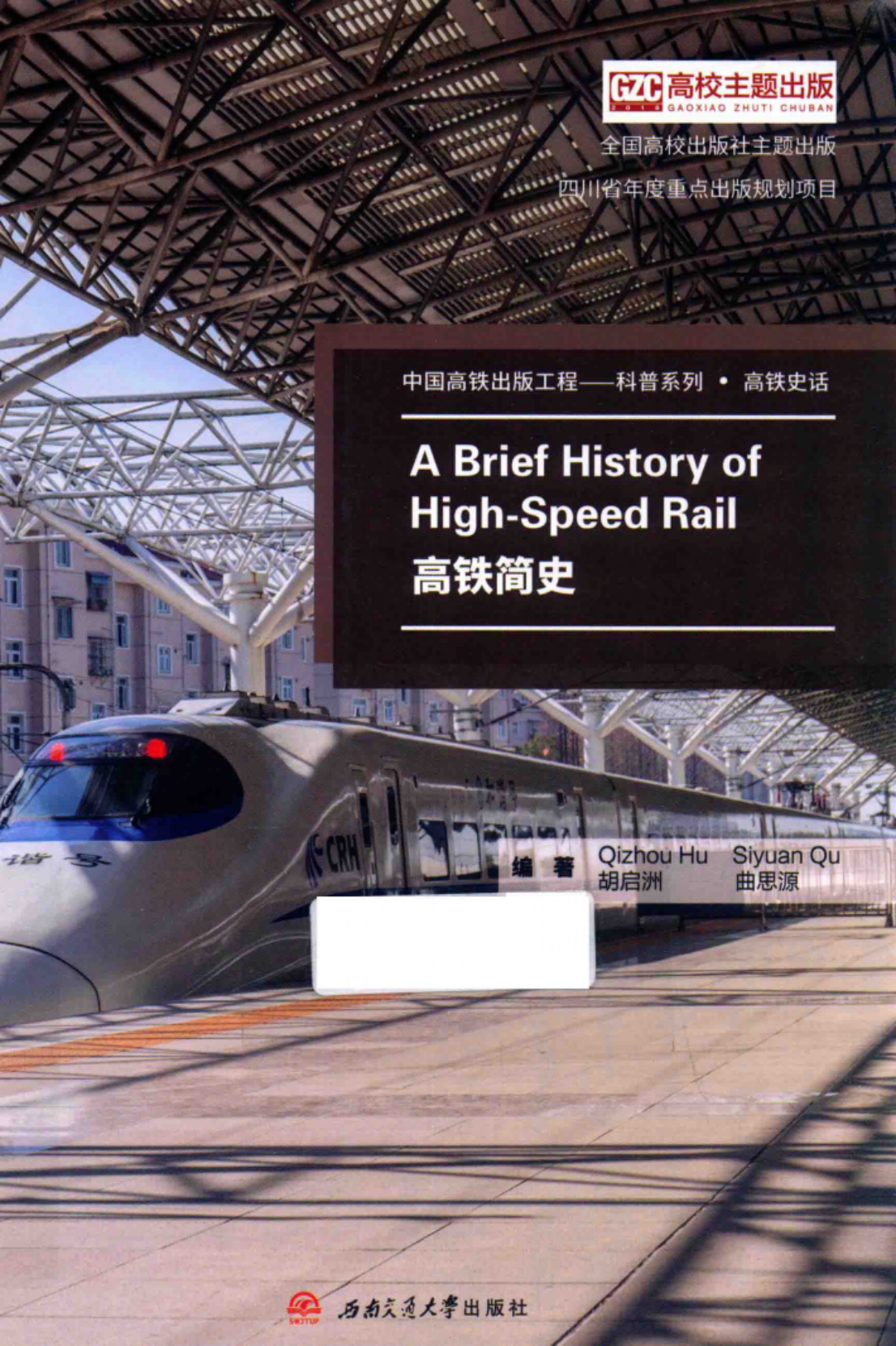

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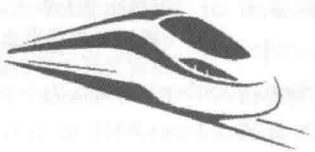

