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The International Maglev Board

MAGLEV TRENDS IN PUBLIC TRANSPORT: THE PERSPECTIVES OF MAGLEV TRANSPORTATION SYSTEMS

Abstract. The idea of considering Maglev systems challenges established ways of thinking on how to deal with an increasing transport demand. Today, the railway industry seems focused on traditional business models that profit from friction, wear and tear of established conventional transport systems. Maglev Systems have begun to challenge those traditional business concepts. Maglev is a fundamentally different concept of transport – which might explain the reluctance, even ignorance, which Maglev systems continue to face.

Keywords: Maglev, High Speed Rail, Paradigm Shift

INTRODUCTION

Throughout history, events have often converged to create entirely new paradigms. Some of those paradigm shifts were entirely predictable; others came as a total surprise. Maglev is one of those ‘disruptive’ technologies that have the power to dramatically alter and improve the way we live and travel.

Magnetic levitation transport, or maglev, is still a modern form of transportation that suspends, guides and propels vehicles via electromagnetic force. This High-Tech method can be significantly faster than wheeled mass transit systems, potentially reaching velocities comparable to turboprop and jet aircraft (550 to 700 km/h) in regular service.

Maglev systems represent a revolutionary transport innovation. At the same time, they can also function as a technology development platform (e.g., superconductors, new materials, shielding methods). They can, in certain cases, bring positive economic benefits through the optimization of spatial networking, travel time reduction and resource efficiency.

Some aspects of the ongoing technology debate will be covered on the following pages.

I. IS MAGLEV A RELEVANT TECHNOLOGY TREND?

High speed ground transport requires a wide-ranging and interdisciplinary discussion in order to promote a sufficiently broad spectrum of opinion. Today, a

realization of any kind of high-speed transport infrastructure cannot be justified anymore just through system technical advantages alone, if they are to find acceptance with the general public and politics.

A. Market Barriers

The less competition in the transport market, the more attractive it appears in the short-term for manufacturers to postpone a technological innovation and to secure current sources of income through long-term maintenance contracts (delivery, spare parts) that are linked to conventional wheel/rail contracts. Such a short term orientation on the commercially lucrative (rather than on the system-technologically superior) can strongly handicap, delay or under certain circumstances completely cancel transportation technological innovations.

Some of the maglev technology know-how leaders are also market-established producers of wheel/rail high-speed systems and even are sometimes also market leaders in traditional railway communication systems and conventional railway infrastructure components. Such companies are faced with a technological-commercial dilemma: managers must decide whether and when new technologies that have significant potential for rationalization should be introduced into the existing highly profitable wheel/rail high-speed transportation market (maintenance, replacement parts, and licensing business). If managerial success is defined on the basis of short-term balances, this feeds developments that disadvantage an innovation of maglev technology [12].

B. Interoperability

High-speed ground transport can only be safe and efficient when it is completely separated from slower systems. The autonomy of a maglev train running on its own infrastructure is hence an important system advantage that makes overall safety, efficiency and punctuality possible in high-speed maglev operations.

The demand for compatibility or interoperability of high-speed rail transport with the operation of slower rail transport is based on traditional steel-wheel/rail planning and is no longer meaningful in this form today.

Vehicles with extremely different speeds on the same traffic path create a mutual hindrance and introduce mutual safety concerns. Safety clearances and time needs must therefore increase. Mixing slow transport with high-speed transport is clearly not advantageous economically for either system. This is equally true for all transport systems: bicycles on a freeway would be just as senseless as auto racing on cycling paths.

Combining rapid and slow transport systems creates a mutual hindrance and lowers the performance of the entire system. The operation of high-speed passenger trains should therefore be separated from freight trains and slower passenger transport. The Japanese Shinkansen train network has been completely separated from slower wheel/rail transport since 1964 and has operated fatality-free with incredible efficiency ever since.

The longer high speed running can be maintained, the better the performance will be, along with the cost effectiveness of the respective system. In this regard, maglev trains have the principle advantage through their independent routes and the automatic exclusion of mixed traffic [2].

C. Infrastructure trends

Through the technological developments of recent years, the infrastructure construction costs for high-speed maglev trains have converged to the same levels as those of traditional wheel/rail systems. Furthermore, there is a potential for further cost reduction. For topographically demanding routes, maglev trains already offer clear advantages in the cost of infrastructure construction.

Some Maglev systems can manage ascending grades of 10 % and more (Transrapid maglev), while traditional railroads are limited to grades on the order of 4 %. Maglevs adapt more easily to the landscape and therefore require fewer tunnels. This offers enormous cost savings in infrastructure construction, particularly in hilly landscapes.

New manufacturing processes in track construction, for example, the spun concrete construction technique and other modular production concepts, make it possible to reduce the costs of mass production considerably. In hilly landscapes, maglev guideways on pier foundations – spaced tens of meters apart – are considerably more economical than the massive, expensive embankments and causeways usually required for the entire length for most wheel/rail systems [2].

