Citation: HAO Yuan, XU Tiandong, WU Sufeng. Conflict and Coordination Between Regular Railway and Cities in the Network Era of High-Speed Railway [J]. Urban Transport of China, 2020 (02): 67–75, 109.

Conflict and Coordination Between Regular Railway and Cities in the Network Era of High-Speed Railway

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Abstract: As the network of high-speed railways develops progressively, the functionalities of general railways start to change along railway corridors served by both high-speed and regular railways. Those changes occur in passenger and freight mixed transportation, freight-dominated transportation, and freight-only transportation. A series of conflicts between the regular railway and urban spatial layout and functionality have appeared, or the original conflicts have become more serious. This paper first discusses the impacts of the initial and networking operation of high-speed railways on the regular railways. It points out the three problems facing the regular railway transportation: the conflict between regular railways and urban space, the support of regular railways to freight system, and the optimization of special regular railway lines. By summarizing the characteristics of regular railway lines and urban functionality and the level of their compatibility through case studies, the paper proposes the solutions to problems accordingly. **DOI:** 10.13813/j.cn11-5141/u.2020.0201-en

Keywords: separate lines of passenger and freight transportation; regular railway; urban functionality; conflict and coordination

High-speed rail ① (hereinafter referred to as "HSR") has currently become a symbol of efficiency, modernity, and advancement. HSR construction in China is in full swing. Cities strive for HSR as an important resource to improve external connectivity and attract investments. With the progressive networking of HSR, regular speed railway② (hereinafter referred to as "regular railway"), in contrast, has a series of contradictions with the city's space and functional needs due to its outdated construction, low-level designed lines, and functionality changes. For example, regular railway forms an obvious barrier to urban space expansion and surface roadway connection; organizing freight transport around freight stations in the city conflicts with urban traffic; rail yards negatively affect the surrounding environmental quality. After the completion of HSR in many cities, there is certain blindness on how to use the existing railway lines and stations. For some cities, the importance of regular railways is significantly reduced after the opening of HSR, and the regular railway lines and stations are expected to be moved to the outskirts of the city. Admittedly, it is important to analyze the economic benefits of relocating existing regular railway lines and stations and the ownership of railway assets and other issues. In the context of gradual improvement of the HSR network, this paper focuses on the relationship between the changes of passengers and freight transport functions of regular railways and urban space expansion and function renewal. It addresses the conflict and proposes the coordination countermeasures between regular railways and cities through case studies.

1 Influence of HSR opening on regular railways

1.1 Rapid growth of railway passenger volume due to HSR

Since the operation of Beijing–Tianjin Intercity Railway, the first recognized HSR in China in 2008, the construction of HSR has been promoted rapidly (see Figure 1a). The operating distance has increased from only 700 km in 2008 to 29 000 km in 2018, with an annual growth rate of 45%. The current operating distance has exceeded two thirds of the world's total distance of HSR [1], accounting for 22% of the national operating railway distance of 131 000 km [2].

According to data from the National Bureau of Statistics in China, from 2009 to 2018, the national railway passenger volume increased from 1.525 billion to 3.375 billion [2] (see Figure 1b), in which HSR played an increasingly important role in passenger traffic. In 2008, 94% of the electric multiple

Received: 2019-07-17
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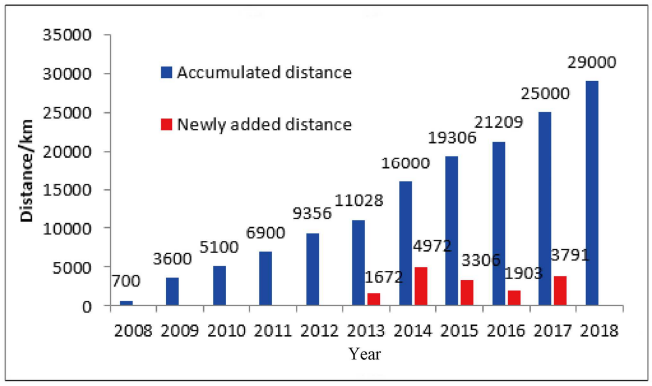
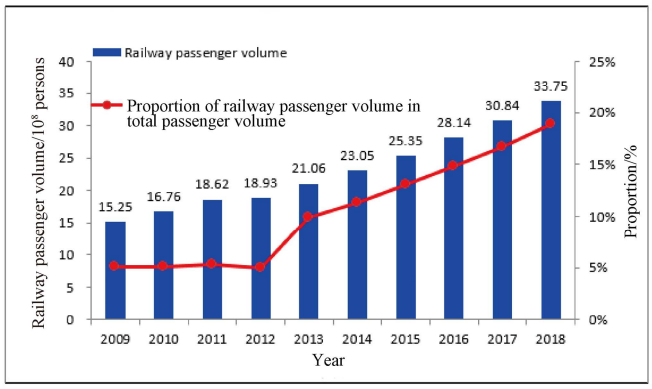
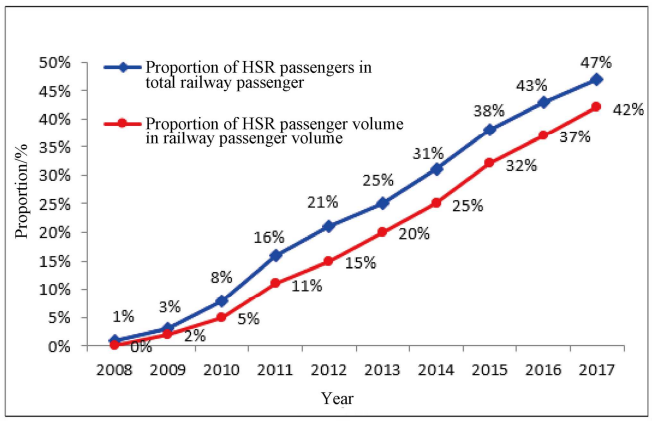


a HSR business distance



b Railway passenger volume



c HSR passenger volume

Figure 1 HSR mileage and passenger volume

Source: Data were obtained from References [1–2]; the data in 2008–2011 shown in the figure are approximate values read from the chart.

