

Outlook of the Superconducting Maglev

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ABSTRACT: Superconducting Maglev has been developed as an ultra-high speed mass transport system. Running tests have been conducted successfully on the 18.4 km long Yamanashi Maglev Test Line since 1997. On the basis of its achievement, the Test Line is to be extended to 42.8km, with renewal of the existing equipment and facilities according to specifications for a revenue service. The construction work is now at its peak. Running tests will start by the end of 2013 on the new test line under the conditions similar to a revenue service line. JR Central has been taking steps towards the first goal, that is, to start a revenue service between Tokyo and Nagoya by 2027 as a bypass route for the Tokaido Shinkansen. It is expected to cost 5.1 trillion Japanese yen, and JR Central will bear the cost for the project without financial support from the government.

1 PROMOTING THE TOKAIDO SHINKANSEN BYPASS

The Tokaido Shinkansen, which began commercial operation in October 1964 as the world first high speed railway, connects Japanese three major metropolitan areas of Tokyo, Nagoya and Osaka. The area along the Tokaido Shinkansen is the heart of Japanese economy, and produces two thirds of Japanese GDP. There is a huge amount of passenger demand, and JR Central, which has taken over the mission to operate the Tokaido Shinkansen from Japanese National Railways (JNR) since its privatization, has ceaselessly made an effort to improve it to meet the demand. Today, thirteen Tokaido Shinkansen trains, each can carry more than 1,300 passengers at the maximum speed of 270km/h, leave the Tokyo Terminal in one hour at its peak time, and about 378,000 passengers use the Tokaido Shinkansen every day. It has almost 90 % market share in the passenger transportation between Tokyo and Osaka metropolitan areas. The income from the Tokaido Shinkansen, 515km long double track railway, amounts to 1 trillion yen (12.5 billion USD) per year.

Throughout its 47 years of commercial train operations, the Tokaido Shinkansen has maintained a

flawless record of no passenger fatalities or injuries due to train accidents such as derailment or collision. Punctuality is also a significant feature of the Tokaido Shinkansen. The average delay per train throughout the year is 0.5 minutes. The Tokaido Shinkansen has sustained Japanese economic activity.

Japan has been hit by serious disasters such as the Tohoku Pacific Ocean Earthquake in this spring. Besides, the Tokaido Shinkansen would require large scale construction works for its rejuvenation in the future. Without the Tokaido Shinkansen, Japanese economy would suffer serious damage. It is necessary to create redundancy for Japan's main transportation artery in order to prepare for future risk. Based on these facts, the Chuo Shinkansen, which will connect the three major metropolitan areas, has been studied as the bypass of the Tokaido Shinkansen.

The Superconducting Maglev has been developed for four decades as the next generation ultra high-speed surface transportation system. It has been confirmed through the running tests that the Superconducting Maglev has excellent features suitable for the high-speed mass transport system, and its technology has already achieved levels sufficient for commercial operation.

On the basis of these facts, JR Central decided to promote the Tokaido Shinkansen Bypass (the Chuo

Shinkansen) utilizing the Superconducting Maglev system, and determined to bear the financial burden of constructing the line.

2 HISTORY OF THE SUPERCONDUCTING MAGLEV DEVELOPMENT

2.1 Miyazaki Maglev Test Track

The development of the Superconducting Maglev was undertaken by JNR in 1970. After fundamental tests, the 7 km long test track was constructed in Miyazaki, south west of Japan. The first test vehicle on the Miyazaki Test Track recorded 517 km/h in 1979. Then the test track was remodeled from the inverted-T shape cross section to the more practical U-shape, and the manned vehicle began to run in 1981. Basic tests with four types of test vehicle were conducted over the 20-year period from its opening in 1977 to its closure in 1996. The development of the Superconducting Maglev was taken over by Railway Technical Research Institute (RTRI) from JNR due to its privatization. Soon, JR Central joined in its development.

