ON THE DEVELOPMENT STRATEGY OF THE HIGH-SPEED MAGLEV IN CHINA

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Abstract High-speed maglev with 500km/h operational velocity can be used for practical passenger transport in the first part of 21-st century. Based on the detailed analysis of the international progress and serious discussion, a development strategy in China was suggested. The paper describes the main past achievements and future work from the point of view of the development strategy.

1 Introduction

The history of the passenger transportation of the whole mankind is characterized with the continuous increase of the operational speed. Every important technical breakthrough and appearance of a new transportation system is always connected with a significant velocity enhancement. A very important achievement in this area for 20-th century is the appearance of the high-speed maglev system, its development proved that the mankind ground transportation veocity will reach 500km/h level in the first part of 21-st century.

The proven advantages of high-speed maglev are: (1) it is the only one high-speed ground transportation system, which can operate to 500km/h. (2) It overcame the main obstacles for increasing the speed of usual high-speed railway, i.e. the existence of mechanical contacts between wheel and rail, and in the power supply system, so it has more wide prospective for further development. (3) Lower power consumption, less noise, more safety and comfort due to the absence of mechanical contact. (4) Higher acceleration and deceleration rate. higher climbing capability.

This paper reported shortly our consideration on development strategy of the high-speed maglev in China based on the international progress and experience, the success of our strategic position study, construction of the Shanghai Demonstration Line and the suggestion for near-future work.

2 International Strategic Progress

The high-speed maglev is an entirely new high-technology transportation system, its development usually could be divided into four phases, i.e. (1) Basic research of the proposed technical concept to prove its scientific and technical feasibility and advantages. (2) Engineering development of the selected concept to prove that the system can be safely, reliably and economically used for practical operation and all components of the system can be produced by the industry. (3) Construction of an enough-long practical operational line and commercialization of all the equipments and engineering. (4) Large scale application and gradual enhancement of its position in the national transportation system.

After about 40 years continuous research and development work in the world, the Germany normal-conducting Transrapid system and Japanese superconducting MLU system have passed successfully the basic research and engineering development phases, their technology is almost matured and could be used for practical operational line, although they already fighted more than 10 years for construction a practical line between Tokyo-Osaka or Berlin-Hamburg, no decision can be made in the near future.

The Germany National High-Speed Maglev Program started at 1969, the first basic research phase prolonged for about 10 years (1969-1979). After the successful demonstration operation of TR-05 vehicles carrying totally about 50000 passengers at Hamburg International Transport Exhibition in 1979, it was decided to go to the engineering development and test phase (phase 2) from 1980, the 31.5 Km Emsland test line and facility were constructed and put into operation, 3 sets of vehicles TR06, TR07, and TR08 were tested with successful improvement of their performance, the highest speed reached 450km/h, no accident occurred. Based on the test results an expert committee made conclusion that the Transrapid system already can be used for practical operation in 1991. Since 1992, the third phase started with the design of the commercial operational Berlin-Hamburg line with the total length of 292 km and the construction preparation, unfortunately Spring 2000 the Berlin-Hamburg line project stopped due to economical consideration. The total investment for high-speed maglev research and development is about 2.6 billion DM for past 30 years.

The Japanese development history is similar to the Germany one. The phase 1 Basic research work started in 1962, the Phase 2 engineering development started in 1977, when the 7 km Miyazaki test line and center began to work till 1996. Since 1997, the new 18.4 km Yamanashi double-track test line and center put into operation, more than 20 years test also made the system matured, it can be used for practical operation. Some design work for practical 500 km Tokyo-Osaka line was performed at late 1980’s.

There are several other technical concepts, such as Swissmetro of Switzerland, Magneplane, Inductrack, Maglev-2000 etc of USA, their scientific and technical feasibility and advantages have been proved, but the support for engineering development is still not available, so they are still staying in the basic research phase.

The main feature of the high-speed maglev development is that the strategic phases of development are quite important and change from one phase to another should be considered carefully and well prepared. If the basic research phase needs several millions dollars financial support, the support for engineering development will be in billion dollars range with construction of a 20-30 km test line. In order to enter the long operational line construction and commercialization phase there are many difficulties connected with the real practical needs, comparison with other transport means and economical consideration, although the world community fighted already for ten more years, up to now no definite success can be seen.