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编著　胡启洲　曲思源

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PREFACE

As the saying goes, "height changes view; angle changes concept and scale grasps life". While "speed" determines transportation, "transport capacity" changes the transport modes and the "technology" ensures the traffic safety. High-speed rail (HSR) is regarded as a vehicle that changes human life and characterized by "There is not a fastest vehicle,but only faster vehicle". Compared with other transport modes, HSR has many advantages such as big transportation capacity, fast operation speed, high safety, high punctuality rate, low energy consumption, less influence of environment, land conservation, considerable economic and social benefits. With its unique technical advantages adapted to the new needs of modern social and economic development, HSR has become an inevitable choice for the development of countries around the world. In particular, the development and operation of China's high-speed rail indicates that HSR has great development space and potential in China. China would better make full use of its latecomer advantage to realize the leap-forward development of HSR. Therefore, "A Brief History of High-Speed Rail" is a reading book that introduces the basic knowledge, concept terms and development history of HSR, and sorts out the main results of HSR at this stage. This book mainly explains the connotation of HSR for readers from two different aspects of theories and technologies. Combining with the characteristics of high-speed and the development trend of the world, this book introduces the development meaning of high-speed rail. The main contents are as follows:

(1) Concept term of HSR. Related terms of HSR, especially the definition of HSR and the speed classification, as well as the main attributes of HSR, such as speed, capacity, safety, comfort, economy, energy efficiency, environmental protection and so on.

(2) Development trend of HSR. Introducing the development trend,

technological features and application prospect of the three classes of Wheel High-speed Rail (WHSR), Magnetic High-speed Rail (MHSR) and Super-speed Rail (SSR), those are the past, present and future of HSR development. This book is mainly about two aspects. Firstly, the author describes the development of HSR in time–yesterday, today and tomorrow. Secondly, the author comparatively analyzes the development trend of HSR in domestic and foreign countries (especially the HSR comparative analysis of Japan, France, Germany and China) in space. Through the comparative analysis, readers can understand the development trend of China's HSR in the world, ranking first in terms of "quality" or ranking first in "quantity".

(3) Regional integration in the environment of HSR. Various types of HSR promote integration level among different regions. WHSR promotes the regional integration, MHSR promotes the continental integration and SSR promotes the world's integration, leading to a global village. Therefore, we must pay attention to the development of HSR. At present, countries that master the core technology of WHSR, MHSR, SSR, etc. will own the world.

This book is created by the Qizhou Hu team of High-Speed Rail Science Research Institute. The team members mainly include the Senior Engineer of Shanghai Railway Bureau Siyuan Qu, graduate students of Nanjing University of Science and Technology Jie Chen, Ziquan Cong, Minjia Tan, Airan Zeng, Lishuang Bian, Xiaohan Li, Min Yue, Hao Zhou, Juanjuan Lin, Yikai Wu.

For a popular science book, benefiting the public is the highest aim. However, some of the pictures and contents of this book come from the Internet. Since we can't find the source, we can only express our gratitude and respect here for them. We are also grateful for the selfless help from the editorial staff when we are in the writing of this book.

This book can be used as a reading material for researchers, engineers and technical personnel, management workers, college teachers and students, and high-speed rail enthusiasts. Limited by time and knowledge of us, there are inevitable omissions and inadequacies in the book. Please enlighten us. Thank you.

The Writer

August 2018

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Chapter 1 Introduction

With the official operation of the world's first High-speed Rail (HSR) in Japan on October 1, 1964, HSR opened a new era of transportation development. Speed and capacity are eternal pursuit of mankind. The requirements of human beings for any means of transportation (trains, cars, airplanes, ships, etc.) not only depend on speed but also on transport capacity.

Although the aircraft operates at a high speed, its capacity is poor. The train has a large capacity, but it runs at a slow speed. Therefore, the pace of human pursuit of transport never ceased, and HSR is the crystallization of human wisdom in transportation. The French Wheel High-speed Rail TGV is as shown in Figure 1.1.

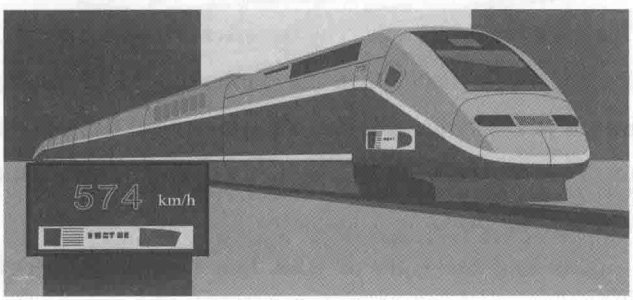

Figure 1.1 French WHSR: TGV

HSR is an abbreviation for high-speed rail. It is a large system composed of dedicated lines, high-speed trains, and dedicated control systems. Therefore, HSR is a system concept but not an individual concept. The "high-speed" in the high-speed rail refers to the quality, and the "rail" is the property. In addition to Wheel High-speed Rail (WHSR), HSR also includes Magnetic High-speed Rail (MHSR) and Super-speed Rail (SSR). Therefore, the narrow sense of HSR refers to the WHSR transport system. The broad HSR includes

not only the WHSR transport system, but also the MHSR, which is using the magnetic levitation technology, and the SSR transport system in the vacuum track. Figure 1.2 is a diagram of high-speed rail train.

