

# PASSENGER-ORIENTED ERGONOMIC DRAWING OF DIAGRAM MAP FOR CHINESE RAILWAY PASSENGERS' LINES

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Abstract: The diagram maps for passengers' lines of China Railways presents a basic reference for decades, however, it can't meet the demand of Chinese passengers today and it can't catch the pace of the achievements and expansion of China Railways. Based on a marketing perspective for caring passengers, brand new diagram maps of Chinese Railway and its High-speed Railway (CRH) with a planning horizon up to the year of 2020 are designed and drawn by using the theories and methods from both the subjects of ergonomics, visual communication design and graph theory. These graphs will convey a new image and modern information of CRH to attract potential passengers, and help to improve the railway service quality.

## 1 INTRODUCTION

The diagram map for railway lines serves all walks of passengers with different literacy and background, and shows them the origin, destination and transfer station quickly from China's dense and expanding railway networks. These maps convey the connectivity and convenience of railway networks, and served as part of the service image of passengers' transport. The maps are published on booking offices, travel agencies, timetables, books, newspapers and even Internet. However, the old diagram map (MOR, 2009) for passengers' lines had decades of history. Owing to the rigidness of lines, shortage of aesthetics, lack of the convenience, the old diagram is hard to be recognized by normal passengers, hence it can not be adapted to the requirement of modern transportation and the railway passengers. With the quick development of Railway system, especially the emerging high-speed railways network in China (Bai and Qian, 2010), the diagram map needs to be considered from a system perspective urgently to help the improvement of railway service. Based on the service and ergonomics, with integrating the theories and methods of marketing, graph theory, human factors and communications, the railway diagram map will be redesigned comprehensively and systematically, making it the "window" of China railway and an

important and integrated part of the Chinese Railway - Corporate Identification System (CR-CIS). Thus, it will convey a brand-new image of Chinese Railways to all the tourists and passengers both from domestic and abroad, in the modernization and advancing drive of high-speed and service quality.

## 2 THE DRAWBACK OF PRESENT MAP

The present diagram map of Chinese Railways is multiple additions and revisions of traditional railway network. It exhibits the connectivity of railway network, but there isn't a system planning from the beginning, and it lies in the following drawbacks.

*Inconvenience to the Passengers.* The old maps were not drawn basing on the passengers' view; passengers with different vision and knowledge levels can not find out their starting, ending and transferring points and on-going lines quickly when they look through the complex network map of irregular lines and dots.

*Non-straightened Backbone Lines.* The high-speed nonstop straight-forwardness and importance of the main lines isn't prominent in the old maps. Such as the busiest and most important Beijing-Shanghai railway line is zigzagged with seven to

thirteen segments in different editions of the traditional railway diagram. Since the diagram maps are not proportional diagrams, the backbone lines should be straight lines to reflect the directed relations of transportation.

*Shortage of Aesthetics.* The traditional diagram with only rigid straight segment lines was drawn by engineers, and usually done without a bit sense of beauty. These segments and their arbitrary angle between connected segments reveal the old mechanical era image. The rigid segments network without any curves inspires readers nothing of aesthetics and modern service.

In all, the traditional diagram was focused on engineering but hardly with the consideration of passengers needs, it is not accordance with the basic theory of human communications and factors, and it is inconvenient for passengers to read the map, hence it is not functioned the illustration of diagram maps to passengers.

### 3 THE BASIS AND REFERENCE FOR IMPROVEMENT

The railway diagram maps illustrate the connectivity between stations; it would be drawn better on network graph with nodes and arcs rather than the proportional geometric map coordinated to the geographic sites. By network graph, the railway stations are nodes and the lines between stations are arcs which can be straight lines or curves by the graph layout. A good example is the metro diagram maps of large cities, such as Paris and New York.

#### 3.1 Metro Diagram Maps and Ergonomics

For a metro diagram map, such as the Paris Metro Map, it is a planar graph with different colours for passengers' convenience, and is designed based on ergonomics and visual communication theories (Sanders and McCormick, 2001). The main characteristics of these diagrams are list as follow.

*Colour Usage.* Colours are used for a quick finding of expected nodes and lines from the network and colours enhance passenger's cognition and memory with each metro line a unique identification colour. Nowadays the metro maps in large Chinese cities are done in such style, but it is hard to find such style in the Railway system.

*More Vertical and Horizontal Lines.* The vertical and horizontal lines are used to illustrate the connectivity, so it is easier to make and read the

graph and fits to human cognition intuition. The slope lines will be used to the least; and a 45 degree slope line is used in case of necessity. In such a degree, there will be a good supporting and visual effect for the graph. And if there is a turning corner of two segments without a node, then the corner will be rounded to smooth curve.

*Nodes Representation.* In the metro maps, different nodes represent different types of stations for a quick cognition by passengers. These representations includes: emphasized circles for origins and destinations of a line, solid dots for non-transfer nodes and circles for transfer nodes. A small transfer station is represented by a small circle, but large and multiple transfer station is represented by a rounded rectangle or a complex shape with rounded rectangle and circles to show stations' connectivity.

