stations. Even if there is a big difference in elevation between the proposed railway routes and the existing urban planning, regional elevation can still be adjusted appropriately in most places, or the station buildings may be leveled so that they can be combined with the design of the interchange hub and square, and any other necessary technical measures can be undertaken.

## Coach Terminal Functional Layout Pattern

### ► Integration with Railway Stations

Coach stations have the same characteristics as railway stations with regard to interchange hubs, as they are both part of the external traffic system.<sup>13</sup> A traffic network is formed when coach stations are built together with railway stations, which makes it convenient for interchange hubs, especially in the case of small and medium-sized interchange hubs, to share resources within the existing internal traffic system (Figure 4.16). Small interchange hubs are usually built in suburban areas. In this case, public transport, cars, and taxis are the main sources of urban passenger transport, while coaches are largely relied upon to deliver passengers to the surrounding cities, towns, and counties. Therefore, coach stations and railway stations should be more closely connected with each other, particularly in the case of small and medium-sized interchange hubs. Provincial cities with large interchange hubs are likely to have multiple coach stations, providing routes to various different locations, although usually only one will be connected to a railway station. In this case, coach stations and railway stations are less closely connected, but they also fulfill the same distribution functions as the internal traffic system of a city.

**Figure 4.16:** Coach Terminal Adjacent to the Interchange Hub in the Jinan West Railway Station



Source: Third Railway Survey and Design Institute Group Corporation 2014.

<sup>13</sup> In this report, a coach is referred to as a road transport service covering long distance journeys while taking passengers from one city to another. In contrast, bus usually covers short trips within the city.

### ► Operational Mode

The layout of a coach terminal integrated with an interchange hub will be different from that of a free-standing coach terminal, as adding an interchange hub changes the layout. An independent coach terminal layout only has to be designed to meet its own passenger flow needs; however, coach terminals integrated with interchange hubs also have to consider the transfer of passengers, and the relationship between railway stations and other interchange hub transfer transportation systems.

In the case of an interchange hub, passengers will be more concerned about transfer distance and convenience. Different approaches to constructing interchange hubs are constantly being explored and gradually developed, so that the means of connecting coach stations to other interchange hubs can be improved and passengers transferred more conveniently, while maintaining its original basic operational pattern.

### ► Functional Layout

Since coach stations are also part of the external traffic system and their operational patterns are similar to that of railway stations, they also have similar functional requirements, such as waiting areas, ticketing areas, security-checking areas, ticket-checking areas, and customer service areas. Taking the circulation design into consideration, loading bays and drop-off areas should be included within the functional space. In addition, the functional layouts of coach stations built within interchange hubs still need to meet the following requirements:

- (i) In small interchange hubs, coach terminals are generally separated from railway stations; instead, they should be close to the railway station for easy access and connectivity.
- (ii) In large interchange hubs, the space should be fully utilized and the stereoscopic parking lot layout should be adopted. On the one hand, planners can make interchange hubs more compact which will also reduce transfer distance. On the other hand, planners can minimize interchange hub land use, thereby creating more space for commercial development by using a stereoscopic parking lot layout. Coach terminal buildings and other interchange hub building facilities should be integrated as much as possible at the design stage, to produce a development which forms an integrated whole, to make transfers within the interchange hub as convenient as possible, and to create a pleasant environment for passengers.

### ► Vehicle Flow Organization

Coach terminals are mainly used by large vehicles, so arrivals and departures need to be coordinated and planned to avoid clogging of vehicles within the interchange hub. The operational routes for coaches can be timetabled so that they are the same as for buses, with individual flow routes for vehicles arriving at and departing from the interchange hub, and internal interchange hub routes created to accommodate vehicle flow. The entrances and exits for coaches should be connected to the trunk road of the city, and coaches also need to be able to depart quickly via the surrounding road network.

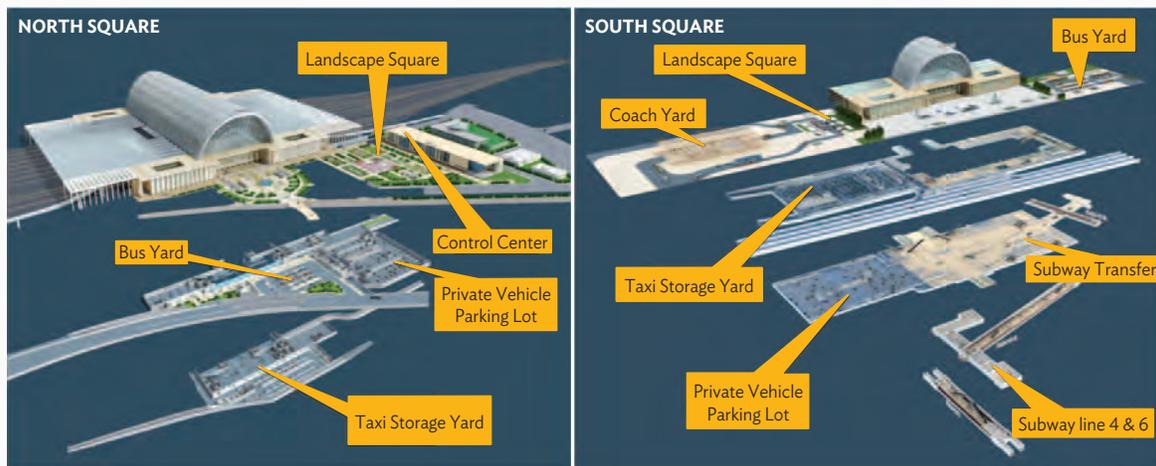
## Planning Layout and Streamlining the Organization of Road Traffic Facilities Relating to Interchange Hubs

The urban road traffic facilities connected with a railway station and a coach station within an interchange hub include a bus park, a drop-off area for cars, parking lots, a pick-up and drop-off area for taxis, and so on. Working out as to how links can be created between the layout form and the surrounding road system comprises the main part of interchange hub planning. All roads used for traffic facilities should have independent, partial or full, access to the surrounding urban traffic facilities.