units (EMUs) were still running on the reconstructed existing lines; by 2013, about 79% of the EMU trains were running on the HSR lines [3]. From 2008 to 2017, the proportion of HSR passenger traffic in total railway passenger traffic increased from 1% to 47%, and the proportion of HSR passenger volume in total railway passenger volume increased from 0% to 42% [1] (see Figure 1c). A large number of intercity trains reduced the average travel distance of HSR passengers. The rapid growth of HSR passenger flow was not only a result of transfer from regular railway passenger flow but also the induction of a large number of new demands (including the attraction of air passengers) by the HSR network. According to the World Bank, the passenger traffic volume of Wuhan–Guangzhou HSR in 2013 was about 50 million, of which 14 million were connected from other lines. This reflected the network effect of the railway, with about half of the traffic volume transferred from regular railways and the other half from induced new travel demands [3].

1.2 Release of railway freight capacity by separation of passenger and freight lines

With the completion of parallel HSRs, the capacity of existing regular railways has been released, which makes it possible to separate passenger lines and freight lines. The change of railway freight volume in China has suggested huge potential of regular railways in freight transport. From 2009 to 2011, the railway freight volume showed an upward trend, with an average annual growth rate of 8.6% [2]. However, since 2012, the decline in economic growth and supply-side structural reform has led to a reduced demand for bulk material transportation, driving a year-on-year decline in rail freight volume. In 2017, railway freight transportation experienced a substantial recovery in China, with a total annual freight volume of 3.689 billion tons and a year-on-year increase of 10.7%, which reversed the three consecutive years of declining trend and reached 4.026 billion tons in 2018 (see Figure 2).

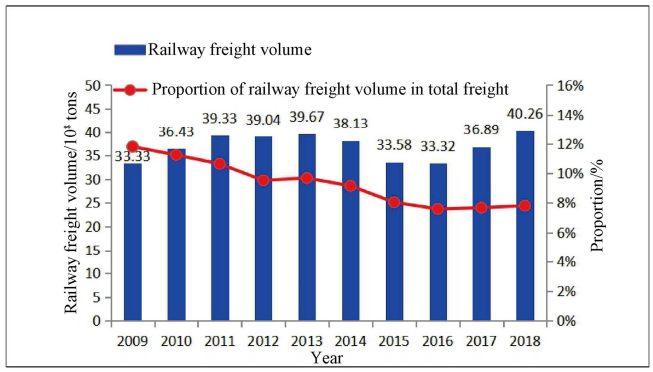


Figure 2 Changes in railway freight volume

Source: based on the data of Reference [2].

1.3 Railway function and its role in composite corridor

HSR is preferentially constructed between and within major urban agglomerations, forming a four-line or multi-line railway transportation pattern in some major urban corridors. This pattern involves the HSR serving long-distance transportation, the intercity railway serving the internal connection of urban agglomerations, and the existing regular railways, such as Beijing–Shanghai corridor, Beijing–Guangzhou corridor, Beijing–Tianjin corridor, Beijing–Qinhuangdao corridor, Chengdu–Chongqing corridor, Shanghai–Kunming corridor, and Lanzhou–Lianyungang corridor [4]. Multi-line railway transportation provides

Table 1 Passenger transportation's departure schedule of trains in various levels on several multi-functional railway corridors

Corridor	HSR	Regular railway	G/C/D-head shifts	Z/T/K-head shifts
Beijing–Tianjin corridor (Beijing–Tianjin)	Beijing–Tianjin intercity railway, Beijing–Shanghai HSR	Beijing–Shanhaiguan railay, Beijing–Shanghai railway	172	29
Tianjin–Shenyang corridor (Tianjin–Shenyang)	Tianjin–Qinhuangdao HSR, Qinhuangdao–Shenyang HSR	Tianjin–Shanhaiguan railway, Shanhaiguan–Shenyang railway	30	50
Beijing–Shanghai corridor (Shanghai–Nanjing)	Beijing–Shaghai HSR, Shanghai–Nanjing intercity railway	Beijing–Shanghai railway	235	58
Beijing–Guangzhou corridor (Beijing–Shijiazhuang)	Beijing–Guangzhou HSR	Beijing–Guangzhou railway	100	64
Chengdu Chongqing corridor (Chengdu Chongqing)	Chengdu–Chongqing HSR	Chengdu–Suining railway, Chongqing–Suning railway (operating speed up to 180 km/hr), Chengdu–Chongqing railway	86	8

Source: https://www.12306.cn/index/.

conditions for the separation of passenger and freight lines. After the separation of passenger and freight lines, the organization of transportation based on existing regular railways is generally classified as three modes: The first is to operate passenger and freight trains in different periods according to the traffic volume; the second is to operate all freight trains; the third is to focus on freight trains with consideration of a few passenger trains [5].

Whether passenger transport is considered in the existing railway system is closely related to the level and area of the corridor.

1) The main national railway trunk lines continues to bear strong passenger transport functions for a period of time, such as Beijing–Guangzhou railway, Beijing–Shanghai railway, and Tianjin–Shanhaiguan railway to Shanhaiguan–Shenyang railway. There are 164 passenger trains between Beijing and Shijiazhuang on the Beijing–Guangzhou railway, of which 64 are general trains numbered with the first letter as Z, T and K (Z/T/K-head shifts) and others (see Table 1). This is mainly because that the HSR network has not been fully launched and the existing lines in these corridors are still needed for the cross-line operation of regular railways. At the same time, due to the limited number of HSR stations, the regular railway can serve passenger transportation in small stations along the railway.