*Text in the Map.* Although different lines are distinguished by identification colours, the text for stations should be in single colour, namely black, for consistence and striking in reading; while main stations are emphasized by bold font style.

#### 3.2 The Theory of Graph and Network

By the theory of graph and network (Hu, 2009), a connected graph can represent the railway network of a country or area while the station acted as node and railway segment as the edge. Recent years with the emerging study of complex networks, some scholars begin the research of a scale-free railway network in China. In the empirical analysis by Li and Cai (Li and Cai, 2007), the statistical properties of the China Railway Network consisting of 3915 nodes (train stations) and 22259 edges (railway segments). The network displays the small-world property, has the fingerprint of a small characteristic shortest-path length, 3.5, accompanied by a high degree of clustering, 0.835. That is after an average of 3.5 times of transfer, any of two stations in the Chinese Railways network can be reached. Here, our main purpose is to study the connectivity of main nodes with multiple edges, and this connectivity is the basis for the scale-free graph. And the location and distance of nodes are considered afterward.

## 4 DESIGN IDEAS AND STRATEGIES

The design of the diagram map for passengers' line should be guided systematically by the theories of ergonomics and visual communication (Sanders and McCormick, 2001). A concise, elegant, striking

diagram map can be achieved with integration and convenience for passengers, based on the status quo and long-term planning of Chinese Railways network. Our design is shown in Figure 1 (Yi, Yuan and Zhang, 2010) with the following strategies.

#### 4.1 Based on the Long Term Planning

The railway construction is booming in China these years with leap in line length and network expansion, an updated diagram map is needed to reflect the planning and development. Our design is based on the Revised Mid and Long term Railway Planning with a horizon up to the year of 2020 (MOR, 2008) and some Five-Year plans before. It focuses on the network connection and grid space to meet the requirement of present framework and future development.

#### 4.2 Straightening of Backbone Lines

Based on the planning of the dual four main Vertical and Horizontal (4V4H) high-speed passenger lines, a

backbone network is formed with these straightened segments, such as vertically Harbin-Dalian Line, Tianjin-Nanjing section of Beijing-Shanghai Line, Shijiazhuang-Guangzhou section of Beijing-Guangzhou Line, and horizontally Xuzhou-Baoji section of Gansu-Jiangsu Line, Jinghua-Changsha section of Shanghai-Kunming Line, Shanghai-Nanjing section of Beijing-Shanghai Line Jinan-Qingdao and Shijiazhuang-Dezhou sections of Yangtze Line. Also, it straightens most of the dual eight main Vertical and Horizontal railway lines (8V8H) by the finished tenth Five-Year Plan such as the Beijing-Kowloon, Lanzhou-Xinjiang, Datong-Zhanjiang, Baotou-Liuzhou (Baotou-Guiyang section), and Lanzhou-Kunming (Chengdu-Guangdong section) Lines, and other existing railways such as Linhe-Yangpingguang, Wuwei-Dezhou, Jiding-Hami, Wuhai-Qinghuangdao, Manzhouli-Suifenhe, Bihong-Baihe Line. Even the Datong-Qinghuangdao Line mainly for cargo transport is represented in straight line on our