3 Suggestion For Development Strategy In China

China has very wide territory, very large population. Its fast developing economy will reach the middle-developed country' s level in the middle of 21-st century, the needs for high-speed passenger transportation are increasing quite rapidly, so it is very important to define a correct development strategy for high-speed passenger transportation in the recent years. The international progress of the maglev research and development of course caused attention among our scientific and technic community. Since late 1980’s, under the support of the ministry of science and technology, a national program started to study the key-technologies of low speed maglev, four research and development groups were organized at the National Railway Academy, the South-West Jiaotong university, the National Defence University and the Institute of Electrical Engineering of the Chinese Academy of Sciences, quite good success has been achieved, several prototype vehicles were built, two short tourist lines Qingchenshan and Badaling were planned.

In connection with the needs of construction the Beijing-Shanghai high-speed railway, we organized the Xiangshan Science Conference in 1994 to promote the high-speed maglev development in China. Then, a coorperative feasibility study for Shanghai-Hanzhou superconducting maglev line was conducted together with Japanese colleagues, a basic research program with high-temperature superconducting maglev was organized in cooperation with Germany colleagues, some progress was also achieved.

Since high-speed maglev research and development needs very high financial support and the international progress already reached the stage of construction a practical operational line, a suggestion of our development strategy was gradually formed in 1998, the strategy is suggested to have five step, i.e. (1) Study on the strategic position of high-speed maglev in China's passenger transportation system [1]. (2) Construction of a short test and operational demonstration line based on the imported technology[5]. (3) Feasibility study for long distance operational line and organization of our internal R&D and engineering work. (4) Construction of a long distance operational line, for example, Beijing-Shanghai line, and commercialization of the corresponding equipments and engineering. (5) Gradually realization of a high-speed maglev network in the country. Up to now the phases 1 and 2, strategic position study and construction of a demonstration line got quite good success, the R&D work is included in the National High-Technology Program (863 Program), the detailed plan is under discussion. The following paragraphs will describe more detailly the related progress.

4 Study On The Strategic Position Of High-speed Maglev In China [1][2]

For passengers, the main factors to select their transportation vehicle are: travel time, safety, economy, comfort and convenience etc. The selection is closely related to the social-economical development level. In comparison with the high-way and airline, the ground rail system including both usual railway and maglev has obvious advantages for safety, comfort and economy, the main challenge is in the operational velocity and convenience, so the increase of operational velocity has significant influence on the future of the rail passenger transportation system. The main purpose of increasing speed is to shorten the travel time which is also closely related to the travel distance. Fig.1 presents the simple analytical curves of the equal travel time for train-airline and train-automobile in dependence on the travel distance and operational velocity.It can be clearly seen that the high-speed railway with maximum velocity of 300 km/h has advantage over airline to attract passengers with travel distance less than 700-800 km, the maglev train with maximum velocity of 500 km/h has the advantage up to 1500 km travel distance. The above conclusion has been proved by real practice of high speed railway. There are totally 13 high speed railway operational lines with total length of 4,368 km. Except Tokyo-Hakata line 1,069 km, all other lines are shorter than 600 km.