2.2 Yamanashi Maglev Test Line

As the next step of the development, the new Maglev test line (YMTL) was constructed with subsidies from the government, in Yamanashi, about 100km west of Tokyo. The test line, which is double-tracked partially, is 18.4km long and has curved sections with a radius of 8,000m and a maximum gradient of 40‰. Approximately 87% is tunnels, and the longest open section is about 1.5 km in length. The Test Center and the power conversion substation are located here.(Fig.1)

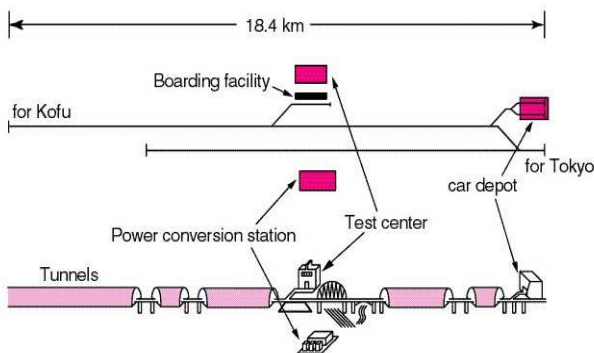


Figure 1. Configuration of the YMTL

The vehicles (MLX) are of an articulated truck type having a truck at each end.(Fig.2) The superconducting magnets (SCMs) mounted on both sides of the truck contain four vertical superconducting coils and a helium/nitrogen tank with built-in refrigerators. The vehicles are equipped with aerodynamic brakes and wheel disk brakes for emergency. Usually trains are decelerated by electric regenerative brake.



Figure 2. The test vehicle MLX01

2.3 Test Results on YMTL

The running tests on the YMTL started in April 1997. In the first three years, the basic running tests and the general functional tests were carried out. In the next five years, main themes of the running tests were the evaluation of durability and reliability, and the improvement of cost performance and aerodynamic characteristics. Tests were carried out smoothly, and various extremely good results were obtained such as setting the world's fastest speed record for railway of 581km/h in December 2003.

In March 2005, the Maglev Technological Practicality Evaluation Committee (the "Evaluation Committee") under the Japanese Ministry of Land, Infrastructure, Transport and Tourism appreciated that "all the technologies of the Superconducting Maglev necessary for the future revenue service were established as a result of great progress in running tests and technological developments by the end of fiscal 2004." On this occasion the framework of the Superconducting Maglev system development changed, and JR Central has been playing a major role since then.

For the further evaluation of durability and the further improvements in core technologies of the Superconducting Maglev, running tests have been carried out on the YMTL. The cumulative travel distance exceeded 850,000km.

3 EXTENSION OF THE YMTL

3.1 Outline of the Extension

The Superconducting Maglev technologies as well as their peripheral technologies have been progressing dramatically through the running tests. Based on this situation, in September 2006, JR Central decided to invest 355 billion yen of its own capital in the upgrading of facilities at the YMTL to practical application specifications, and to extend the existing 18.4km line (the priority section) to 42.8km. It will be a part of future Chuo Shinkansen. The overview of the YMTL is shown in Fig.3. As it is in a mountainous area, most of the line is in tunnel. The power conversion station and the vehicle depot are located at the same place of the existing line. A full scale construction started in April 2008. It is proceeding with the objective of completion by the end of 2013.

3.2 New Vehicles

New vehicles for the extended YMTL are now under development. They are the prototypes of the first generation vehicles for the Chuo Shinkansen. Compared with the existing MLX vehicles, there are two observable differences, the cross-sectional shape, and the nose shape of the leading vehicle. The cross-sectional shape of the upper half of the vehicles is squarer than that of the existing vehicles in order to secure enough overhead space, and it will also contribute to the reduction of manufacturing cost. The overhead space of the new vehicles is equal to that of the latest Shinkansen vehicles (Series N700), and the rack can hold carrier bags.

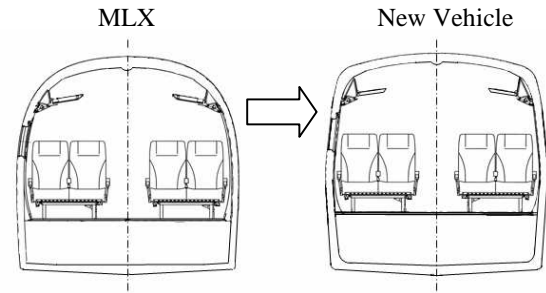


Figure 4. Cross section of vehicles

The nose length of the original leading vehicles is 9.0m. The experimental leading vehicle with a 23.0m long nose was introduced in 2002, and aerodynamic phenomena have been investigated using these vehicles. Based on these studies, a 15.0m long new nose shape was designed for the new leading vehicle, which enables a larger seating capacity and good aero-dynamic characteristics. There will be 68 seats in the middle vehicles and 24 in the leading vehicle. Many technologies developed through the running tests are applied to the new vehicles in order to improve the ride comfort.