2) Given that regular railways have relatively low network connectivity, low line level, and low operation speed, its passenger transport function to serve some secondary corridors has been largely transferred to the new built HSRs. For example, after Chengdu–Chongqing HSR (via Neijiang) was opened to traffic, the passenger transport of the Chengdu–Chongqing regular railway has been nearly eliminated. Although it still undertakes certain cross-line transport (such as the Liupanshui–Chengdu route), the number of passenger transport trains is quite small (see Table 1).

1.4 Conflict between regular railways and cities

On the one hand, the HSR network is gradually improved, and the function undertaken by regular railways is gradually changing; on the other hand, cities are developing rapidly. The existing regular railways, due to the change of their functions, correlate with urban space and functions in an increasingly complex way. The relationship between regular railways and cities, in particular, is the coordination of regular railway lines and stations with urban space.

Regular railway lines include both main railway lines and special railway lines (branch lines). Main railway lines are generally busy in transportation, while certain special railway lines are initially built to serve the transportation of industrial and mining enterprises. However, with the change of national energy policies and the adjustment of industrial structure, many special lines have been left unused. The conflict between regular railway lines and urban space is mainly reflected in three aspects. 1) Railway lines become a barrier between the urban functional areas on the both sides, and the connection between the two sides of the railway becomes inconvenient due to limited passages across the railway. 2) When the railway passes through the urban area, especially the freight transport of regular railways, noise and dust have a negative impact on the urban environment. 3) In cities with special space forms, the space of the traffic passage is greatly restricted, while the railway often occupies the most important urban traffic corridor.

Regular railway stations include passenger stations, freight stations, and common stations of passengers and freight. The conflict between regular railway stations and urban space is mainly reflected in three aspects. 1) Freight stations in the inner part of cities disturb urban traffic; moreover, with the industrial enterprises moving to the periphery of the city, existing freight stations do not match the urban functions. 2) The urban construction around passenger stations is generally old and the traffic organization is usually chaotic. 3) With HSR stations becoming the main passenger transport hubs, the passenger flow of regular railway stations drops sharply; transport hubs have gradually deteriorated functions but still occupied the precious land in the core area of cities.

In most cases, regular railway freight stations are usually

moved out of the urban area and located with the industrial area of cities. Accordingly, it is necessary to build the outer lines of freight railways connecting new freight stations. In addition, it is also necessary to consider the multi-modal transport demand of the regular railway freight and other modes (such as water transport) as well as the support for optimizing or strengthening functions of the urban freight hub. The determination whether the existing regular railway lines and passenger stations in the urban area need to be demolished or moved out should be based on the following situations: 1) Considering the regular railway network layout of the city, if it is necessary for the existing regular railway lines to continue to undertake the suburban transportation or passenger transport, it is recommended to retain it in the core area of the city. 2) If it is really necessary to vacate the space of the existing regular railways, another station site can be selected according to the urban planning and located as close as possible to the core area of the city. 3) Based on the urban regular railway network, if the existing regular railway is not necessary to undertake suburban transportation or to only undertake a small amount of passenger transport, it can be considered to move passenger stations out of the core area of the city or share them with freight stations.

To summarize the above analysis, this paper intends to discuss the coordination between regular railways and cities from the following three aspects: the coordination of passenger transport of regular railways with urban space and functions, the coordination of freight transport of regular railways with urban space and functions, and the optimum utilization of the special lines of regular railways.

2 Coordination of passenger transport of regular railways with urban space and functions

2.1 Outward relocation of regular railway passenger stations

In areas along secondary railway corridors, the primary function of regular railways focuses on freight transportation after the HSR network is gradually formed. Many cities tend to relocate existing regular railway lines and stations inside the city, but the advantages and disadvantages of relocation need to be assessed comprehensively.

The cases of Neijiang and Yibin of Chengdu–Chongqing urban agglomeration are good examples. At present, there are Chengdu–Chongqing regular railway and Neijiang–Kunming regular railway in Neijiang, which is the transfer node of Guizhou, Kunming, and other places connecting with Chengdu and Chongqing. Yibin is an intermediate station of Neijiang–Kunming railway. According to the *Medium-and-Long-Term Railway Network Planning* (2016–2030), there are HSR lines in the current national regular railway corridors in South Sichuan, and the connectivity of HSR network is more complete. In this context, Chengdu–Chongqing railway and Neijiang–Kunming railway with low grade and low speed will be mainly responsible for freight transport (see Figure 3). However, there are different measures in Neijiang and Yibin for the relocation of existing regular railway lines and stations in the urban area. For Neijiang, it is suggested to move the freight line outside and build a new freight station in the surrounding area in combination with the industrial park, while retain the original location of the existing passenger stations. For Yibin, it is suggested that the existing lines in the urban area be completely moved out with new selected stations. The space of the existing regular railway lines should be reserved for urban rail transit. The different measures in the two cities are mainly based on the following factors.

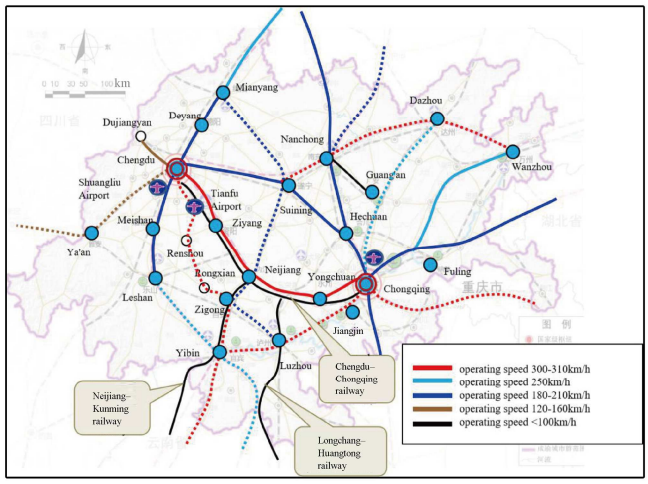


Figure 3 Spatial relationship of Chengdu–Chongqing Railway and Neijiang–Kunming Railway with HSR network of Chengdu-Chonqing city cluster