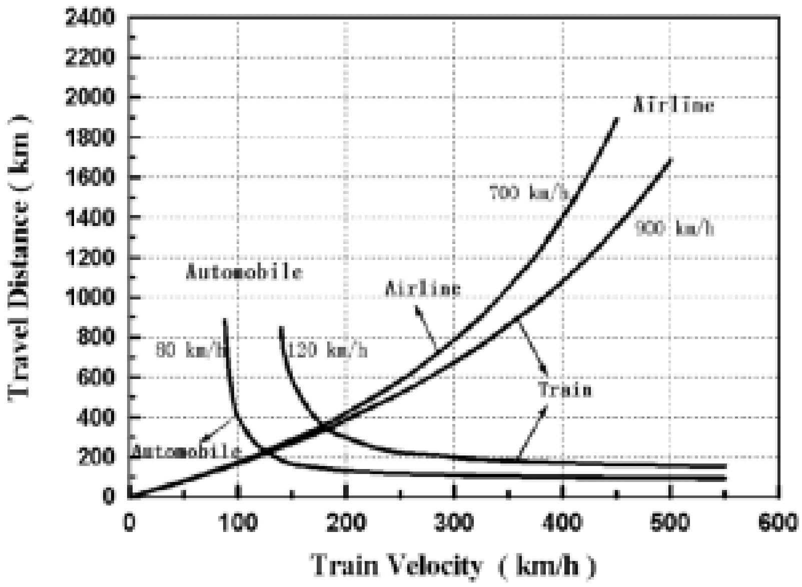

Fig.1 Equal Travel Time Curves

From above discussion it is clear that the high-speed maglev train whose speed can reach 500 km/h has obvious advantage and could be mainly used for high capacity passenger transportation in long distance between large cities. Its strategic position in the national passenger transportation system for different countries is dependent on the development needs of the passenger transportation and the situation of existing transportation systems. Each country should define its development strategy in accordance with its own conditions.

The first railway in China was built in 1876. Through development over 70 years till 1949, its total length was 21,800 km, carried 65% of the total passenger volume and 85% of the total passenger turnover, became the main transportation tool. Since establishment of the People' s Republic, railway has quite fast development, the operation mileage has increased rapidly to present 68,000 km and it maintained the main function in national passenger transportation until the late 1970s. Since the 1980s, due to the rapid development of highways and civil aviation, the function of railway in passenger transportation obviously declined. The percentage of railway in national passenger transportation volume declined to 7% and the turnover share declined to 35% in 1997 (see Fig. 3). People have recognized that it is necessary to increase the operational speed in order to keep and to recover the main function of railways in passenger transportation. In recent years. it has made significant achievement in speed increase of existing railways and in the preparation for the construction of high-speed railway.

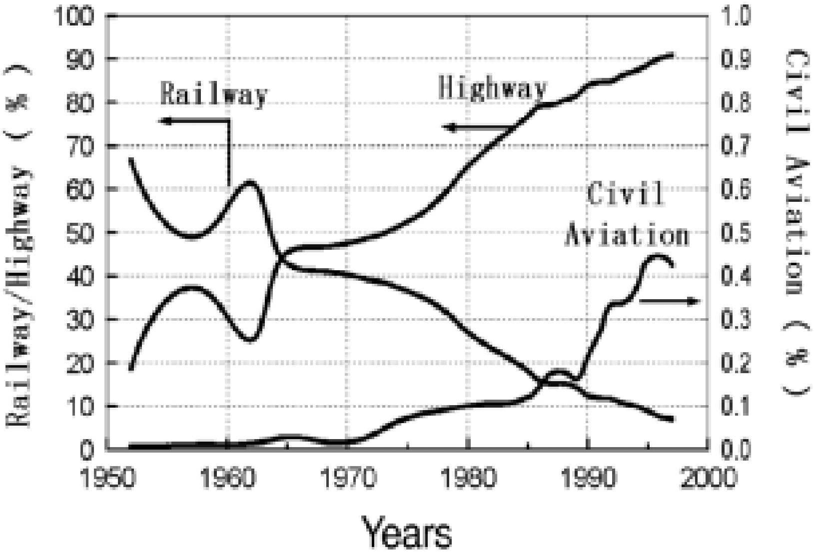

Fig. 2 Percentage of Different Transportation Means in the National Passenger Transportation in China.

There was a study to forecast the needs and development of railway in China for first half of 21st century[3]. According to the study, it is estimated that in 2050, the population in China will reach about 1.47 billion and town citizens will account about 75%; the average railway person-riding rate will increase from present 0.8 to 3 times per year; the average travel distance will increase from present 360 km to 460 - 500 km; the railway passenger transportation capacity will reach 2.0 - 2.2 thousand billion person-kilometers. In accordance with the above forecast, it is suggested to enlarge national railway from present 68,000 km to 120,000 km, and the whole railway network will be composed of three parts: about 8,000 km high-speed passenger network; about 22,000 km fast network for transportation of both passengers and freights; about 90,000 km normal railway network. Figure 4 is the schematic diagram of the suggested high-speed passenger network, showing also the present population of the large cities and the distance between them. Obviously, the high-speed maglev train is suitable for the suggested high-speed passenger network, its present length is zero and total length will reach 8,000 km and it will be built in the first half of 21st century. The main strategic problem is to adopt high-speed maglev train running at 500 km/h or to adopt high-speed railway running at 300 km/h for this network.