Barrier-free design is adopted for the new vehicles, and some are equipped with interior equipment of the future revenue service level and toilet facilities. New vehicles are called "Series L0", after the first generation Tokaido Shinkansen vehicles, "Series 0". "L" means a "linear motor car".

Four leading vehicles and ten middle vehicles will be manufactured. Of these fourteen vehicles, two leading vehicles and three middle vehicles will be ready to start trial operation in 2013. The other nine vehicles will be delivered till the end of 2015.

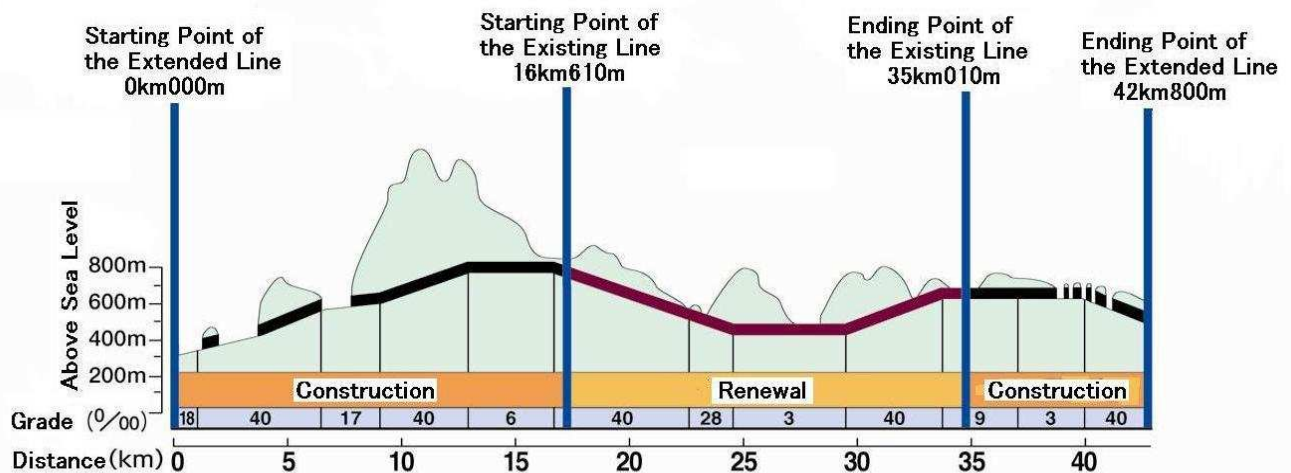


Figure 3. The outline of the extended YMTL

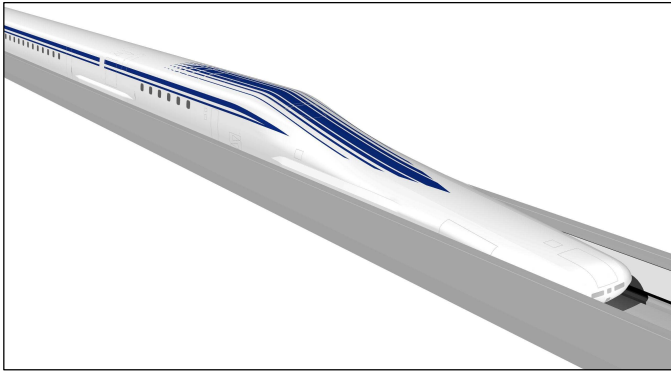


Figure 5. Image of the new leading vehicle

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4 PROGRESS OF THE MAGLEV CHUO SHINKANSEN PROJECT

4.1 Legal Procedures

The Chuo Shinkansen is put forth under the Nationwide Shinkansen Railway Development Law (the “Law”) enforced in 1970. The master plan of Shinkansen network was notified under the Law in