1) Connection of existing regular railways in cities

Neijiang City has two districts, two counties, and one city under its jurisdiction. Chengdu–Chongqing regular railway passes through Neijiang urban district and the core area of one county and one city its jurisdiction. Weiyuan County is not passed through by the Chengdu-Chongqing regular railway but has two special lines connecting with it. In the future, the two special lines can be extended to the national railway network. The HSR also passes through Neijiang urban district and one county and one city under its jurisdiction, but the North Longchang Station is 12 km away from the urban area of Longchang urban district (see Figure 4). Regular railway is good for serving the connection between the downtown area and the city area of Neijiang, which provides another green transportation mode besides highway transportation. Currently, the Neijiang Station of Chengdu–Chongqing railway is close to the core area of the city, which is suitable to be the suburban transportation hub [6].

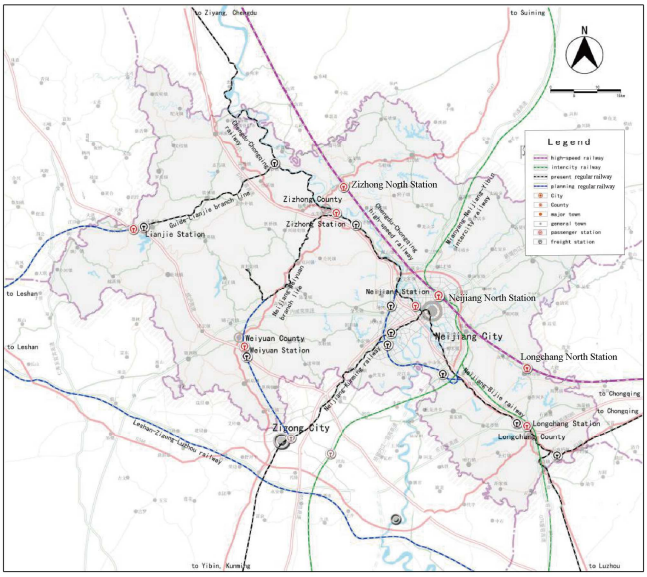


Figure 4 Railway network planning of Neijiang City

Source: Reference [6].

Yibin has different cases. Yibin City includes three districts and seven counties under its jurisdiction. The existing regular railways include the national railways, Neijiang–Kunming regular railway and Yigong branch railway, as well as the local railway, Jinyun special railway. The mileage of Neijiang–Kunming regular railway is relatively short within the scope of the city. Except for passing through the central urban area, Neijiang–Kunming railway has not passed through or involved stations in other districts and counties. According to the *Medium-and-Long-Term Railway Network Planning* (2016–2030), Yibin will form a five-direction HSR radiation pattern in the future, covering three districts and five counties. Therefore, it is not necessary for the existing regular railway to undertake the organization of suburban passenger transport.

2) Connection of new lines and overall consideration of railway hub optimization

The access of new lines is an important opportunity to optimize the organization of urban railway hubs. According to the *Medium-and-Long-Term Railway Network Planning* (2016–2030), there is a new railway line planned to connect Yibin and Xichang. Assessment factors, such as where the new railway connects with the existing Neijiang–Kunming regular railway and whether there is enough space for the passages of existing Neijiang–Kunming general railway in the urban area, will be used as comparison contents to determine whether to use the existing passages and stations or choose another new line and new station. On the basis of comprehensive comparison, the final plan of Yibin is to move the existing Neijiang–Kunming regular railway out of the urban area and choose a new station site by leveraging the access opportunity of Yibin–Xichang railway, achieving the simultaneous movement of freight hubs and passenger hubs [7] (see Figure 5).

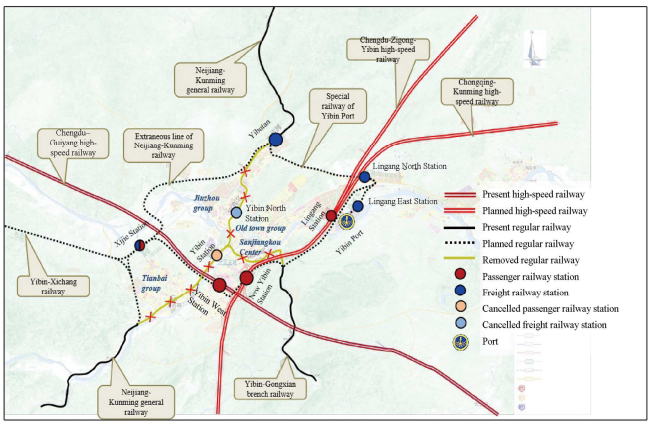


Figure 5 Railway terminal plan of Yibin City

Source: Reference [7].

3) Value of occupied passages for cities

It is an important consideration for the optimized layout of urban railway hubs by vacating the space of the existing regular railways for the city development. The existing regular railways are often located in the core area of cities, with their passages serving as the cities' main passenger flow corridors. The urban area of Yibin presents a valley shape parallel to the mountains. The passage of Neijiang–Kunming regular railway is also an important transportation corridor connecting Xuzhou group, Laocheng group, and Jiuzhou group across the Yangtze River. It will be very beneficial for the connection among urban groups, especially the connection across the Yangtze River, to move the railway out and leave the space of the railway passage to urban rail transit.

2.2 Reservation of original sites of regular railway passenger stations

In areas along the main national railway corridor, such as cities along the Beijing–Guangzhou regular railway, the passenger transport function of regular railways is still important. The original locations of transport hubs for regular railway passengers are usually reserved, such as Baoding Station of the Beijing–Guangzhou regular railway. In areas along secondary railway corridors, the passenger transport function of regular railways has been weakened significantly after the HSR gradually becomes a network. However, some cities still have regular railway passenger stations that are not appropriate to be relocated. There are two typical cases as discussed below.