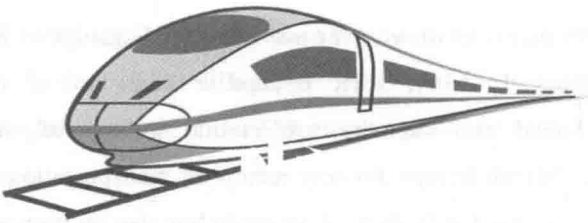

Figure 1.2 HSR train

HSR has become a hot issue in the world. This is because HSR has some technological advantages that are incomparable to other modes of transportation. The first advantage is the high speed. The French WHSR TGV set a world record with the speed of 574.8 km/h. Japan's MHSR set a world record with the speed of 603 km/h. The America SSR set a world record with the speed of 1,000 km/h (faster than the normal speed of the airplane). The second advantage is the large volume. The interval of HSR trains can be as short as 4 min. Twelve trains can be operated per hour in one direction, which is incomparable to highways and aviation. The third advantage is the high safety. The quality and precision of HSR line facilities are high. The train operation control system uses mature electronic technology and intelligent software which ensures the safety distance between the two trains. Therefore, there are few accidents in HSR around the world. Fourthly, HSR can operate throughout the day because it cannot be affected by rain, snow, fog, wind. Fifthly, HSR also has the features of low energy consumption, land conservation, light pollution and high comfort. Therefore, HSR has been welcomed by most countries in the world since its birth.

1.1 Emerging conditions of HSR

(1) The production of vehicle requires certain conditions. In any means of transportation, human beings appraise it from three aspects. Human beings judge the quality of vehicles usually from the following three criteria. First is the functionality such as speed, capacity, and safety. Second is the economics such as cost, energy, and efficiency. The final one is the ecology such as noise, radiation, and environmental protection. As a means of transportation, HSR also takes the load into account while pursuing high speed. Noting that high speed and heavy loads are the eternal pursuit of mankind, HSR exactly meets human needs. Figure 1.3 shows Wheel High-speed Rail train.

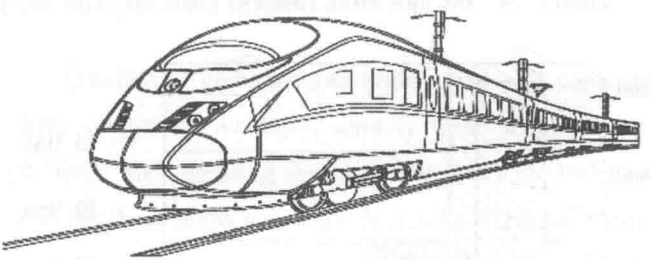

Figure 1.3 WHSR train

(2) The speed of HSR. Speed is the basic requirement for transportation. It is exactly for the rapidity and high efficiency that the HSR has been loved by humans and has been greatly developed. A comparison of speed between HSR and other vehicles is shown in Figure 1.4.

(3) The load of HSR. The basic demand of human for transportation is huge load capacity. The comparison of the loading capacity between HSR and existing vehicles (cars, airplanes, ships, traditional trains, etc.) is shown in Figure 1.5, from which we can obtain that the HSR is the vehicle with the largest load.

Concorde	■■■■■■■■■■■■	2 000 km/h
Hyperloop	■■■■■■■■	1 200 km/h
BOEING737	■■■■	800 km/h
Bullet train	■■	500 km/h
Eurostar	■	300km/h