### ► Bus Yard Layout and Traffic Organization of Bus Flow Entering an Interchange Hub

- (i) **Location setup.** The railway station is located on one side of the yard, whereas the bus station is located centrally on the side corresponding to the railway station; when the railway station allows passengers to enter and exit the station on both sides of the yard, the bus yard will be located in such a way as to ensure that the bus station is correspondingly set up on a single side or on both sides, according to the direction of the urban passenger flow; if the station is set up on both sides, the scale of the bus yard on both sides will be determined according to the location of the directional passenger flow (Figure 4.17).

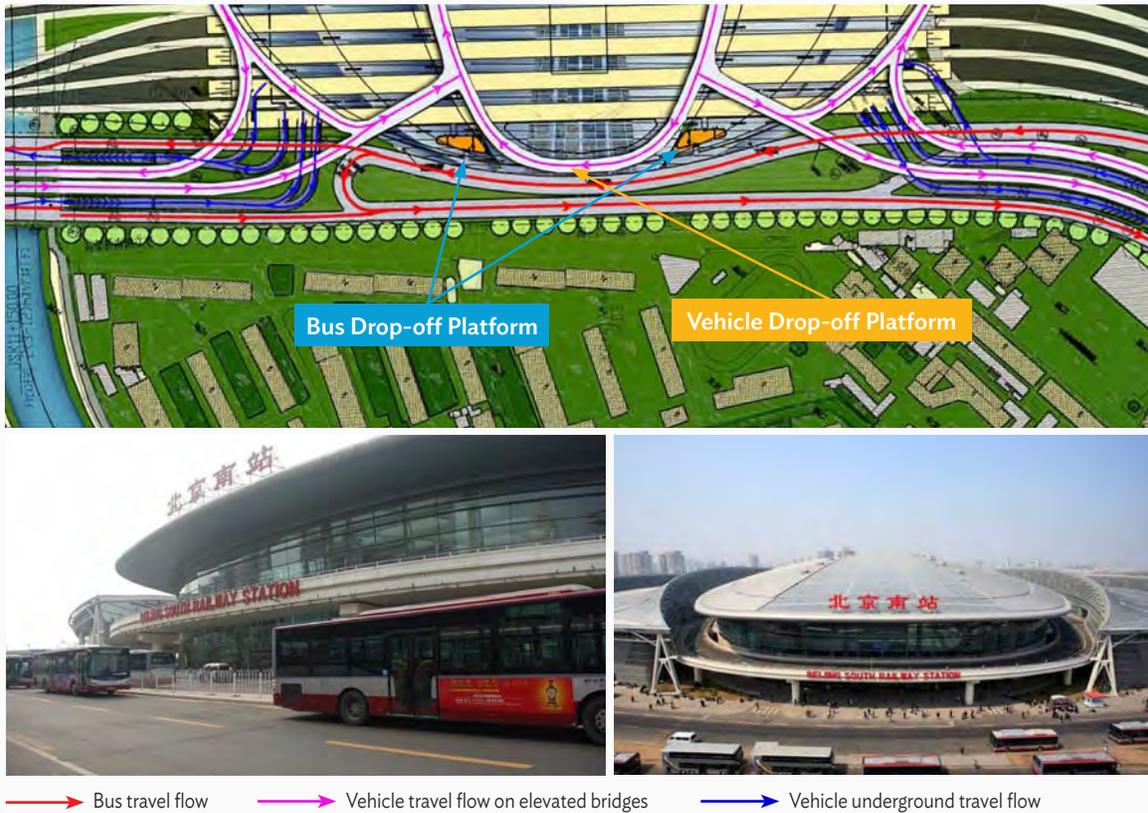
**Figure 4.17:** Integrated Layout of the Bus Station and the Interchange Hub



Source: Third Railway Survey and Design Institute Group Corporation 2014.

Interchange hub planning design should reflect the principle of bus priority; therefore, the place where passengers get on and off the bus should be located such that it facilitates convenient transfer and ensures the shortest possible walking distance (Figure 4.18). The pick-up and drop-off area and the arrival and departure yard can be merged into a single bus yard, or they can all be located separately. As the floor area of the arrival and departure yard for buses is larger, the pick-up and drop-off area should be set up separately and located as close to the railway station as possible. The parking lot should be located in an area farthest away from the main entrance and exit of the railway station.

**Figure 4.18:** Bus Drop-Off Areas in the South Square of the Beijing South Railway Station



Source: Third Railway Survey and Design Institute Group Corporation 2014.

In an interchange hub with a three-dimensional layout, the bus yard should not be located underground; one reason is that buses have limited ability to cope with gradients, but the main reason is that it is very difficult to effectively treat the exhaust emissions produced by buses; therefore, the semi-underground or open underground model should be considered.

For interchange hubs in central urban areas, the setup of the stop-over bus station should also be taken into consideration.

- (ii) **Functional composition.** Bus stations in this situation are relatively larger than bus stations in cities. Therefore, to separate passengers and cars more effectively, different areas should be set up to allow passengers to board and alight the buses. The arrangement of the passenger drop-off and pick-up areas should also be taken into consideration in relation to the mainstream passenger flows. Passenger drop-off areas should be directly connected to the pedestrian areas of the railway station and other traffic facilities. After arriving at the pick-up area, passengers should also be able to access respective area platforms guided by appropriate marking systems.