1) For tourist cities, complete regular railway network can serve for tourism

Chengde city is located in the north of Hebei Province, with rich tourism resources. Chengde Mountain Resort in the urban area, the Saihanba Grassland in northern city, the Fengning Grassland to the north of Beijing are all famous tourist attractions. The current regular railway network of Chengde City includes Beijing–Chengde railway, Jinzhou–Chengde railway, Beijing–Tongliao railway,

Chengde–Longhua branch line connecting Beijing–Chengde railway and Beijing–Tonghua railway, Zhangjiakou–Tangshan railway, Zhangbaiwan–Shuangfengsi railway, etc. The HSR under construction and planning includes Beijing–Shenyang HSR, Tianjin–Chengde intercity railway, and Tangshan–Chengde intercity railway (see Figure 6). At present, there are two railway passenger stations in Chengde: One is the Chengde Station on the Chengde–Longhua branch line; the other is the Chengde South Station connecting HSRs and intercity railways. Chengde South Station will be the main passenger station of the city in the future, and the passenger transport function of Chengde Station will decline significantly.

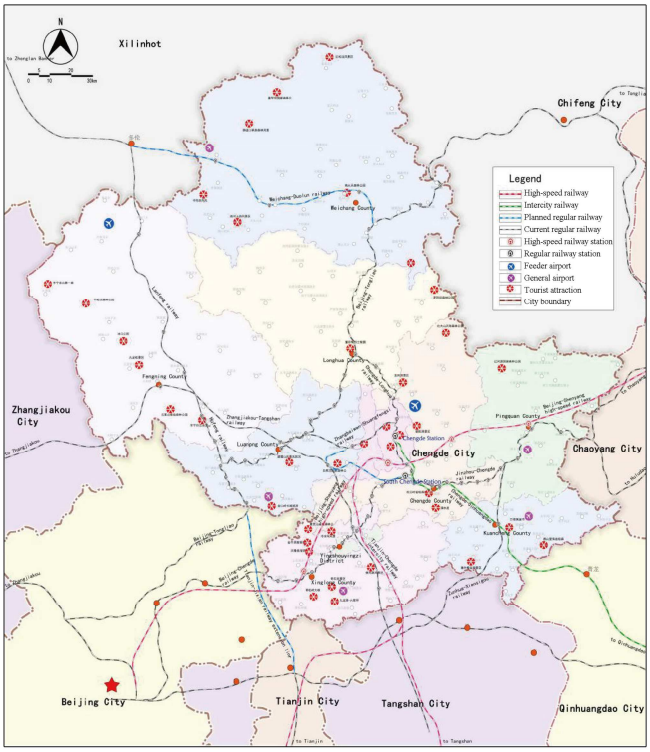


Figure 6 Commuter railway planning of Chengde City

Source: Reference [8].

It is suggested to retain the existing Chengde Station and strengthen its functions serving tourism organization and suburban transportation. Four main factors are considered. First, the regular railway network in Chengde City basically covers all districts and counties, which is rare in cities across the country. With high-quality and rich tourism resources, the touring by general tourism trains can become a characteristic for Chengde City. Second, HSR services will cover most areas in the future, but regular railways are still needed to connect with the Inner Mongolia, and the regular railway stations have to be reserved. Third, Chengde Station is adjacent to the core area of the city and Chengde Mountain Resort, which is convenient for serving residents's travel and tourists' arrival. Affected by the spatial pattern of Chengde urban space, it is difficult to choose a more suitable new site if the station is moved. Fourth, most of the regular railway sections in the urban area are close to the edge of the mountain. Although the railway lines form barriers to some areas of the city, they can be basically solved by increasing new passages. The planned subway transit corridors can coexist with the current regular railways, without the need to vacate the railway space [8].

2) In mega cities and large cities, excess capacity of regular railways can be used to facilitate suburban transportation

In mega cities, with the increasing integration of urban areas and the release of transport capacity of passenger and freight rails, the regular railway transit gradually undertakes the suburban transport function. For example, Beijing plans to use the radial regular railway network to serve the suburban transportation of the central urban area and the municipal towns, as well as the Sanhe County, Xianghe County, Dachang County, Gu'an County, Langfang City, and other towns around Beijing. The organizational hubs of these regular railways are still located in the inner part of the central urban area, which are not relocated.

2.3 Function enhancement of passenger stations of regular railways

In some areas, especially those with special terrains, regular railways have both positive and negative effects. Even if there are HSR lines, the role of regular railways needs to be strengthened instead of being ignored. The following is an example of Xining–Haidong urban development zone.

1) Contradiction between railways and urban space and functions

Lanzhou–Xining urban agglomerations have terrain constraint, showing a strip pattern, in which Lanzhou is in a belt pattern along the Yellow River; Minhe County and Ledu District in Haidong is in a belt pattern along the Huangshui River; Xining is in a cross-valley pattern. Lanzhou–Qinghai railway passes through Lanzhou, Ledu, Minhe, and Xining, which connects with Qinghai-Tibet Railway in Xining. Lanzhou–Wulumuqi HSR is arranged in parallel, turning northern to Zhangye in the west of Xining Station; the current layout of railway passenger stations and railway shifts are shown in Figure 7. The contradiction between the railway and the city is mainly reflected in the following aspects. First, the length of four valleys in Xining reaches 20–25 km respectively, while currently there is only one passenger station in Xining, which is not very efficient for serving the city. Second, the urban space of Minhe and Ledu in Haidong is narrow and long, with that in the narrow axis direction as only 2 km. Lanzhou–Qinghai railway and Lanzhou–Wulumuqi HSR are arranged along the Huangshui River, occupying a large amount of urban space and forming a large division of the city traffic.