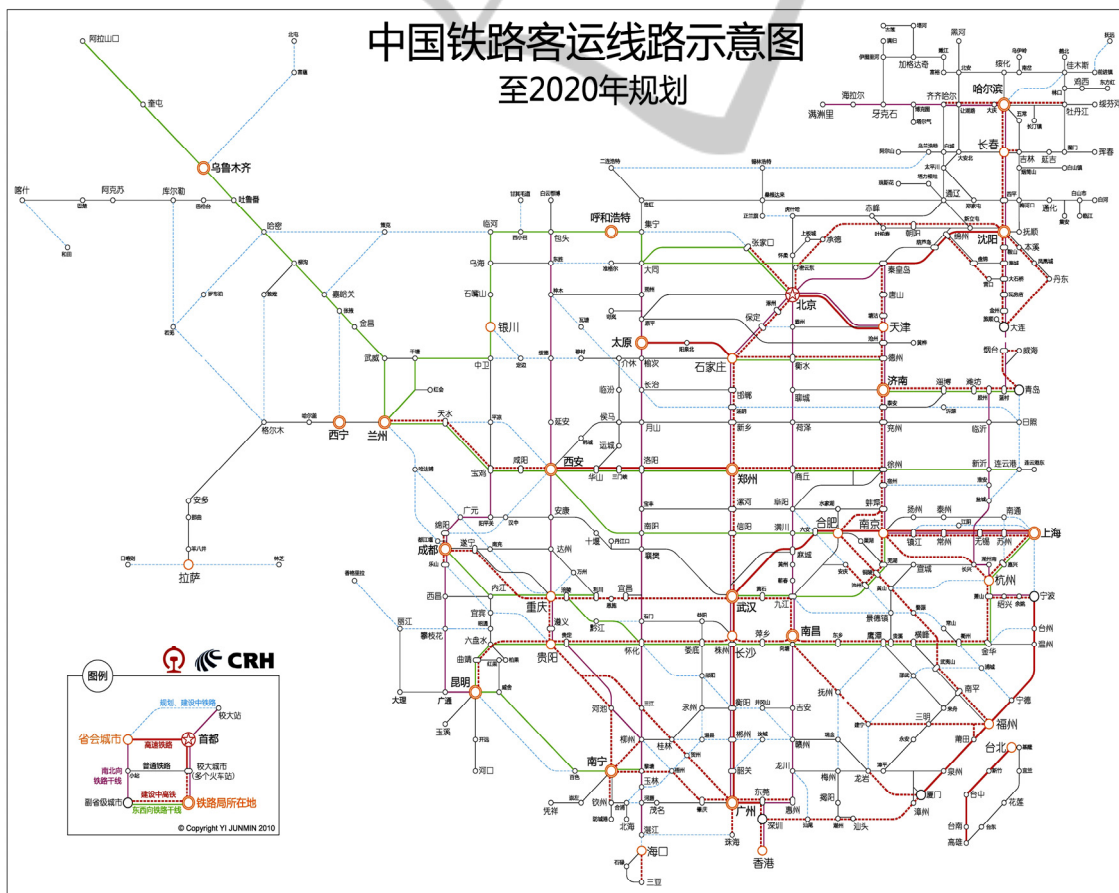


Figure 1: Our design of the diagram map for Chinese Railways passengers' lines.

diagram map. Non vertical or horizontal lines are laid in 45 degree orthogonal with curved corner for streamline effect. In all, the diagram map conveys a backbone straightforward high-speed concept, which Chinese Railways is undergoing.

### 4.3 Line Types and Colouring

According to the principles of ergonomics and visual communication, four types of line and colour are used to classifying different types of railway. A red line with line width of 1 is for the latest CRH High-speed railway service, while a dashed one for such railway under construction, an example is the new Wuhan-Guangzhou CRH line paralleling to the old ones (one of the 8V in pink with line width of 0.6, while 8H in green). A watery blue line with line width of 0.3 is for planned lines while black one for existing line with rated speed less than 200 km/hour. The colours are chosen by railway tradition and general colour meanings. The ratio of line width is 1:0.6:0.3, which has a clear variation.

### 4.4 The Nodes

The nodes are on the top priority for passengers to find the origin and destination from the map quickly. By considering of the complexity, robustness and dependence between stations in Chinese railway network (Derrible and Kennedy, 2010, Wang, Y-L et al, 2009), in our design, five categories of node are classified based on the stations in old diagram map and planned new stations.

- Category 1. Beijing is represented by a five-pointed star in a large circle for the normal meaning of state capital and top railway hub.
- Category 2. Cities where railway administrative bureau seated are represented by a dual large circle, these 17 cities are both provincial capital now.
- Category 3. Other provincial capital cities and five large sub-provincial level cities are represented by a large circle.
- Category 4. Cities in the intersection of several lines, especially with both normal line and CRH line are represented by a long circle.
- Category 5. Other stations are represented by a small circle.

There are several hundred railway stations under construction in China's railway boom today, thus there are large cities rather than stations to be shown in the map for it is hard to show all the passenger stations for a large city in the map. For example, there are Beijing Station, Beijing West, South and

North stations in Beijing City only and Wuchang, Hankou and Wuhan stations in Wuhan city now. The structure of one-city-multiple-station can be summarized by a table by the side of the map, as shown in Figure 2.

### 4.5 Font for Nodes

The font of stations and cities are necessary and meaningful to read the diagram. In our design, the font is always in black sans serif for clear reading, and there are four types with two fonts. Type 1 is for Category 1 and 2 cities aforementioned by Microsoft Yahei font with font height of 5; Type 2 for Category 3 cities by Youyuan font with font height of 5; Type 3 for Category 4 by Youyuan font with font height of 3.5; and Type 4 for Category 5 stations by Microsoft Yahei font with font height of 2.5. The ratio of font height is 1:0.7:0.5 close to the golden section, which has a clear differentiation.

These arrangements with broad and fine line, single and double circle and large and small size confirm to ergonomic principles, and the total layout is striking for passengers' quick and meaningful reference.

## 5 DESIGN RESULTS

The finished diagram map includes 370 cities / stations in a 166 · 112 lattice, with space for more stations in the future. The map reveals several interesting findings.

- In general, there are more horizontal lines than vertical ones, but the North to South vertical backbone lines are more strong and in evidence.
- Slope lines lie more in the West and the South, with a reflection of less orthogonal and straight lines in these mountainous regions.
- There is a distinct difference between the South and the North by the Gansu-Jiangsu Line. There are more straight lines in the North, while more curves in the South, and especially in the vast Northwest China, the sparse railway lines can be drawn just straightforward. This is consistent with the analysis of Wang's Geographic coarse graining analysis of the railway network of China (Wang et al., 2008).
- By density, the highest lies in Northeast China and The Yangtze River delta. While there are more lines by planning and under construction in the regions of East China (South) and Southwest China, which reflects the potential demand of railway service.