There are two patterns of arrangement which can be adopted to separate passenger flows and vehicle flows effectively. First is by providing corridors and escalators so that passengers can access the bus areas and then to each platform. Pick-up platforms can be arranged in parallel, either with or without direct links between them. An example of this pattern is the South Square of the Beijing

South Railway Station. Second is by providing staircases linked with the pick-up platform in the bus area for passenger access. Pick-up platforms are arranged in parallel with no direct links between them. One example of this type is the North Square of the Beijing South Railway Station. With the help of signs and symbols, underground passengers are able to find the buses that correspond to individual staircases.

- (iii) **Coordination offices.** The basic coordination offices that maintain normal operational orders are either collectively arranged near the bus area or individually arranged corresponding to the respective lobbies.
- (iv) **Driving area.** The driving area should be arranged in the following order: bus inbound, drop-off, pick-up, and outbound; during the design stage, the turning radius and the length of the bus must be taken into account.
- (v) **Vehicle access.** Buses come under the category of large vehicles, and the bus lane has to be set accordingly; the inbound and outbound passages can be separately set up for buses within the interchange hub and the surrounding roads to avoid mixing with other traffic.
- (vi) **Passengers entering or leaving.** After arriving at the interchange hub by bus, passengers access the station building through platforms in front of the building or through underground staircases. Passengers in the interchange hub can reach the bus area through special staircases or directly after getting off the train. For example, the passenger drop-off area in the South Square of the Beijing South Railway Station is located adjacent to the south platform of the bus station, less than 1 minute's walking distance. Similarly, the bus area in the North Square of the Tianjin West Station is located in a semi-underground space. Passengers getting off the bus can access the railway station through elevators. Passengers getting off the train can also access the bus area through elevators.

### ► Layout of Car Drop-Off Areas and Car Flow Traffic Organization

- (i) **Location setup.** As car travel is more flexible as a mode of transport and the position of the drop-off area is generally close to the main entrance of the railway stations, the location of the car drop-off area is usually determined while selecting the type of railway station to be set up. If the interchange hub has a coach station, the drop-off area should be set up separately and should be connected via the roads within the interchange hub.
- (ii) **Car flow organization.** The inbound car flow generally uses a special inbound passage connected to the fast urban roads or the main trunk roads to ensure an inbound flow that is fast and efficient. Two options should be considered for the inbound flow of cars; first, cars may arrive directly at the drop-off area or, second, cars directly enter the parking lot. A special passage is generally provided for outbound vehicles, and in some cases they share the passage with other vehicles; during departure from the interchange hub, it may also be possible for cars to use the peripheral ordinary roads to help relieve congestion in the outbound car flow. To streamline the organization of an interchange hub, measures should be taken to ensure the fast passage of inbound car flow. The requirements of outbound car flow are lower than those of inbound flow, and this is known as “fast inbound and slow outbound.”
- (iii) **Inbound and outbound flow of passengers.** Passengers who arrive at the station by car should alight the car and enter the station through the drop-off platform in front of the station building, while passengers leaving the station by car should enter the parking lot directly and leave the station in their vehicles.

## ► Parking Lots

- (i) **Differences between parking lots in large and medium-sized interchange hubs.** Underground parking lots are usually combined with the general underground excavation work and built in large interchange hubs with subway transfer stations. Small and medium-sized interchange hubs are usually built without subway transfer stations, and the parking lot is generally built on the surrounding ground instead. Similar to the bus park, the parking lot is influenced by the urban planning structure as a whole.
- (ii) **Separation between pedestrians and vehicles.** The location and arrangement of parking lots needs to ensure that vehicles and pedestrians do not get in each other's way.
- (iii) **The parking of large vehicles.** While parking for small vehicles clearly has to be provided when planning for an interchange hub, there will also be a significant amount of large vehicles using the interchange hub, and their needs must be considered to meet the demands of tour groups, other large parties, and so on. Large parking lots can be built at the ground level. One option is to create exclusive lanes for large vehicles, or they can share lanes with ground yards.

## ► Size and Location of Parking in an Interchange Hub

The size of parking lots required for an interchange hub can be estimated by forecasting passenger flow. For instance, it is assumed that approximately 10,000 passengers per day will pass through an interchange hub and that 25% of those passengers would drive private vehicles. A specific formula can be used to calculate how many vehicles will need to park, which then enables us to estimate the size of parking lots that will be required in an interchange hub.

When selecting the location of parking lots, factors such as the cost of investment, technical specifications, and different approaches to design have to be taken into account. For example, parking lots had to be designed and built as basement car parking under the railway station at the Beijing South Interchange Hub because there was only limited space available on the surrounding land. However, although basement car parking is very convenient for passengers who need to transfer between the underground and ground level railways, facilitating a seamless transport mode connection at the Beijing South Interchange Hub, the investment required for basement car parking is much higher than for ground-level car parking. Also, some technical design issues have to be dealt with for basement car parking under railway stations. Therefore, the location of parking lots in an interchange hub should be considered primarily from the perspective of investment demand and the different design methods required.

## ► Parking Standards Regarding the Amount of Different Transport Parking

In the PRC, there are currently no detailed parking standards or regulations that can be used to forecast the parking allocation per passenger at a station for private vehicles, bicycles, buses, or taxis. In addition, the return on investment is only calculated on the basis of the railway line as a whole rather than per passenger for each station. For example, the predicted expenditure for the Beijing–Shanghai high-speed railway, which covers 5 large interchange hubs and 12 small interchange hubs, was over CNY200 billion. Over time, the amount for

car parking provision should be reduced in interchange hub designs, with every effort made to move passengers to and from interchanges by public transport, walking, or cycling—this would be more consistent with low environmental impact.