2) Future railway network and city development

From the perspective of regional pattern, Xining is located in the northwest and the gateway of the Qinghai Tibet Plateau. From the perspective of the national railway network

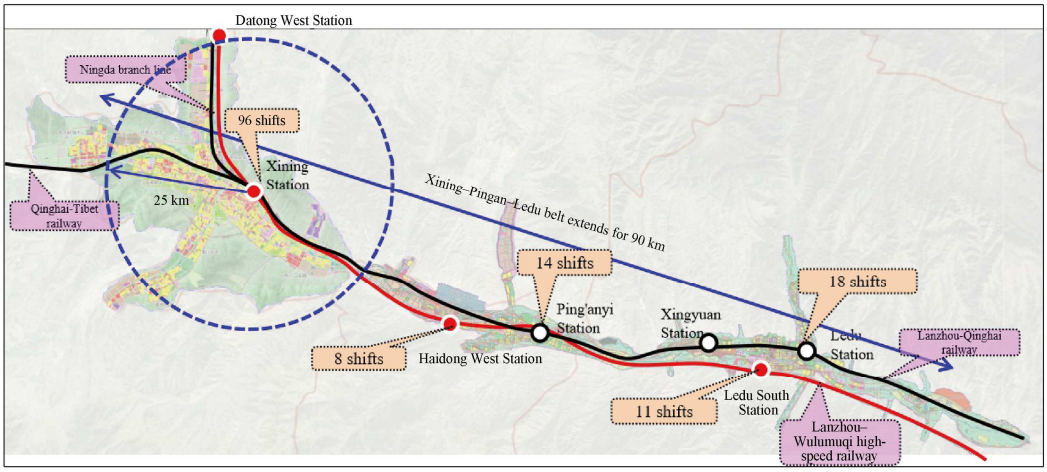


Figure 7 Railway layout in Xining–Haidong urban development belt

planning, there will be a new (fast) speed railway connecting Xining and Chengdu in the future; while in the face of the Qinghai Tibet Plateau, there is only the current Qinghai-Tibet railway, which will still play an important role for entering/existing Tibet via Xining. In terms of urban space, the cross-valley spatial form of Xining will further extend, mainly in the east-west direction. East valley and Ping'an County extend together, and the integration of Ping'an and Xining will be further strengthened. The new city of Duoba will be built in the west valley, becoming the sub-center of Xining City.

3) One enhancement measure of regular railways: optimize the balanced service of railway passenger transport hubs for Xining

It is supported to develop the west valley of Xining City, set a new railway passenger station, and improve service efficiency. Xining West Station, currently located in west valley, can serve as the Xining Second Passenger Station [9]. The distance between Xining West Station and Xining Station is about 14 km, advancing the land expansion and functional improvement of the west valley.

4) Another enhancement measure of regular railways: connect the passenger transport of Xining urban area, Ping'an County, and Ledu (Haidong urban area) region

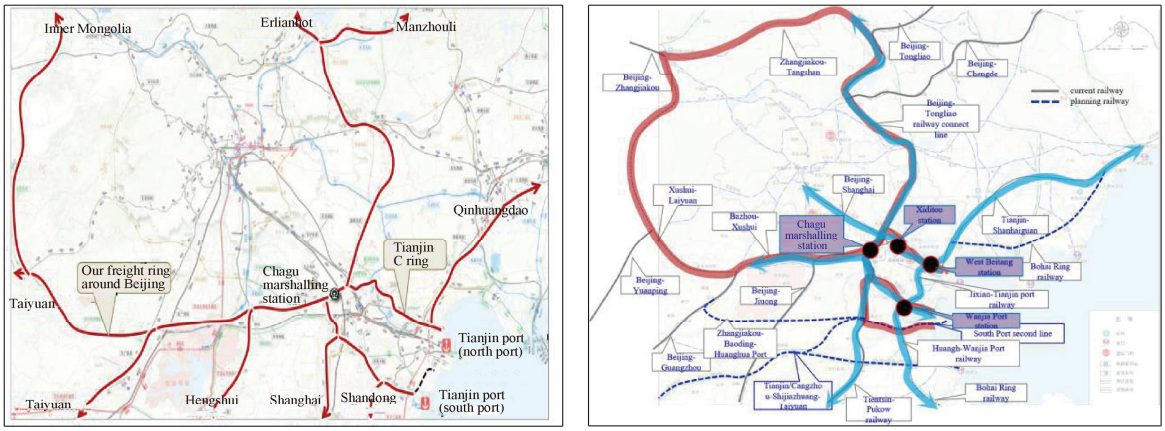
It is believed that the integration of Xining City, Ping'an, and Ledu needs the support of urban rail transit lines. However, the cost of construction, operation, and maintenance of rail transit is very high. According to *Standard for Urban Rail Transit Network Planning* (GB/T 50546-2018), the planning and layout of urban rail transit lines should conform that "the passenger flow density of fast lines should not be less than 10^5 people·km·(km·d)$^{-1}$", which is a basic indicator to ensure no monetary loss from the fast lines. The urban planning data of Xining and Haidong in 2035 suggest that passenger flow intensity between Ping'an and Ledu and that between Xining and Ping'an in the future is about 27 000–87 000 people·km·(km·d)$^{-1}$, which is far from the threshold of urban rail transit. In order to effectively solve the problem of Xining–Ping'an–Ledu rapid public transport connection, this paper suggests maximizing the use of the national railway system. There are two lines among the central urban areas of Xining, Ping'an, and Ledu. The first is the Lanzhou–Qinghai—Qinghai-Tibet railway, with LeduStation, Xingyuan Station, Ping'anyi Station, Xining East Station (passenger transport is recommended), Xining Station, and Xining West Station. The average inter-station spacing is 12–15 km, which can basically satisfy the connection among important functional groups. The other is the Lanzhou–Wulumuqi HSR. The stations include Ledu South Station, Haidong West Station, Xining Station, and Datong West Station, and the inter-station distance is about 30 km. It only serves the rapid connection among Ledu, Ping'an, and Xining. Regarding the ticket price, K-head ticket between Ledu and Xining is CNY 12.5; D-head second-class ticket is CNY 17.5, while bus ticket price is CNY 21. Travel by trains is cheaper, but train shifts are not flexible. In the future, it is considered to utilize the surplus capacity of railways to open shifts for metropolitan passenger transportation, which can further increase the number of shifts. It is expected to meet the public transport demand of serving the Xining–Ping'an–Ledu corridor together with bus transport.