Maglev guideways can avoid obstacles without special additional bridge constructions. At-grade crossings with other traffic routes are eliminated and, therefore, collisions are rendered impossible. In the case of elevated track, alternative uses of the land under the track are still possible.

D. Environmental trends

Maglev trains do not create direct pollution emissions and are always quieter in comparison to traditional systems when operating at the same speeds.

In high-speed intercity transport, using maglev trains can offer an especially good cost-benefit ratio as regards land purchase, construction, operation, maintenance

and environmental protection. Future technological advances can be expected to improve this ratio even more.

In the area of noise emissions, maglev trains are superior in every way to wheel/rail systems (when operating at the same speeds), not to mention airplanes.

Comparisons made at the same speed show that all rolling friction noises, every track screech, all shocks from wheel-on-rail contact are eliminated in maglev systems that use magnetic forces rather than physical contact to keep the vehicle upright. Noise generated by air turbulence is also greatly reduced with maglev high-speed trains, making them clearly superior to all wheel/rail vehicles. In particular, the noise from the conventional train's pantograph is replaced in maglev by a process of induction and the required energy is transferred without physical contact.

At speeds under 200 km/h (125 mph), maglev systems can hardly be heard, especially in an urban environment – an important advantage for populated areas. The Chinese Transrapid in Shanghai and the Japanese Linimo in Nagoya, as well as all urban transport maglev trains, offer impressive proof of this.

Maglev routes also do not divide the landscape as highways, train tracks and waterways typically do. Animals can cross under elevated maglev guideways, which they do without hesitation, and farmers can still use the land undisturbed, as this was shown by observation and experience at the test facilities in Japan's Yamanashi Prefecture and Germany's Emsland town of Lathen.

There is a strong demand to design future rail route architecture more aesthetically and open, in contrast to the massive constructions of the past. This public concern will affect maglev trains as well as wheel/rail systems [2].

E. Trends in Comfort and Safety

In the areas of travel comfort and safety, maglev trains clearly exceed other rapid transit rail systems. The design of the guideway – whether the German “T” shape for the wrap-around vehicle or the Japanese “U” shape with the vehicle enclosed – ensures that the trains are safe from derailment.

Today, maglev trains can generally be considered to be among the safest and most comfortable rapid transit systems in the world.

The amount of space available inside maglev cars is generous compared to the relatively narrow proportions of many established train cars. For example, a German Transrapid interior is nearly a meter wider than conventional rail cars, which makes for more spatial freedom, a wider range of seating options and contributes to a higher overall comfort level. The levitation of the vehicle using magnetic forces ensures a quiet and smooth ride, even at the highest speeds, whereas wheel-on-rail systems sometimes struggle with this even at the lowest speeds. The Japanese

Linimo as well as the South Korean Rotem Urban Maglev can substantiate this claim for quiet, comfortable travel in city transport applications [2].

F. Economics: Wear and Tear

While high-speed maglev infrastructure is relatively expensive to build, maglev trains are less expensive to operate and maintain than traditional high-speed trains, planes or intercity buses. Most of the power needed is used to overcome air drag, as with any other high speed train.

Maglev systems can operate at very high speeds almost without deterioration and are therefore more economical to operate than wheel/rail rapid transit systems that require regular intensive maintenance and experience exponentially increasing erosion with increasing speed. The fundamental freedom from mechanical erosion is one of the main advantages of maglev high-speed systems.

Maglev is the only trackbound transport system that has practically no mechanical friction during operation. In maglev, all the weight, propulsion and lateral guidance forces of the vehicle are transferred contact-free to the guideway, including the braking forces. As a result, maintenance costs of some maglev systems are only a fraction of the costs of traditional wheel/rail systems.

In traditional wheel/rail operations, the wheels eventually wear out. In addition, the resultant grit on the running surface of the tracks causes abrasion of the railheads.

Example: Each German InterCity Express (ICE) train wheel alone loses about 68 kg/150 lb of steel through friction from driving and braking before it is withdrawn from service, usually after two or three years (an entire ICE train loses about 8 metric tons / 17 600 pounds). TGV, KTX and conventional Shinkansen trains are equally subject to wear and tear [2].

G. Ethical requirements

For all transport infrastructure projects, it is of fundamental importance that long-term social orientation increases and the corresponding objective cost-benefit comparisons are made as the basis of future decisions rather than the short-term profit motives of the established wheel/rail manufacturing sector.

Transport infrastructures affect living spaces for many decades afterwards; future generations will carry the social and financial burden of the today's decisions made to build relatively inefficient and uneconomical structures.

Even when projects in transport infrastructure continue to be tested on a case-by-case basis to decide which technology should be put to use, maglev systems

can often (not always) offer a qualitatively superior solution when subjected to an objective cost-benefit comparison [2].