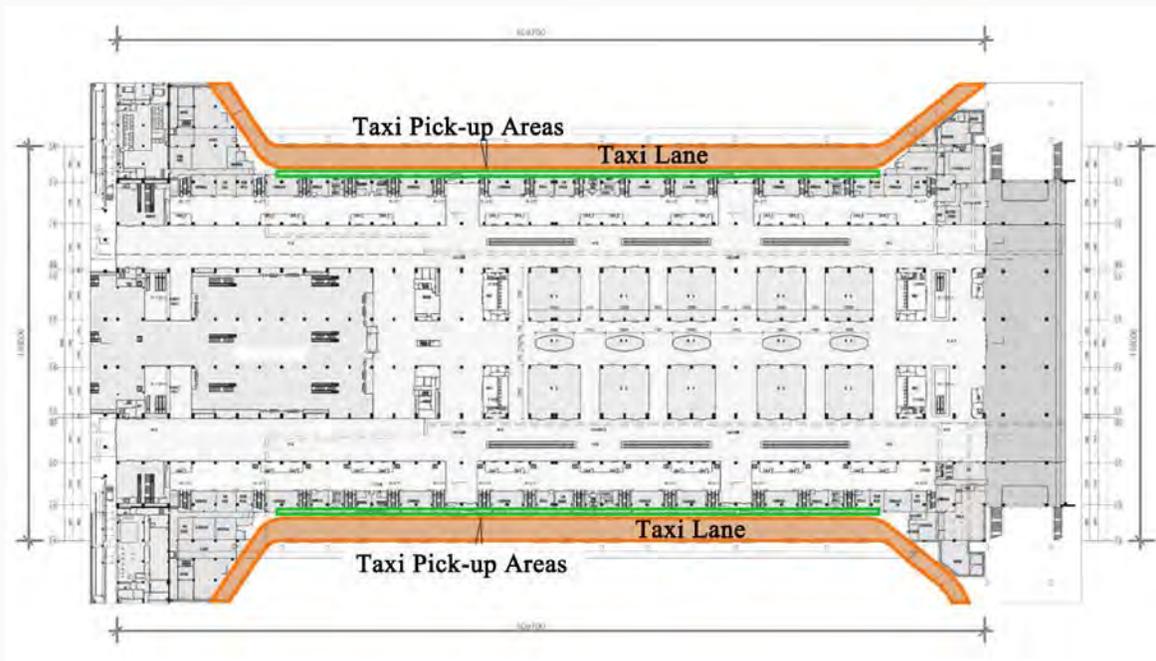
### ► Taxi Pick-Up Areas and Taxi Storage Yard

- (i) The construction of taxi pick-up areas should be given priority in the design process of interchange hubs since they are important to passenger flow. They should be built close to the outbound passenger flow, and there can be several taxi pick-up areas and exits around the interchange hub (Figure 4.19).

Most taxi pick-up areas and storage yards are built underground when the initial excavation work takes place. In addition to this, there are still some areas for taxis built at the ground level, such as in the case of the Harbin West Station. Small and medium-sized interchange hubs all adopt the ground-level form of taxi pick-up areas.

- (ii) Interchange hubs that have provision for coach travel should also be equipped with passenger pick-up areas and taxi storage yards. The position of the taxi pick-up area should be convenient for coach passengers if the ground taxi storage yard arrangement can be used in combination with the interchange hub storage yard. As the passenger flow from coaches only accounts for a small part of the overall passenger flow in an interchange hub, the scale of the storage yard and pick-up area required is correspondingly smaller.

**Figure 4.19:** Taxi Parking Lots in the Shanghai Hongqiao Station



Source: Third Railway Survey and Design Institute Group Corporation 2014.

- (iii) Special car storage areas should be built either at the ground level or underground. Under normal circumstances, these are built at the same level as the taxi pick-up area. The scale of the storage yard will be determined based on an analysis of car flow. As the squares are located in front and at the rear of the large interchange hub yard, taxi storage yards of different scales are usually placed at the front and in the rear squares. In the case of a small interchange hub with no underground space, the taxi storage yard is usually located within the ground-level square.
- (iv) An interchange hub needs to consider including a taxi storage yard lane after the pick-up area for taxis. Some taxis are in no hurry to leave the interchange hub after dropping passengers off at the station. Therefore, a connecting passage between the drop-off area and the taxi storage yard should be considered in the planning of an interchange hub. In the case of a small interchange hub, if the pick-up area, drop-off area, and storage yard for taxis can all be located close together at the ground level, this goal is easier to achieve. However, in the case of a large interchange hub, the drop-off area is generally located at the ground level or overhead, while the pick-up area is usually underground. To ensure that the different modes of transport and pedestrians do not crisscross, and to facilitate car flow such that it fits in with the other traffic systems, the distance between the taxi drop-off area and the storage yard generally involves a much longer detour.

## KEY GUIDING PRINCIPLES

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Effective planning of the layout of the core area of the interchange hub ensures seamless multimodal interchange. Accessible and safe ingress and egress of passengers should be the main goal in designing the layout. All entrances and exits to the interchange hub should have a direct connection to the urban road facilities surrounding the interchange hub to provide interchange hub users with more options. The layout of the core area also facilitates sustainable urban development. The core area layout of the hub affects existing and future mixed use development within its range of influence.

# DESIGNING ANCILLARY FACILITIES

Ancillary facilities within the hub are important to ensure efficient operations, facilitate more convenient and comfortable travel experience, and seamless multimodal transfers. This chapter discusses design principles, layout, and methods for various components of hub facilities including public spaces. It emphasizes the role of commercial and retail facilities (e.g., cafes, restaurants, shops, etc.), comprehensive service facilities (ticketing machines, toilets, information booths, etc.), and other features. Hubs with well-designed ancillary facilities can improve the overall journey experience and increase usage efficiency. Through these facilities, passenger waiting time can become more productive than ever. The hub can also be used not only for travel related routines, but can also become an activity center for the community. This chapter also discusses the provision of public spaces as a vital element to enhance the appeal of the hub to passengers and tourists alike.

