The Superconducting Maglev Train & Impacts of New Transportation Infrastructure


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Transportation Technology & Economic Development

Japan's achievement in reaching high economic growth in just under 20 years after the end of World War II was once called a "miracle". Twenty years further on, following the oil shock, there was talk of "Japan as Number One" when the rest of the world was suffering from recession. Behind these two phenomena were not just the quality and manufacturing costs of Japan's industrial products, but also technological innovation in its transportation system.

During the high economic growth period, achievements were made in marine transport via containerization, and also through mass reduction in transportation costs with the introduction of specialized vessels for transporting motor vehicles and crude oil, as well as large vessels. Without these developments, industrial products from distant Japan could not have proved competitive in Europe or the United States. In addition, without the high-speed motorway network and development of coastal industrial zones, factory construction would not have advanced and the Japanese manufacturing industry would not have been able to maintain its international competitiveness through cheap rents and personnel costs. In addition, the development of the Shinkansen bullet train contributed to the revitalization of the regional economies of Japan, and hence to Japan's high economic growth.

While the US Congress in the early 1970s decided not to pass a bill to regulate automobile gas emissions, having concluded that it would be technically impossible to develop, Japan succeeded in developing an engine that met these needs for emission regulation. Since fuel efficiency was not good in automobiles equipped with gas emission control capabilities, technology to save energy was developed. Immediately afterwards, gasoline prices shot up with the oil crisis, and together with that, exports of Japanese automobiles with better energy efficiency rose. This was the main contributing factor to Japan's economic boom, while the rest of the world suffered from recessions that came with the oil crisis. The economic effects of investments in building infrastructure, such as the Shinkansen and the expressways, also had a great impact on Japan's economic growth.

Development of high-speed transportation infrastructure revitalized regional economies, and allowed Japan to achieve economic growth while reducing the income gap between various regions. Many countries have since achieved high economic growth, but with widening income gaps between regions. In this respect, Japan achieved a different outcome.

What impact, then, will the current development of new transportation infrastructure have on Japan?

Superconducting Magnetic Levitation Railway

Process of development

Construction for the superconducting magnetic levitation railway, the Chuo Shinkansen, began in December 2014, and by 2027 it will only take 40 minutes to travel the 286 kilometers between Shinagawa Station in Tokyo and Nagoya Station. The current Tokaido Shinkansen runs on a different route, and it currently takes 90 minutes to travel the 335 km between Shinagawa and Nagoya. The new Chuo Shinkansen will only take 67 minutes to travel the 438 km between Shinagawa and Osaka.

Japan National Railways first began researching superconducting magnetic levitation back in 1962, two years prior to the opening of the Shinkansen bullet train service between Tokyo and Osaka. The first reason behind developing the superconducting magnetic levitation railways method was that in an earthquake-prone country like Japan, levitating 10 centimeters was regarded as preferable to the 1 cm of the normal conducting magnetic levitation method. Secondly, while this normal method had problems with current collection, the superconducting method did not require supply of electricity, such as through pantograph current collectors. Research began with miniature model railway vehicles, and 20 years later in 1982 manned test runs began on test tracks in Miyazaki Prefecture. After the privatization of Japan National Railways, JR Tokai and the Japanese government completed construction of the test track in Yamanashi Prefecture *(Photo)* as part of the Tokyo-Osaka Line. Test runs began in 1997, and various aspects of practical techniques relating to safety, reliability, workability, environmental impact, and cost reductions have been developed. Once safety was verified, over 156,000 passengers rode the 500 km per hour test run trains. The government established a Technical Assessment Committee to complete assessment at every stage of technology development, and the committee finally determined that the technology was ready for practical application. I served as the chairman of the committee, and in making the final decision requested that all the committee

PHOTO
Test tracks in Yamanashi Prefecture

Source: Compiled by Author

members identify solutions to all of the questions and answers on superconducting magnetic levitation railways around the world. Many challenges were identified and discussed: the stability of levitation forces, the impact of magnetism on health, the risk of fires and emergency evacuation, and the environmental impact of aerodynamic shock waves and micro-pressure waves at tunnel exits.

Moreover, the matter was taken to the Council of Transport Policy for assessments on economic benefit and cost, profitability, technical issues, selection of route, and environment. Once the assessments were completed, the construction order was issued by the government to JR Tokai and construction finally began at the end of December 2014. It has been 52 years since the development of superconductive magnetic levitation technology first began. It has also been 17 years since the test runs began on test tracks in Yamanashi, but major improvements were still made during these years, including superconducting coils, substation facilities, track structures, trains *(Chart 2)*, and control systems.

There still remain various challenges ahead such as land acquisition, many tunnel constructions in fault areas where the site is sometimes 1,400 meters deep from the mountain top, and disposal of waste soil. It may not be easy to start the new system within the planned time frame and budget, but Japan is aiming to enable foreign tourists to experience the 500 kph trial ride on the partial construction site during the Olympic and Paralympic Games in 2020.