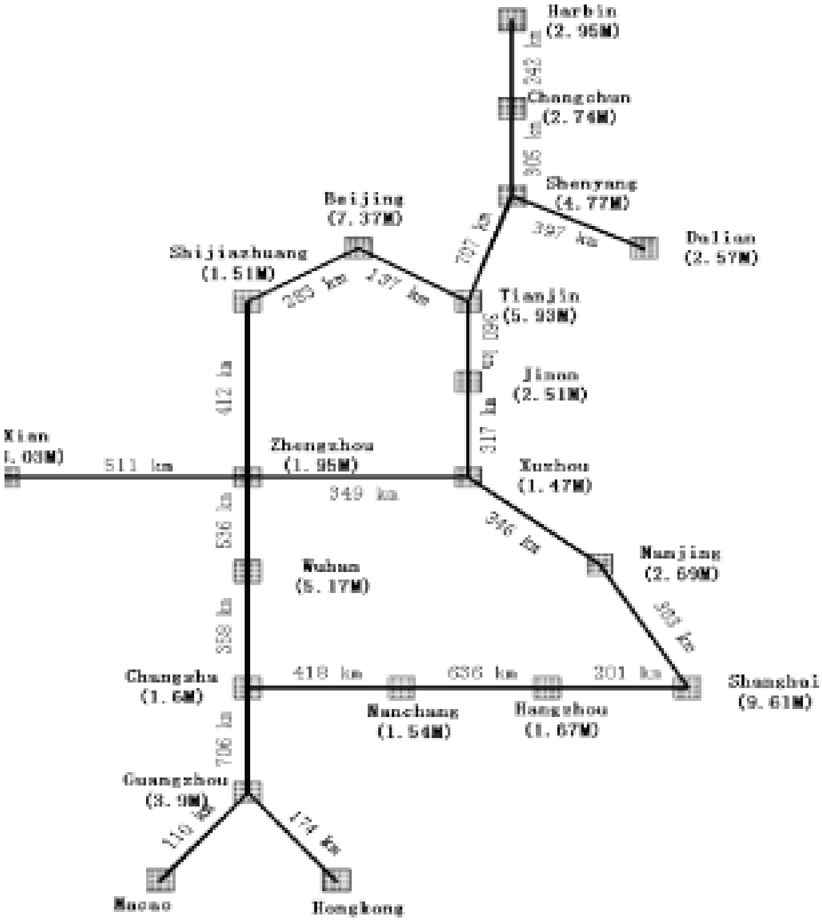

Fig. 3 Schematic Diagram of the High-speed passenger Network in China

From extensive discussion, the importance of high-speed maglev for future China is recognized, so it is agreed to give higher priority to the development of high-speed maglev. The reasons are: (1) The length of most high-speed passenger railway lines exceeds 1000 km, 500km/h maglev speed is more attractive than 300 km/h high-speed train. (2) China still has no special passenger railway lines, it gave us an important opportunity to use and develop directly the most advanced modern technology. (3) High-speed maglev can promote the development of many new technologies, which can play important role to form new industries.

Up to now, the study is concentrated mainly on the comparison of high-speed railway and maglev systems, it will continue to include the reasonable, coordinated development strategy for different passenger transport systems, such as: maglev, railway, highway and airline.

5 Shanghai Demonstration Line [4][5]

Since high-speed maglev is needed for future China, we have almost no our own strong research and development basis, and the world still has no one operational line, the construction and operation of a short demonstration line based on the most advanced international technology is very important as first step to promote the maglev development in China. November 4, 1999, the New and High Technology Development Department of the Ministry of Science and Technology and the Transrapid International Inc. signed an agreement to conduct a cooperative pre-feasibility study for construction of a test-operation line in China. From the beginning of 2000 a pre-feasibility study group with about 20 experts was formed, after about half year quite intensive work, the group made a suggestion for our government. Its main content includes: (l)For high-speed maglev development in China, as first step construction of a test and operation line is the most important. (2) The construction of a demonstration line based on Germany Transrapid technology is realistic with small technical risk. The Germany side is quite highly interested in cooperation. (3) From the two options of the demonstration line Beijing and Shanghai it is preferred to choose Shanghai line. June 30, 2000, during the visit of Chinese Premier Zhu Rongji to Germany, an agreement of cooperative feasibility study for Shanghai maglev demonstration and operation line is signed between Shanghai city and Transrapid International Inc.