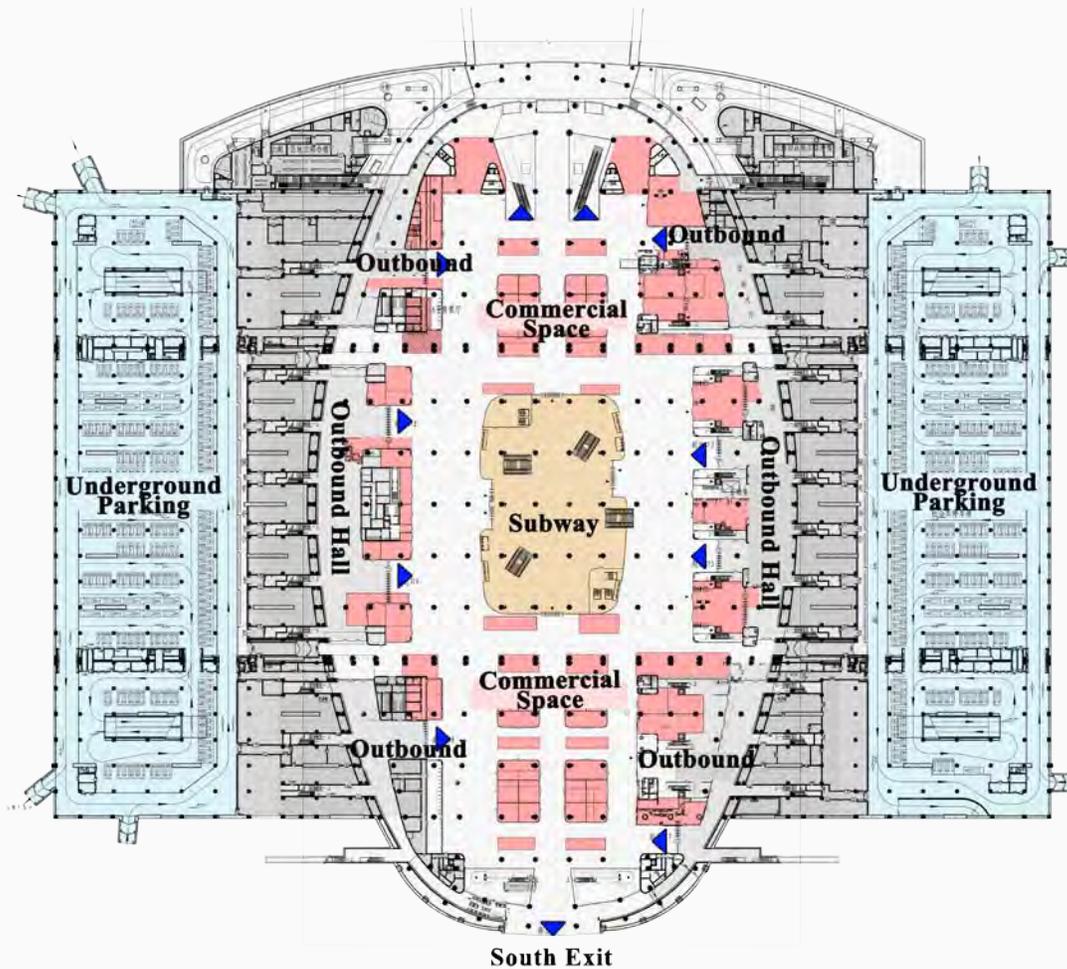
## Setup of Commercial Facilities

### ► Current Situation of Layout of Interchange Hub Commercial Facilities

The commercial layout is important to an interchange hub, as it caters to passenger convenience and enhances the service content at the hubs. Commercial activities benefit the interchange hub operation as the profits thereof are used to manage and maintain the hub. Space layout for commercial and retail facilities should be carefully considered at the start of hub planning and design.

However, there is still no conclusive direction with regard to quantitative research on the scale of interchange hub development. Interchange hub planning remains largely based on the technical elements (e.g., hub size, core layout, transport connectivity, site selection), and analysis of similar projects. Commercial planning companies and potential investors for mixed use development rarely participate during the planning stage. The role of commercial activities is fundamental not only in generating revenues, but also on enhancing the hub's appeal to passengers. Therefore, research on and estimation of probable volume of business development should be part of layout planning of commercial facilities at an interchange hub.

**Figure 5.1:** Commercial Layout of Underground Space in the Beijing South Railway Station



Source: Third Railway Survey and Design Institute Group Corporation 2014.

### ► Service-Supporting Commercial Facilities in Interchange Hubs

The service-supporting commercial facilities in interchange hubs fulfill the travel needs of passengers and are closely linked to passenger transfer stations (Figure 5.1). A suitable layout of commercial space improves the overall service level in interchange hubs and raises the use ratio of interchange hub space. The following factors should be considered during the construction of transport oriented commercial facilities for passengers:

- (i) Commercial facilities should be easily accessible to passengers in the transfer platforms and waiting areas. However, this arrangement should not affect the seamless movement of passengers in an interchange hub. Retail shops can be arranged on both sides of passageways to ensure access to passenger platforms is unobstructed. The layout of commercial facilities should also ensure unnecessary movements within the hub.