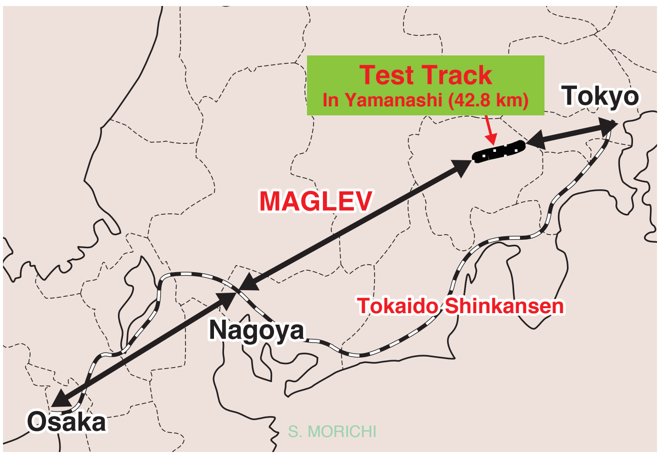
Social and economic importance

It takes two hours and 22 minutes to travel the 515 km from Tokyo through Nagoya to Osaka on the existing Tokaido Shinkansen. The new superconducting magnetic levitation Chuo Shinkansen will run on a direct route through the mountainous area of 438 km *(Chart 1)* at a maximum speed of 500 kph, and the journey will take 67 minutes. While a two-hour journey is equivalent to an inter-city transportation system, a one-hour journey is that of urban transportation.

The first social and economic impact of this project is on the change in people's behavior. For example, when a journey between the regional city of Kofu and Tokyo becomes only 15 minutes, compared to what used to be a two-hour trip, it greatly impacts behavioral patterns and frequencies in terms of commuting to work and to school, and of recreational activities. The current Shinkansen shortened the length of travel between Tokyo and Osaka from 6.5 hours on the old railway system to three hours and 10 minutes, and led to considerable change in the movement of people. For example, a business day-trip from Tokyo was made possible, and led to the closing of many corporate regional offices in Osaka and Nagoya. Moreover, many corporate headquarters in Osaka were moved to Tokyo. A Kyoto University professor is now able to lecture in Kyoto in the morning, attend a conference in Tokyo in the afternoon, and then take part in a research meeting in Osaka in the evening. Transportation for tourism has also risen sharply, and a 16-car train with a capacity of 1,300 people currently runs every four minutes between Tokyo and Osaka. It is already running like an urban transportation system. The superconductive magnetic levitation Chuo Shinkansen is sure to have greater impact.

Second, the great metropolitan areas of Tokyo, Nagoya, and Osaka will now function as one metropolitan area, and with a population of

CHART 1
Tokaido Shinkansen & Chuo Shinkansen



Source: Compiled by Author

CHART 2

Development of railway vehicles

【Mc1】: Manufactured in 1995
・Front car : 9.1m
※ The first train

【Mc5】: Manufactured in 2002
・Front car : 23m
※ Trial configuration extended to maximum length

【Mc5 Front car configuration modification type】
・Length of the front car : 15m (modified in 2008)

Aiming for modifications by securing station intervals and improving the comfortability of cars

Source: JR Central

75 million and travel time of one hour, it will become the world's largest economic area with great economic impacts. The world's largest market which can be covered by one office can expect both domestic and foreign investments, and the economic effect of size and efficiency will be huge.

Third, it will overcome Tokyo's weakness: the long commuting hours, expensive land prices, and limited access to recreational activities in the natural environment. There will be more locations accessible within a travel time of 30 minutes, and with that, living areas, corporate areas, and activities areas will rapidly expand, giving a wider selection of options for Tokyo.

Fourth is the impact the superconductive maglev technological innovation will have on railway systems around the world. Just as the success of the Japanese Shinkansen had greatly influenced railway industries around the world, the new 500 kph railway system will have a competitive edge over air travel on long-distance routes of over 1,500 km, and therefore an inherent potential to change the global railway network and air travel network.

Fifth, for Japan, with its risks of natural disasters such as earthquakes, tsunami, and flood damage, long-term suspension of Shinkansen tracks that connect the three grand metropolitan areas could be a fatal blow to the Japanese economy. For high-speed expressways, the New Tomei/Meishin Highway and Chuo Highway are already multiplexed, but the mass transport Shinkansen that run every four minutes are impossible to substitute by airplanes. The new superconductive magnetic levitation Chuo Shinkansen does not run on rails, hence will not derail, and therefore will be resilient to disaster damage. This gives it the substitute role for the current Shinkansen, and will greatly heighten Japan's resilience.

Sixth, construction investment effects worth 5 trillion yen are expected with the railway facilities alone, and combined with investments in the development of areas surrounding the stations, the impact will be enormous. Since JR Tokai bears the cost of the railway construction, there is no government expenditure involved. This is the largest infrastructure investment for Japan, which is trying to steer away from deflation, and it should serve as a big boost to the Japanese economy.

Seventh is the spillover effect of superconductive magnetic levitation technology into other non-railway sectors. The development of superconducting material and its control technology should bring new developments in various sectors.

Other Transportation Infrastructure

While it is not a new project, the Shinkansen connecting Tokyo and Kanazawa which opened this year has had a great impact on regional communities. In March this year, a new circular line on the Metropolitan expressway was completed and has helped to alleviate traffic jams in central Tokyo. The outer circular high-speed motorway is almost complete and with these new transportation infrastructures in place, many businesses are expanding to regions along the motorway and tracks, reaffirming the impact of transportation infrastructure on regional economies.

Areas for new technological development include fuel cell vehicles and new intelligent transport systems (ITS). The impact of technological development of fuel cells goes beyond environmental issues in transportation, and is expected to have a huge impact on energy issues concerning housing and industries as well. On ITS, an automatic driving system is in the implementation stage, and a bi-directional information system is expected to provide various services to vehicle drivers and to the distribution system. JS

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