August 2000, a project proposal report was approved by the State Planning Commission, then Shanghai Maglev Transportation Development Co. Ltd. was established with a registered capital of RMB 2.0 billion invested by Shanghai Shentong Holding Co. Ltd. and other 5 shareholders. After very active cooperative work and negotiation, a “Contract of Supply and Service for Shanghai Maglev Line “at value of DM 1.293 billion was officially signed at Jan. 23,2001 between Shanghai Maglev Transportation Development Co. Ltd. and Germen consortium of Siemens AG., Thyssen Transrapid System GmbH, and Transrapid international GmbH, a “Contract on Technical Transfer of Maglev Transrapid Hybrid Guideway System” was signed at Jan. 26,2001 between Shanghai Maglev Transportation Development Co. Ltd. and German Transrapid Guideway Consortium with a grant of DM 100 million by German Government .The practical work for realization already started since March 2001and is well in progress.

The main parameters and features of this demonstration line are: (1) The double-track route started from Longyang Road Station of the subway line No.2, and ended at the Pudong International Airport Station with total length of 30km. It has 7 curves with minimal radius of 650m and maximal radius of 8,000m, the total curve length is 18.6km, i.e. about 62% of the total length. (2) The maximum operation velocity is 430km/h. The acceleration and deceleration is limited to 1 m/ s^2 . The single journey time is about 8 min. (3) It is planned to have three sets of 5 section TR-08 train with average capacity of 100 passengers per section for first phase of operation. (4) It will have just two terminal stations with 210m long, 7m wide platform. It is possible to add an inter-middle station in the future. It will have two propulsion substations, an operational control center and a maintenance yard. (5) All the civil engineering, guideway manufacturing and installation work will be done by Chinese side and all the equipments will be provided by Germany side. (6) All design and equipment ordering work is already finished, all civil engineering work is completed, the guideway girder manufacturing and installation work is going to the end.

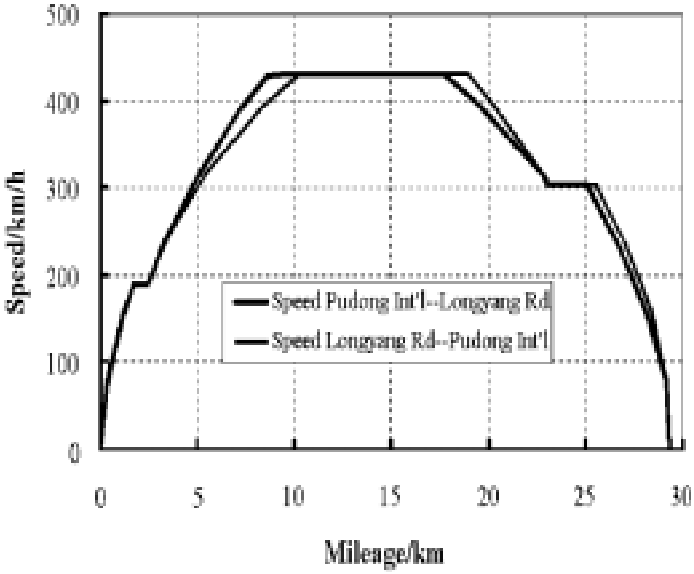

Fig. 4 Calculated Velocity Curves for Shanghai Line

First maglev train will be assembled and commissioned since September 2002, a three-section maglev test-operation on single track will start at January 2003. The test-run of maglev trains on double track will be finished at September 2003, and then will be put into operation. Whole line inspection and acceptance will be completed by December 2003.

The successful construction and reliable economical operation of the Shanghai Line will create the confidence that the high-speed maglev can be used for our future high-speed passenger network. As first operational line, it will create and train a strong engineering and operation team in the world. It will be also the high-speed test base for future R&D in China.