- (ii) The layout of commercial ancillary facilities should ensure that interchange hub space is used efficiently. The internal space of an interchange hub is generally high and broad with large architectural scale. There are some untapped spaces that cannot be used for functional aspects. Depending on the characteristics of the available space and setting, the corresponding business will improve the utility of the space. For instance, the interlining shops can be set up in the broad building, and the commercial ancillary facilities are set up on the corner of the interchange hub function area.
- (iii) The commercial and retail ancillary facilities should cater to the demand and needs of the passenger. Shops that provide the most basic passenger need (e.g., food and water, medicine, tickets, communication, and the like) should be easily accessible to passengers near the interchange platforms. On the other hand, shops that are more upscale (e.g., high-end restaurants and cafes, clothing boutiques, entertainment facilities, and others) can be grouped and located at a designated space within the hub. Different types of commercial and retail activities should be identified in the early stage of hub development planning.

### ► Commercial Development

Commercial activities induced by the presence of interchange hub results in the formation of an urban subcenter. Increase in traffic generated by such activities should be taken into account during hub planning and design. The interchange hub should be harmonized with city and regional urban land use planning as it connects different modes of transport on different scales. Hub layout should be integrated so that ensuing land development is in line with the overall planning layout of an interchange hub.

The commercial development scale of an interchange hub should be matched with the projected interchange hub traffic. Professional real estate planners should be consulted to determine strategies on future land development around the hub. The people who visit the commercial outlets should also be included in the total passenger flow composition. The commercial development area should be provided with a short and direct link to the interchange hub. At the same time, interchange hubs should connect the peripheral development areas. Consequently, the commercial development in an interchange hub acts as a point of contact between the interchange hub and the surrounding areas.

## Layout of Hub Facilities

The passenger-oriented service facilities<sup>14</sup> in an interchange hub play an essential role in making the journey experience more convenient and enjoyable. These facilities should be strategically located to maximize efficiency in movement within the hub. Attractive public spaces such as parks and squares should also be part of the interchange hub as these enhance the passenger experience. Service amenities mainly include escalator, washroom, information display screen, signage guidance system, and public facilities for passengers. Facilities designed for easy access for differently abled, pregnant, and elderly passengers should also be provided.

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<sup>14</sup> The service facilities discussed in this section refer to the facilities that are arranged in the public area of the interchange hub.

## ► Vertical Transportation Facilities

Vertical transportation facilitates passenger movement between floors within the interchange hub. Escalators are generally found in large or small interchange hubs with multistoried structure, which are usually located in the passageway. The elevators and escalators should be strategically located where passengers can easily access, specifically the differently abled, pregnant women, and elderly (Images 5.1 and 5.2). Currently, moving walkways have not been widely used in interchange hub facilities in the PRC since it is restricted in single and long-distance channels.

**Image 5.1:** Escalators inside the Beijing Station



## ► Washrooms

There are no specific requirements (scale, location, and distance) in setting up washrooms in an interchange hub. However, washroom arrangement is vital to an interchange hub. For instance, a passenger railway station has set up a certain number of washrooms at the outbound space according to the railway passenger flow in the underground space of the Beijing South Railway Station, while toilets have not been set up in the adjacent inbound space. Hence, passengers who use the bus and the subway in an interchange hub as well as some residents are forced to use the washrooms in the outbound space of the railway station. Consequently, this station is frequently lacking available washrooms.

**Image 5.2:** Escalators inside the Tianjin Binhai Railway Station

Washrooms have to be located both in the outbound and inbound spaces of the interchange hub. Washrooms should be located in places where there is large passenger flow. Sufficient lighting, proper sanitation, and availability of toiletries are key features of well-designed washrooms. At present, the typical provision of washrooms in the interchange hub in the PRC is 1 every 100 meters. The number of washrooms and related facilities should be determined based on the volume of interchange hub users.

### ► Information and Signage System

In an interchange hub, the information system is essential in providing accurate, simple, quick, and clear guidance services for passengers (Images 5.3 and 5.4). A simple and user-friendly interchange hub layout combined with good information and signage system make movement within the hub more efficient and less cumbersome. Good signage

**Image 5.3:** Information Signs 1

**Image 5.4: Information Signs 2**

system should follow consistent design and format (e.g., font color, size, etc.). Dual-language signage system also makes way finding much easier. The information and signage system should also encompass all modes of transport within the hub. For example, access to information on arrival and departure times of buses and trains, and other traffic related information should be readily available. A large interchange hub would require a comprehensive signage system to help passengers navigate their way in the underground space. Information on potential destinations surrounding the hub (e.g., location of business districts, commercial hubs, shopping malls, offices, and the like) should also be accessible to passengers. Information booths are also very useful facilities.

### ► Layout of Public Facilities

Public facilities include waiting lounges, seating provision, garbage and disposal systems, airconditioning, and so on. Presently, there are no specific standards and specifications for public facilities. Generally, transport hubs are seen as mainly a space for people to come and go, and passengers are not expected to stay or wait for a long time. Therefore, sufficient seating provision is not prioritized. However, many passengers do wait for lengthy periods of time; hence, the design of waiting areas should be given more detailed consideration. In more advanced interchange hub designs, passenger waiting area have gone beyond mere provision for seats and benches. Waiting lounges can feature other amenities such as Internet connection, entertainment, and more comfortable waiting room chair.

Garbage management and sanitation systems are indispensable facilities for passengers in the interchange hub. Control, monitoring, and regulation of collection and waste disposal should be in place.