1973. The Chuo Shinkansen is included in it. Topographical and geological surveys between Tokyo and Osaka were instructed in 1990, after the privatization of JNR, by the Minister of Land, Infrastructure, Transport and Tourism (the “Minister”). JR Central determined to bear the cost of construction to promote the Maglev Chuo Shinkansen, and to construct the line between Tokyo and Nagoya area as its first step in December 2007. The report of topographical and geological surveys was submitted to the Minister in October 2008. Then the Minister instructed to conduct surveys related to the remaining four items (refer to chart at bottom). In July 2009, the Evaluation Committee announced the result of overall evaluation on the technologies of Superconducting Maglev as follows “the technologies of the Superconducting Maglev have been established comprehensively and systematically, which make it possible to draw up detailed specifications and technological standards for revenue service.” JR Central submitted four survey reports to the Minister in December 2009. In response to this, in February 2010, the Minister consulted the Council for Transport Policy (the “CTP”) pursuant to Article 14-2 of the Law about the designation of an operation / construction entity and the decision on a development program.

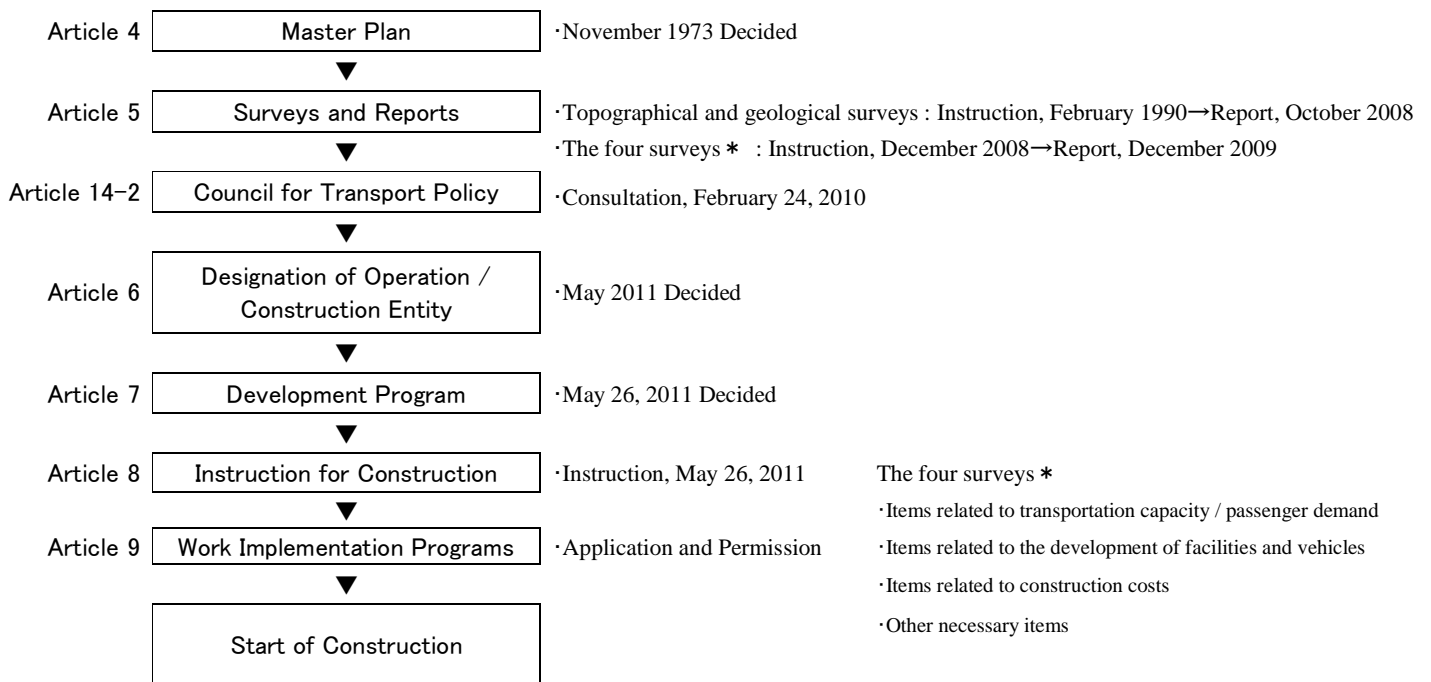


Figure 6. Flow of works based on the Nationwide Shinkansen Railway Development Law