6 Feasibility Study For Long Distance Operational Line And Organization Of Internal Research And Development Work

For high-speed maglev development in China the main achievements in the recent years are "China needs high-speed maglev" is recognized and the Shanghai demonstration line construction started. The next strategic goal is to construct a long distance operational line and to promote the commercialization, i.e. to enter the third strategic phase. For effective preparation the high-speed maglev technology is included in the National High-Technology Development Program (863 Program) of our National 10-th Five-year Plan (2001-2005), it has two main objectives: (1) Feasibility study for long distance operation line: (2) Organization of internal research and development work.

Long distance line feasibility study is very important at present stage, since the high-speed maglev is most advantageous for long distance high capacity passenger transportation and only long distance line can effectively promote the commercialization and formation of new industry. For example, the 30 km Shanghai demonstration line needs 15 TR-08 vehicles and two 50 MW variable frequency substations which we can get from existing manufactures without expansion, operation of 1300 km Beijing-shanghai Line needs several hundreds to one thousands TR-08 vehicles and more than twenty 50MW substations, without creation of new industry and commercialization it will not be possible.

The most attractive long distance line in the near future is Beijing-shanghai line. Our railway ministry already worked more than 10 years for prefeasibility and feasibility study, a proposal for construction of Beijing-shanghai high-speed railway line was ready in 1998, Fig.5 presents the scheme of the proposed Beijing-shanghai high-speed railway, the total length is 1307 km with 24 station, the annual design passenger capacity in one direction is 60M persons, operational velocity is 250-300km/h, the travel time from Beijing to Shanghai is about 6-7 hours.

Since Beijing-shanghai line has 1307 km total length and quite large passenger volume, use the 500km/h high-speed maglev instead of 300 km/h high-speed railway has obvious advantage, it can compete with civil airline to attract more passengers, and it will effectively promote the maglev commercialization not only in China, but also in the world. Quite serious discussion about selection of maglev or high-speed railway for Beijing-shanghai line already started. To convince the government to accept maglev for this line, besides successful construction and operation of the Shanghai demonstration line, detailed feasibility and preliminary design study is very important and urgent. The international cooperation for this study is also very helpful. Of course, the other possible lines are also under consideration.

Fig.5 Proposed Beijing-shanghai high-speed railway scheme

For the future research and development work a high-level and strong team should be organized, this team will become the core force for feasibility and design study, for the corresponding prototype-equipment development and production, and for the innovation study to improve the system and component performance and to lower the capital and operational cost. The related work is just starting.

When our government decides to accept maglev for Beijing-shanghai line, China will enter the long line construction and commercialization phase, as first one in the world.

7 Conclusion

1) The high-speed maglev is the only one ground passenger transportation system which can work to 500 km/h operational velocity and can be practically used in the first part of 21-st century. It has obvious advantage for long distance high capacity passenger transport between large cities.

2) As an entirely new high-technology, the high-speed maglev development could be divided into four strategic phases, i.e. (1) Basic research. (2) Engineering development. (3) Construction of operational line and commercialization. (4) Large scale application. The Germany Transrapid and Japan MLU systems already successfully passed the first two phases and fighted more than 10 years for operational line construction without definite success.

3) Based on the analysis of the international progress and the practical needs, the high-speed maglev development strategy in China is suggested to have 5 steps, i.e. (1) Strategic position study. (2) Construction of a short demonstration line based on imported technology. (3)Long distance line feasibility study and organization of the internal R&D work. (4) Long distance line construction and commercialization. (5) Realization of the high-speed maglev network.

4) Some important achievements for high-speed maglev development in China have been obtained in the recent years, mainly they are: (1) “China needs high-speed maglev” is recognized. (2) The Shanghai 30 km demonstration line construction started. (3) The R&D is included in the National High-Technology Development Program of our National 10-th Five-year Plan (2001-2005).

5) Besides the successful construction and operation of the Shanghai demonstration line, the main effort in the near future in China will concentrated on the long distance line, especially Beijing-shanghai 1300 km line, feasibility study and organization of our internal R&D work.

6) When the government decided that the Beijing-shanghai line will be high-speed maglev, China will enter the long distance line construction and commercialization phase as first one in the world.

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