### ► **Barrier-Free Accessibility in an Interchange Hub**

Seamless accessibility is an essential feature of a well-designed hub. The hub's structure and facilities should be designed based on the principle of "design for all people." Barrier-free facilities enables the elderly, pregnant women, and differently abled persons to access the hub with ease. Common examples of barrier free design include the following:

- ❖ accessible and adequately sheltered parking lots specifically allotted for persons with disabilities (permanent and temporary);
- ❖ audible announcements and braille markings to enable the blind or partially visually impaired to be aware of the hub's environment and activities;
- ❖ handrails, grab bars, and ramps for passengers using wheelchairs;
- ❖ nursery rooms (with diaper-changing station) for new or expectant mothers; and
- ❖ washrooms with features dedicated to the needs of differently abled passengers.

## **Building and Interior Design of the Interchange Hub**

It is important to have a flexible interchange hub design. Planners should be able to take full consideration of the unique environment and conditions that can affect building and interior design. The natural and geographic characteristics should be given great importance when designing the interchange hub. The vast area of the PRC requires planners to take into account differences in climate and geography. For instance, interchange hubs in northern PRC will have to deal with extremely cold winters while hubs in the south will tackle tropical or subtropical climate and extreme rainfall. The unique characteristics of the hub's location should be reflected in its building design and features (Image 5.5).

Well-designed interchange hubs not only provide for efficient movement of passengers, but also create an enjoyable environment for passengers. A hub may be designed for activities that stimulate various senses, and become a destination in its own right. The interior design of the hub can feature spectacular architectural innovations, inspirational art works, sculptures, murals, live music, dramatic lighting, and cultural shows can all add to the passenger experience.

### ► **Full Use of Natural Conditions**

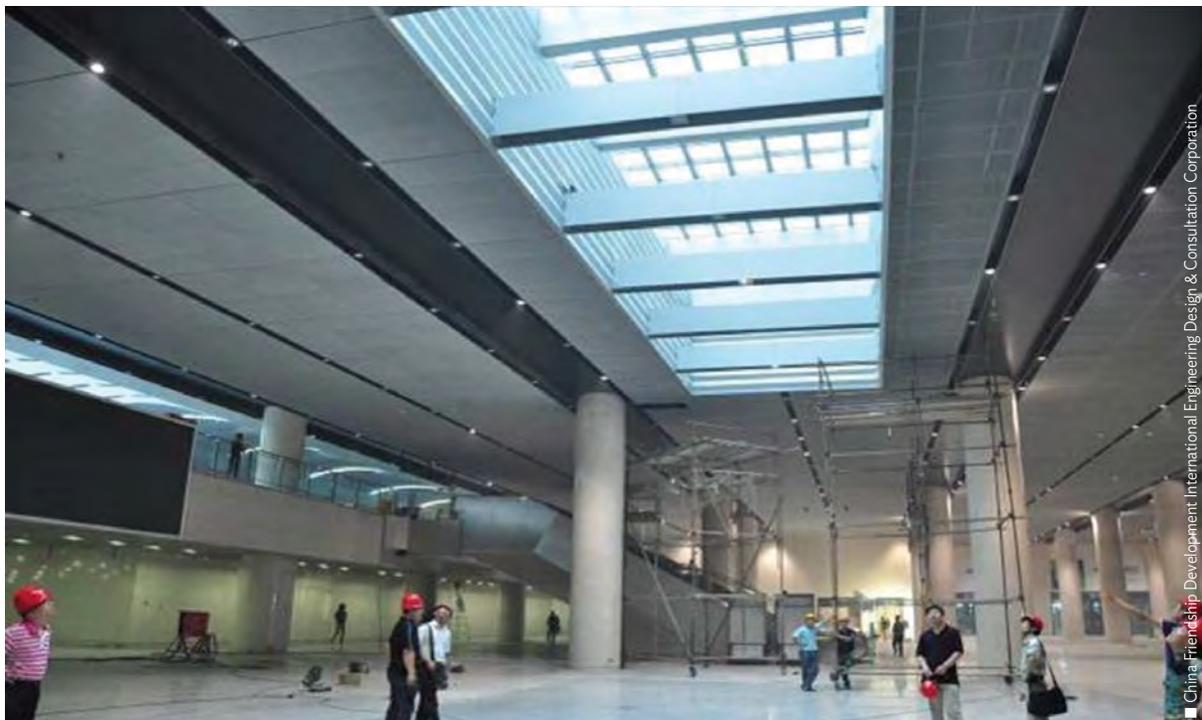
The use of natural light plays a very important role in the planning of an interchange hub (Images 5.6 and 5.7). Since a lot of main spaces of an interchange hub are set underground, incorporating natural light can create a cozier environment in the basement, save energy at the same time.

The use of natural light in the main interchange hub facility (i.e., above ground) should also be considered. Large roofs with skylights can bring in ample light that creates bright and comfortable environment in an interchange hub.

**Image 5.5:** Design of the Yujiabao Interchange Hub Waiting Area



**Image 5.6:** Design of the Basement in the Tianjin West Railway Station by Using Natural Light



**Image 5.7:** Designing the Use of Natural Light in the Shanghai Hongqiao Railway Station



Another common practice in the design of an interchange hub is the use of natural ventilation. Since there will be many underground spaces in an interchange hub, which will be used for parking and other functional facilities, the use of natural ventilation will reduce the input of equipment. The full use of natural conditions can create a better hub environment while also minimizing energy requirements.

### ► Promoting Productivity and Activity in the Hub

Long waiting time has an impact on productivity as well as passenger comfort. Retail shops, restaurants, and cafes with can be a haven for passengers who need to endure long waiting time. Internet connection in cafes can allow business passengers to access important e-mails or finish work while waiting inside cafes.

The interchange hub can go beyond a mere transport station, and become a destination in its own right. Retail shops combined with entertainment facilities can make the hub an activity center. Many visitors can access the hub to shop, meet with friends, or have a quick lunch without necessarily using transport related facilities.