From a national economic perspective, an important goal is to provide future generations with an efficient, high-capacity transport system whose long-term benefits are distinguished by its low operation and maintenance activities and hence its low life-cycle costs. Therefore, the decision as to the suitability of future intercity transport systems (air, wheel/rail or maglev) should be based on the cost-to-benefit ratio of the system as it develops over the decades.

In other words, we should think beyond the initial start-up costs of construction, infrastructure and vehicles and consider more clearly the future costs of upkeep and maintenance in order to create the most sustainable transport system [2].

H. Expectations

As magnetic levitation (maglev) systems might begin to come on line around the world, questions surrounding these new transportation technologies will naturally and inevitably arise; especially, as the price of oil continues to climb. This will increase awareness of transportation engineering options, traffic congestion mitigation, and improved land development and energy policies.

As a general requisite, Maglev Systems should be seen and evaluated in context with existing infrastructure, available resources and the future needs of society. Looking only at prospects and barriers of the maglev technologies without taking relevant context into account cannot provide realistic, helpful transport solution for the future.

Scarcely one hundred years ago when electricity began to be distributed into people's homes, it too was viewed with fear and amazement. However, it was not long before societies came to rely on reliable supplies of the now omnipresent electric power to light homes and factories after dark, to power labor saving machines, and to make instantaneous telecommunications possible worldwide. Indeed, it is our reliance on readily available supplies of reliable electricity that defines our world - without it, our modern world ceases to be modern.

Some experts consider Maglev as the logical progression of the electricity revolution that was begun by Edison and Tesla in the late 19th century, and were in fact conceived in the early 20th century. However, it was the rapid advancement in computer processing in the late 20th century that really propelled maglev development forward and transformed it into today's premier transportation option.

Today, maglevs are essentially highly reliable computer-controlled electronic transportation systems, with most maglevs requiring no moving mechanical parts for suspension, acceleration or braking.

All these innovations could result in potentially much lower operational and maintenance expenditures relatively lower energy consumptions while also enabling significantly higher speeds and faster rates of acceleration and deceleration.

Magnetic levitation is achieved in a variety of ways. What all these maglev systems share is the use of electro-magnetic power to suspend vehicles above and away from their guideways (tracks) rather than using wheels; although some systems use wheels for suspension at low speeds and while at rest.

By suspending vehicles away from their guideways, the friction resulting from wheel on track contact is eliminated as an impediment to higher speeds. This same electro-magnetic power is also used to propel vehicles, which also means they are not polluting their rights of way. The regular use of mechanical friction brakes is also eliminated, along with the need for expensive brake maintenance. High temperature superconducting materials are likely to play an increasingly important role and are already being tested in some Japanese systems.

Maglev systems are expected to be cost effective, quiet and energy efficient. If implemented according to their technological strengths, they might promise to fit seamlessly into the vision of developing sustainable and livable communities that enhance, rather than compromise, citizen mobility [2].

II. CONCLUSIONS

As the lifetime of high-speed rail/wheel infrastructures comes to an end, the technology question will arise again. Based on the operation experiences with high-speed-trains, the technology question is likely to arise significantly earlier than generally expected. The question then will be whether in restoring or maintaining high-speed routes the conventional wheel/rail technology continues to be used or whether such corridors should better be based on high-speed Maglev technology.

Worldwide, there are quite some corridors, for which interurban high-speed Maglev transport is potentially qualified or might appear meaningful, for example:

- Brazil: Rio de Janeiro - Sao Paulo corridor;
- Japan: Tokyo – Osaka Maglev line;
- Europe: Bruxelles / Hamburg – Berlin – Warsaw / Baltic States – St. Petersburg – Moscow [3] ;
- Asia: Moscow – Beijing (“Silk Road” / TransSib),
- Europe: St. Petersburg Harbor – Moscow Cargo Maglev corridor
- Europe: Pan-European corridor IV (Berlin – Prague – Vienna – Budapest);
- USA: Washington – Baltimore;
- Europe: London – Liverpool; Glasgow, Edinburgh;
- India: Delhi – Mumbai – Chennai.

For such corridors and routes, a detailed, fair technology comparison and examination should be made with regard to high-speed Maglev [4].

Japan already leapfrogs to high speed Maglev systems. Russia strives for Cargo Maglev strategies. China and Korea boost the implementation of Urban Maglev technologies. Transrapid Maglev technology is being further developed by Chinese Universities. Germany has begun to build cable-free elevators based on Transrapid Maglev technology [5].

These are signs of upcoming, fundamental changes in transport policies and even might be considered trendsetters in deciding on updated renewal concepts for aged rail transport infrastructure.

A paradigm shift in transport in favor of Maglev seems likely.

III. ACKNOWLEDGMENT

The results presented in the article also represent the official view of the International Maglev Board [2], [6].

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Information about the authors:

Kluehspies Johannes, Dr. habil. Dr. h.c., full professor;
ORCID: 0000-0001-6089-9853
E-mail: jok@maglevboard.net

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