In order to further release the limited urban space, the plan [10] has proposed to gradually move the Lanzhou–Qinghai to the edge of the urban space. Given the long and narrow space, the distance between the relocated station and the city is still in a suitable range.

3 Coordination between freight transportation of regular railways and urban space and functions

3.1 Optimization of regular railway freight transport based on multi-modal transport

In the process of moving freight stations, it is important to



a "double ring" pattern

b "C-ring + cross corridor"

Figure 8 Optimization of railway freight network in Beijing- Tianjin-Hebei region

Source: Reference [12].

combine with industrial functional areas and promote multimodal transport for the location of new stations. In port cities, special attention is paid to the multi-modal transport of railways, highways, and water transport. In general, the railway is directly connected to the port area through the newly built special port line. With Yibin City as an example (see Figure 5), the original freight station, Yibin North Station, located inside the city is removed, and the new Yibutan freight station is set in the north of the city. The railway is extended to Yibin port through the special railway line of Yibin port, forming the combined transport of railways and water transport [11].

3.2 Optimization of regular railway freight transport to support function improvement of urban freight hubs

For railway corridors with complete separation of passenger and freight lines, the regular railway will fully undertake the freight function. Whether the layout and organization of the regular railway can support the urban function is also a matter of concern. The following discussion takes Tianjin as an example.

1) Railway freight planning in Beijing-Tianjin-Hebei region

The *Beijing-Tianjin-Hebei Coordinated Development Planning Outline* clearly defines Tianjin as a freight hub in Beijing-Tianjin-Hebei region. According to the General Plan of Beijing-Tianjin-Hebei Railway Hub, the Fengtai network marshalling station is transferred to the Chagu marshalling station in Tianjin as the main marshalling station in Beijing-Tianjin-Hebei region. The Chagu marshalling station is then taken as the organization hub to form a "double ring" structure in this area (see Figure 8a). The bigger ring in the "double ring" is the outer freight ring around Beijing, which realizes the freight collection and distribution in Beijing. The smaller ring in the "double ring" is the Tianjin C-ring, which achieves the multi-modal transport with Tianjin port and the freight transportation out of the central urban area of Tianjin.

2) Strengthen "longitudinal passages" on the basis of existing railway planning

Tianjin's C-ring railway is indeed helpful to address the contradiction between the traffic lines for relieve stress on ports and urban space. However, is the C-ring the most suitable organization form and is there a better plan?

Tianjin's, as a freight hub, on the one hand, is oriented to Beijing-Tianjin-Hebei region and "Shanxi Province, Shaanxi Province, western Inner Mongolia" areas, which is well supported by the two-ring structure and Chagu marshalling station discussed above. On the other hand, it is oriented to the Bohai region, which needs to detour by 170 km to achieve connectivity and greatly reduces the function. Therefore, the freight organization pattern of "C-ring + cross corridor" is proposed [12] (see Figure 8b). The fundamental difference is how to understand the function of longitudinal railway passages (the railway line between West Beitang and Wanjia port, hereinafter referred to as "longitudinal passage"; see Figure 9) for freight railway organization and linkage between ports in the direction of Bohai Sea Region. There are several insights about this vertical channel. First, it is beneficial to improve the organization efficiency of freight transportation in Bohai Sea Region to incorporate the longitudinal passage into Tianjin freight organization system. Second, forming a railway link between the northern and southern port areas of Tianjin is convenient for cargo distribution and complementary interaction. Third, the railway line has been completed and located between the "two cities" (central urban area and core area of Binhai New Area) of Tianjin, which is far away from the urban area and therefore has little impact on the urban living environment. In addition, the Jizhou-Tianjin Port railway has been transporting cargos since its completion in 2000.

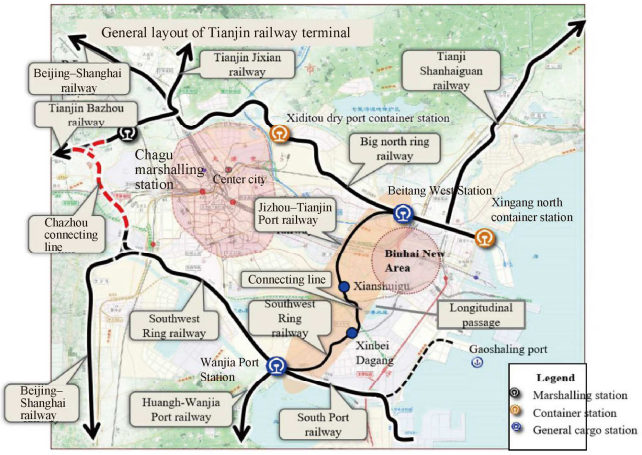


Figure 9 Longitudinal passage of Tianjin freight network

Source: Reference [12].

4 Optimized utilization of regular railway special lines

Regular railway special lines can be roughly divided into two categories based on locations. One is the special line located in the outskirts of the city, which is connected from a station of the national railway trunk line to an industrial and mining enterprise in the city. The other is the special line for the power plant, cement plant, steel plant, or other industrial and mining enterprises in the city. At present, while some special lines are still busy with transportation, most special lines are idling with substantial decline in freight function due to the adjustment of national energy structure, resource exhaustion, and other reasons, or they have been moved to avoid passing through residential areas.