### ► Using Architecture and Art to Animate the Hub

Highly efficient and functional interchange hub structure when combined with fabulous architecture and art can promote the hub as an iconic destination, not just for passengers but also for tourists and other users. The hub architecture can be patterned after traditional designs to evoke cultural heritage among users. For example, the Beijing South interchange hub has a spectacular curved roof that reflects traditional Chinese temple roof, and can be an inspiring for the traveler (Image 5.8).

Detailed features such as clocks, flooring, and signage that beautifully designed can also make the passenger environment more attractive (Image 5.9). Artworks incorporated in the hub's interior design can also further enhance the journey experience. For example, murals found on walls and ceilings of Tianjin East interchange hub can provide a cultural experience to hub users (Images 5.10 and 5.11).

**Image 5.8:** Beijing South, PRC. Curved Station Roof Reflects Traditional Temple Design



**Image 5.9:** Beijing South, PRC. Easy to read station clocks as essential element of good interior design



**Image 5.10:** Tianjin East, People's Republic of China. Painting on the Ceiling Station



**Image 5.11:** Tianjin East, People's Republic of China. Murals on Station Walls



## KEY GUIDING PRINCIPLES

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Each hub will have a unique design depending on location factors. Planners should take into account the implications of factors that can affect the layout of ancillary facilities such as climate, topography, and land use restrictions. Ancillary facilities greatly improve interchange hub user experience. Retail and entertainment facilities can increase the productivity of passengers and make the waiting time more fun and something to look forward to. Ancillary facilities can also make the hub a social activity center and attract users other than passengers. High quality architecture and interior design are important to further enhance the user experience. Art works, detailed facilities (such as flooring, clocks, landscaping, and others), and overall architecture can be used to evoke a cultural experience among users.

## CONCLUSION

Planning for interchange hubs is a complex process as there are many requirements, often with competing issues. Effective hubs require an integrated and coordinated approach. Hubs should deliver safe, convenient, comfortable, and accessible spaces to all users. This report provides a discussion on a range of important issues in the interchange hub design. It also provides a general approach in developing a good interchange hub. This report also raises awareness of good practices in interchange hub design. Four key stages, with many interlinked elements, in the interchange hub planning are identified to guide hub planners and designers:

- (i) **Site selection.** This stage makes it possible for interchange hubs to be located in optimal positions, following a systematic site selection process, connecting different transport modes with the railway as the central element. There are also important urban planning dimensions, in linking the interchange hub to the central and the other parts of the city, and often in using the interchange hub as the focal point of a new neighborhood. The following issues need to be considered:
  - (a) the relation of the site to the planning strategy for the city;
  - (b) the potential for developing a new neighborhood around the interchange hub, contributing to transit-oriented development and a polycentric city form;
  - (c) the potential for consolidating rail interchange modes and facilities, including with high-speed railway, bus, and coach stations, and potentially airports;
  - (d) the need for land acquisition and resettlement; and
  - (e) the composition of the interchange hub, including the station size and the associated facilities, such as the pedestrian square, bus and taxi services, car and cycle parking, and the surrounding commercial development.
- (ii) **Transport planning.** Demand estimation of passenger, motor vehicle, and public transport flows is important to determine the size, layout, and scale of the interchange hub. Traffic flow surveys are an important consideration in this stage. The following issues need to be considered:
  - (a) surrounding contextual factors, such as regional development, socioeconomic characteristics, regional and local transport infrastructure and conditions, and target mode share;
  - (b) the scale and level of the interchange hub;
  - (c) the characteristics of passenger flow to and within the interchange hub;
  - (d) the approach to passenger flow forecasting; and
  - (e) connections to other transport modes, such as subway lines, private car and taxi facilities, and the provision for walking and cycling.
- (iii) **Core area layout planning.** This stage determines the core interchange hub functions and the layout of different transport modes and facilities. The following issues need to be considered:
  - (a) the relationship of the interchange hub to the surrounding neighborhood;

- (b) the architectural and engineering layout of the interchange hub, the internal and associated facilities, and the station type;
  - (c) the extent of waiting and commercial facilities;
  - (d) entry and exit patterns, and passenger routing;
  - (e) ticketing and service counters;
  - (f) connections to and facilities for other transport modes; and
  - (g) provision for accessibility.
- (iv) **Planning and design of ancillary services.** This stage considers the arrangement of different commercial and public facilities in the interchange hub. Ancillary facilities should be designed in consideration of different user needs. Planners should be incorporate functional design with great architectural (exterior and interior) design. The following issues need to be considered when deciding planning for ancillary facilities in the hub:
- (a) the layout and design of waiting and commercial facilities, the close integration with passenger flow;
  - (b) detailed passenger routing, including escalator provision;
  - (c) information displays, waymarking, and signage;
  - (d) the layout of public facilities;
  - (e) barrier free accessibility; and
  - (f) building and interior design.

Because of the vast territory of the People's Republic of China, the requirements of all regions are different and the development of all regions is not balanced. The design of interchange hubs should reflect these contextual differences, meaning that individual hubs should be of different scales and internal designs, with particular relationships to their external environments. Planners should be fully aware of these contextual differences, specifically when adopting best practices applied on interchange hubs in other locations.

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## **Improving Interchanges**

*Introducing Best Practices on Multimodal Interchange Hub Development in the People's Republic of China*

The multimodal interchange hub is vital for achieving a sustainable transport system. It stitches together different modes of transport and serves as the gateway to mobility and greater accessibility. This publication presents planning and design ideas to improve interchanges and the overall journey experience of passengers. It highlights how the hub can be a place not only of transport connection, but also of social interaction. The lessons and recommendations presented here may be used to build the next generation of multimodal hubs in the People's Republic of China.

### **About the Asian Development Bank**

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to the majority of the world's poor. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.



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