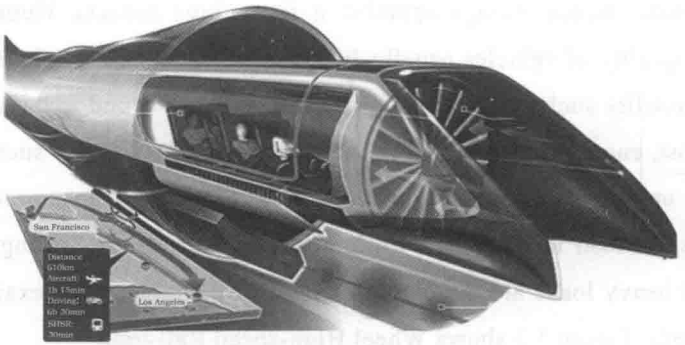

Figure 1.4 the operating speed of different vehicles

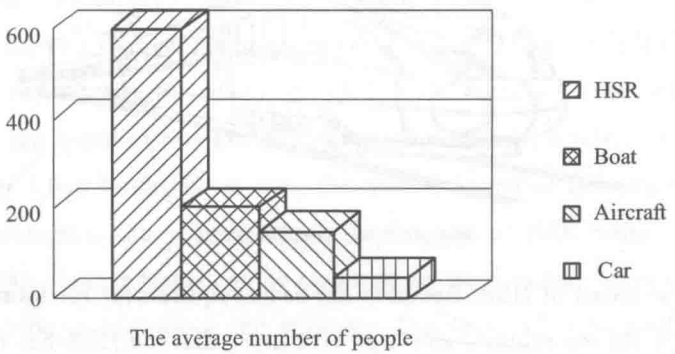

Figure 1.5 Comparison of the loading capacity between HSR and other vehicles

(4) The safety of HSR. Since HSR is operating in a fully enclosed environment and has a series of comprehensive safety protection systems, its safety is unmatched by any other means of transportation. Several major HSR countries have to operate thousands of HSR trains every day. While the accident rate and casualty rate are far lower than other modern modes of transportation. Therefore, HSR is considered as the safest transportation. The comparison of safety between HSR and other various vehicles is shown in Figure 1.6.

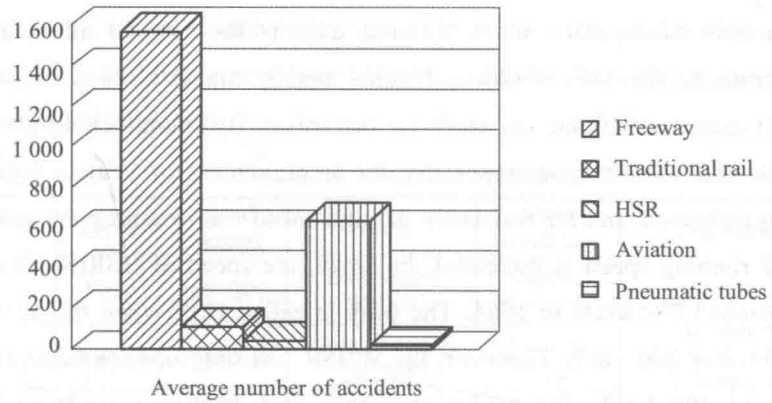

Figure 1.6 Comparison of safety between HSR and other various vehicles

1.2 Three leaps of HSR

In order to satisfy the demands for both speed and capacity, the HSR experienced three qualitative changes, namely three leaps. From WHSR to MHSR to SSR, from the operating speed of 200 km/h to 500 km/h to 1,200 km/h, this is also the three leaps in human demand for transportation.

1.2.1 The first leap: improve the speed of operation and the birth of WHSR

The first category:Wheel High-speed Rail (WHSR). To improve the speed of the train brings the first leap. So the first type of HSR, the WHSR was born. The traditional train and WHSR train are shown in Figure 1.7.

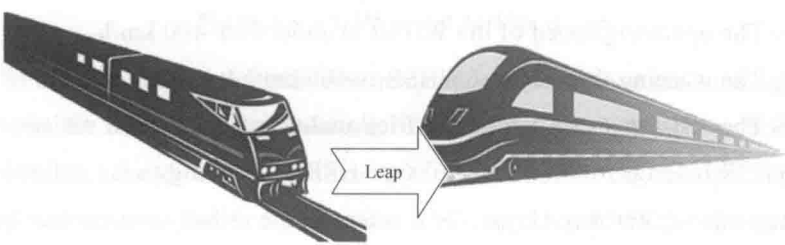

Figure 1.7 Traditional train and WHSR train

In term of capacity, the traditional train is the king of all modes of transportation. However, traditional trains usually run at a speed below 200 km/h. It cannot satisfy human needs for fast travel. By strengthening the study of track and vehicle type, especially the improvement of vehicle type, the friction resistance and air resistance of high-speed train running are reduced, and the running speed is increased. In Japan, the speed of HSR(Shinkansen) train reached 200 km/h in 1964. The train is called HSR when the operating speed is over 200 km/h. However, the WHSR can only operate between 200 km/h and 400 km/h due to air resistance and frictional resistance. The operating speed of 400 km/h is the warning threshold of WHSR. Exceeding this speed is extremely easy to derail and cause traffic accidents. WHSR train is as shown in Figure 1.8.