4.2 Three Routes

The route of the Chuo Shinkansen was a controversial theme. As the Chuo Shinkansen will pass through the steep mountain areas, such as Akaishi Mountains and Kiso Mountains in Nagano prefecture, topographical and geological study on these areas has been conducted long. Three routes, namely, “Route A”, “Route B” and “Route C, have been proposed.

Route A is otherwise called Kiso valley route, which turns aside both Akaishi Mountains and Kiso Mountains.

Route B is otherwise called Ina valley route, which turns aside Akaishi Mountains, passes through the comparatively populous Ina valley, and crosses Kiso Mountains by tunnel.

Route C is almost a straight line crossing Akaishi Mountains and Kiso Mountains both by tunnels.

The comparison of these three routes is shown in the report in December 2009. (Table 1)

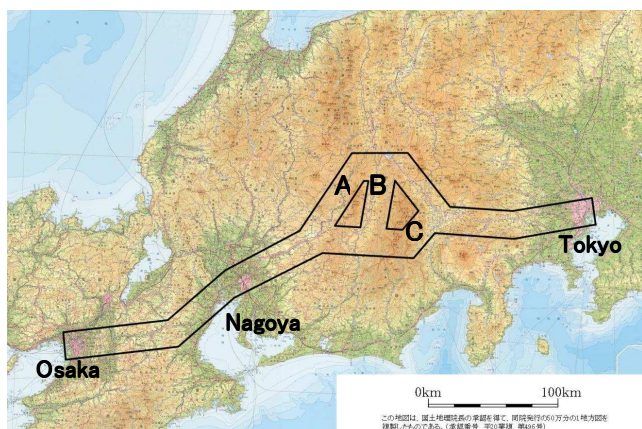


Figure 7. Three Routes

Table 1. Data of the Chuo Shinkansen between Tokyo and Osaka

	Route A	Route B	Route C
Length of the line	486km	498km	438km
Length of open section	170km	170km	126km
Travel time (express train)	73min	74min	67min
Construction cost (Trillion yen)	9.57	9.68	9.03
Traffic demand(in 2045) (billion passenger-km)	39.6	39.2	41.6

In October 2010, the CTP Chuo Shinkansen Subcommittee publicly announced a financial analysis that showed the economic benefits under Route C were the highest. According to the subcommittee study, for the base-case Tokyo – Osaka section, Route C would cost 5.5 trillion yen

and generate the economic benefits of 8.4 trillion yen, while Route B would cost 6.0 trillion yen and generate the benefits of 7.5 trillion yen.

4.3 New Phase of the Project

The CTP reported followings to the Minister in May 2011,

The Chuo Shinkansen is necessary for Japan. JR Central should be designated as the operation entity and construction entity of the Chuo Shinkansen.

The Chuo Shinkansen should adopt Super-conducting Maglev system.

According to this report, on May 26, 2011, the Minister determined the Chuo Shinkansen development program pursuant to Article 7-1 of the Law as shown in list 2. On the next day the Minister instructed JR Central to construct the Chuo Shinkansen.

Table 2. The projected Chuo Shinkansen

Construction line	Chuo Shinkansen
Section	Tokyo~Osaka
System	Superconducting Maglev system
Maximum Operation Speed	505km/h
Construction cost (including vehicles)	Approx.9.03 trillion yen
Route	C route

It is necessary to carry out the environmental assessment before drawing up the implementation program. JR Central plans to start the environmental assessment this December and the construction work in 2014.

5 ACKNOWLEDGMENT

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6 REFERENCES

- Kazuo Sawada, “Outlook of the Superconducting Maglev”, Maglev 2008, San Diego, USA, December 15-18, 2008.
- “Promoting the Tokaido Shinkansen Bypass by the Super-conducting Maglev System”, JR Central Annual Report, May 2010