4.1 Special lines around cities

The most typical feature of a special railway line located outside of cities is the end-type line, which has only one end connected with the national railway trunk line and cannot form a network. For such special railway lines, the general arrangement is to extend them and connect the other end with the national railway trunk line to form a network. If they are not extended, these lines usually change functions instead of being removed.

With Jinshawan–Junlian special railway as an example, it runs through Gongxian, Gaoxian, and Junlian Counties, which is a special line for coal transportation. With the change of coal industry, the freight volume of Jinshawan–Junlian railway is decreasing year by year. There are two ways to optimize the railway. The first approach is to take advantage of the rural tourism and other resources along the line to transform it into a tourism railway. The second approach is to connect it with the existing Neijiang–Kunming railway by adding Junlian–Yanjin railway and strengthen the external railway connection of Gongxian County and Junlian County along the line (see Figure 10).

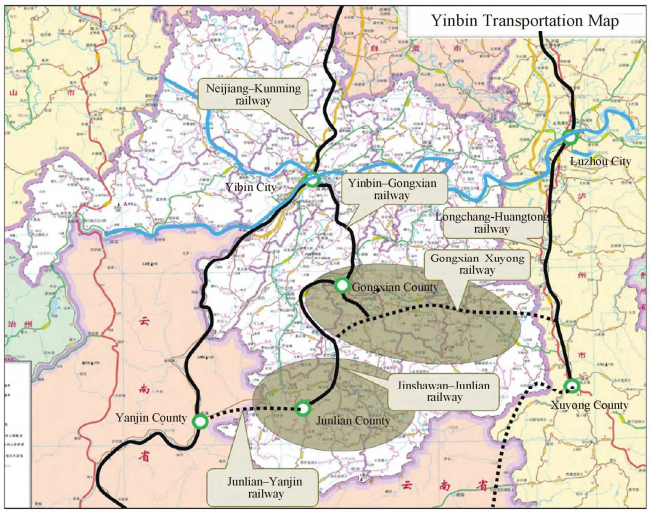


Figure 10 Extension of special railway lines in Yibin City

In addition, some existing regular railway lines have been converted into suburban railways. For example, Beijing uses the abundant capacity of the Beijing–Baotou railway and Kangzhuang–Yanqing branch line to open city commuter trains, namely the line S2 from Beijing North Station to Badaling Great Wall and the Jinshan line of Shanghai sub-urban railway reconstructed from the original Jinshan branch line.

4.2 Special lines within cities

There are two types of optimized utilization of special railway lines in urban areas.

1) The railway passage is reserved as the urban rail transit corridor, which is appropriate for the passage through the core area of the city. For example, the special railway line of HBIS Group Chengsteel Company connects the two most important functional groups of the old urban area and the west area of Chengde. In cases with scarce corridor resources in mountainous cities, the passage is reserved as an urban rail transit corridor. It is similar for Shanghai Metro Line 3 and Line 4, which are reconstructed from the old Shanghai–Hangzhou railway.

2) The railway passage is reserved as green space, parks, and greenways. It is suitable for the railway-crossing areas close to tourist attractions, characteristic landscape areas, leisure and entertainment areas, or secondary passenger flow corridor areas. For example, the extension line of the original Yingtan–Xiamen railway in Xiamen has been transformed into a plank road for pedestrians. With Chentang branch railway as the axis, Tianjin will build its first green-way park.

5 Conclusion

The construction of HSR network and the separation of passenger and freight lines have changed the relationship between regular railways and cities. For some regular railways located in the secondary corridors with low grade and low speed, the passenger transport function has declined significantly, and the contradiction among railway lines, stations, and cities is prominent.

Relocating passenger stations of regular railways in the urban area are mainly dependent on the following situations: 1) The layout of current regular railway lines in the urban area: If the regular railway network in the city area has high accessibility and good combination with cities and towns, it is suggested to utilize the passenger transport organization function of the regular railway network in the city area, and the railway station in the central city area is suggested to be retained at the original site. 2) The overall consideration of access of new lines and optimization of railway hubs: The access of new regular railway lines will be generally evaluated with respect to whether the present regular railway passage has enough space, whether the present regular railway stations have enough capacity, whether the surrounding road network has enough collection and distribution conditions, and whether the changing transportation demand matches the urban space. Based on these evaluations, it can be decided if the present regular railway stations should be retained or moved out. 3) In some cities with special forms, the benefit and cost of transforming the present regular railway passage into the urban traffic passage should be evaluated. This situation requires a comprehensive evaluation of the opportunity and cost of railway relocation as well as availability of alternative passages and other factors.

The coordination between the regular railway, which mainly or completely undertakes the freight transportation, and cities needs to focus on the following points: 1) whether the lines and stations divide the urban space and result in urban environmental impacts; 2) whether the lines and stations are conducive to support the function improvement of urban freight hubs and multi-modal transport.

The special lines for regular railways are characterized by dead-end lines. The special lines of regular railways in cities are usually extended to connect the other end with the national trunk railway. For the lines with reduced freight transport function, they can be converted to undertake suburban transportation or tourism transportation. The special lines of regular railways in cities can also be reserved as the rail transit corridor or transformed into green space, parks, and greenways.

Anotation

① The high-speed railway discussed in this paper follows the definition presented in the scientific brief from the website of the State Railway Administration of China: the newly-built EMU trains with designed speed of greater than 250 km·h−1 (including reserved scenario) and passenger dedicated railway with at least 200 km·h−1 operation speed.

② The regular speed railway discussed in this paper refers to non-passenger dedicated lines with a speed of no more than 160 $km \cdot h^{-1}$ and passenger dedicated lines with a speed of no more than 140 $km \cdot h^{-1}$.

Acknowledgements

The authors appreciate the source materials, case studies, and insights provided by Quanbo, Li Changbo, and Chen Zhong.

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