Figure 1.8 WHSR train

Wheel High-speed Rail is mainly a transportation system running on the track, which people refer to as WHSR, also called conventional HSR. The main features are as follows:

① The operating speed of the WHSR is about 200–400 km/h.

② The warning threshold of WHSR is 400 km/h.

③ The resistances of WHSR are frictional resistance and air resistance.

WHSR belongs to the wheel-rail type HSR. According to the definition of the International Railway Union, HSR refers to the railway system that has an operating speed of more than 200 km/h by transforming the traditional line

(straight line, gauge standardization), or has an operating speed of more than 250 km/h by building a new line. This book divides WHSR into three types. See Table 1.1 for details.

Table 1.1 Types of WHSR

Number	Types	Speed /(km/h)	Name	Main countries	Remarks
1	First	200–300	Low-speed WHSR	Japan, Germany	The warning threshold of WHSR is 400 km/h
2	Second	300–350	Normal-speed WHSR	France, China	
3	Third	350–400	High-speed WHSR	China	

1.2.2 The second leap: the removal of frictional resistance brings the birth of MHSR

The second category: Magnetic High-speed Rail (MHSR). In order to reduce the friction between the wheels and the rails, the second leap has been made. MHSR, the second type of HSR, was born. The WHSR and MHSR trains are as shown in Figure 1.9.

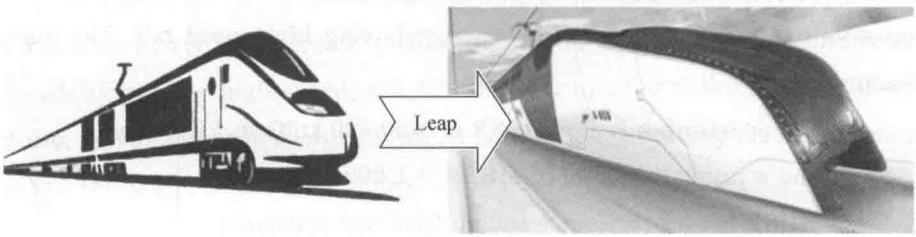

Figure1.9 WHSR and MHSR trains

In order to reduce the frictional resistance and improve the running speed and meet the fast travel requirements of human beings, MHSR was born with the running speed of more than 400 km/h based on the principle of "same-magnet repelling and opposite-magnet attraction". During the operation of the MHSR, the magnet train does not directly contact the track, but floats on

the track so that there is no frictional resistance and then the running speed is improved. In 2015, the MHSR in Japan has reached 600 km/h and more. Although MHSR is not affected by the frictional resistance, it can only operate between 400 km/h and 1,000 km/h due to the limitation of air resistance. The operating speed of 1,000 km/h is the warning threshold of the MHSR. When this speed is exceeded, the operating cost will be too high. MHSR train is as shown in Figure 1.10.

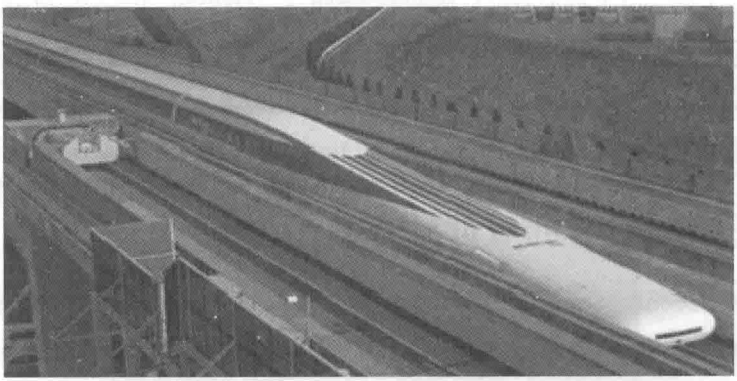

Figure 1.10 MHSR train (picture from the network)

MHSR is the magnetic suspension type HSR, which is mainly suspended on rails to run. It is also called superconducting high-speed rail. The main features are as follows:

① The operating speed of MHSR is from 400 km/h to 1,000 km/h.

② The warning threshold of MHSR is 1,000 km/h.

③ MHSR has air resistance and no frictional resistance.

MHSR belongs to the magnetic suspension HSR. As a new type of ground transportation, magnetic train has moved from the experimental stage to commercial operation and overcame the problems of traditional train such as the adhesion limit, mechanical noise and wear, etc. Besides that, MHSR has the features of high speed, strong climbing ability and low energy consumption, high noise, low comfort, no fuel, and less electromagnetic pollution. It has