

Magnetic Suspension Technology for Mass Transit Railway in Hong Kong Opportunities, Challenges, and Strategic Pathways

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Abstract—

This paper presents a detailed review of magnetic suspension (maglev) technology and its potential application to the Mass Transit Railway (MTR) system in Hong Kong. Medium-low speed maglev technology can be a feasible alternative for certain urban corridors, with the existing Hong Kong rail infrastructure under increasing pressure of capacity, space limitations for underground expansion, and growing environmental sustainability demands. Based on the technical documents of existing maglev lines in Mainland China (Changsha, Qingyuan, Beijing S1 Line), policy discussions of the Guangdong-Hong Kong-Macao Greater Bay Area integration initiatives and research results of the National Rail Transit Electrification and Automation Engineering Technology Research Centre of Hong Kong (CNERC-Rail), this article provides a systematic analysis of the technical features, economic feasibility, operational needs and strategic implications of the analysis shows that while maglev technology enables considerable gains in terms of construction cost reduction (about one-fourth of underground tunnel systems), operational efficiency and environmental performance, its implementation faces challenges in terms of technology localisation, regulatory adaptation, integration with existing rail networks and public acceptance. The article proposes a phased rollout approach for maglev, starting with selected corridors such as Kwun Tong to Kai Tak, and positioning Hong Kong as a potential pilot for maglev links in the Greater Bay Area.

Keywords—*Magnetic suspension, Mass Transit Railway (MTR), medium-low speed maglev, rail transit innovation, urban transportation*

1. Introduction

The Mass Transit Railway (MTR) in Hong Kong is one of the world's most efficient, reliable and profitable urban rail systems. Since its inception in 1979, the MTR has grown to encompass more than 270 kilometres of rail lines, with 5 million passengers using its trains daily. However, the system now faces unprecedented challenges. These include population growth in new development areas, especially the Northern Metropolis, intensifying congestion on existing corridors, especially Kwun Tong line, physical constraints on further underground excavation due to dense urban development and existing utility infrastructure, and mounting pressure to reduce carbon emissions from transportation [1].

These challenges have stimulated policy makers, engineers and researchers to search for innovative rail technologies that can complement and extend the capabilities of conventional steel-wheel-on-steel-rail systems. A very promising alternative is magnetic suspension or maglev technology. Maglev [2] uses electromagnetic forces to eliminate physical contact between vehicle and guideway. It can lead to smoother, quieter and possibly less expensive operations.

Since China's first domestically developed medium-low speed maglev line, the Beijing S1, entered commercial operation in 2017, the relevance of maglev technology to Hong Kong has been increasingly focused. Other projects, such as the Changsha Maglev Express (2016) and the Qingyuan Maglev Tourist Line (2020), have proven the technical maturity and operational viability of medium-low speed maglev systems in urban and suburban settings. In Hong Kong, they have noticed these developments. CNERC-Rail centre of Polytechnic University has been actively engaged in the research of maglev health monitoring and control in collaboration with Tongji University and Hunan Maglev Corporation. PolyU held the first and second seminars on the

development of the maglev train in the Greater Bay Area (GBA) in 2019 and 2024 respectively, to gather leading experts to exchange views on the regional application of technology.

Yet, despite this growing scholarly and policy interest, there has been no systematic assessment of maglev's prospects for Hong Kong's MTR since Lam's 2001 master's thesis [3]. That study, nearly a quarter of a century ago, was conducted before the commercial introduction of medium-low speed maglev systems and was unable to incorporate the many technological advances that have occurred since. The current paper addresses this gap by providing a contemporary evidence-based assessment of the applicability of maglev technology to the distinctive urban, geological and institutional context of Hong Kong.

The structure of the article is as follows: The technology of maglev systems is described in Section 2 with the focus on the medium-low speed systems most relevant for urban transit. In Section 3, the context of Hong Kong MTR is reviewed and specific corridors where conventional rail expansion is constrained to prohibitive levels are identified. Section 4 discusses the opportunities provided by the adoption of maglev including economic, operational and environmental benefits. Section 5 presents challenges and barriers to implementation. Section 6 reviews the existing research and policy infrastructure that support maglev development in Hong Kong. Section 7 provides a strategic pathway for phased deployment, and Section 8 concludes with recommendations for policymakers and researchers.

2. Medium-Low Speed Maglev Technology: Principles and Performance

2.1 Fundamental Operating Principles

Maglev (magnetic suspension) technology [4] employs electromagnetic forces to levitate, guide and propel vehicles with no contact between the vehicle and the guideway. Unlike

conventional rail systems where steel wheels run on steel tracks, maglev vehicles float above the track using electromagnetic attraction (electromagnetic suspension, EMS) or electrodynamic repulsion (EDS).

The EMS based medium-low speed maglev systems have been adopted as the dominant configuration for urban transit applications. The nominal levitation gap of these systems is about 8-10 mm, with the vehicle hanging below a ferromagnetic rail. Electromagnets on the underside of the vehicle exert an attractive force against the gravitational force, levitating the vehicle. Sophisticated control systems keep the gap within tight tolerances by adjusting current to the electromagnets thousands of times per second as load conditions change.

The propulsion is from a linear induction motor (LIM) or linear synchronous motor (LSM). In the LIM configuration, the primary winding is mounted on the vehicle, and the reaction plate is fixed to the guideway. When AC current is fed into the primary winding, a travelling magnetic field is generated. This induces currents in the reaction plate and thrust is produced. No mechanical gearbox parts to service enhanced energy efficiency.

2.2 Technical Characteristics of Medium-Low Speed Maglev

The term “medium-low speed” separates urban maglevs from high-speed maglevs intended for intercity service (e.g., the Shanghai Transrapid, which runs at 430 km/h). Medium-low speed maglev systems are typically designed for maximum speeds of 100-120 km/h and average operating speeds of 60-80 km/h. This performance envelope is well suited to urban and suburban transit requirements.

The key technical specifications of the operational medium-low speed maglev systems are Shown as Table 1.

Table 1: Key technical specifications of the operational medium-low speed maglev systems

Parameter	Typical Value	Comparison to Conventional Rail
Maximum speed	100-120 km/h	Comparable to metro systems
Minimum turning radius	75-100 m	Substantially smaller (conventional 250-300 m)
Maximum gradient	70‰ (7%)	Double conventional capability (30-35%)
Levitation gap	8-10 mm	N/A
Noise emission (at 80 km/h)	≤ 65 dB(A)	Significantly quieter than steel-wheel systems
Power consumption (propulsion)	2.5-3.0 kWh/km	Comparable to conventional light rail

Source: Compiled from technical specifications of Changsha Maglev Express, Beijing S1 Line, and Qingyuan Maglev Tourist Line.

2.3 Distinctive Advantages for Urban Applications

The technical features listed above give rise to several operational benefits which are of relevance in a dense urban environment such as Hong Kong.

(a) Better adaptability of geometry -- Maglev systems can take curves with radii as small as 75 meters, compared to 250-300 meters for conventional rail, and thus can follow existing road alignments and navigate around built structures. This

versatility is very useful in areas where land acquisition for wide radius curves is very expensive or impossible.

(b) Great climbing skills -- Maximum gradients of 7 % enable maglev vehicles to climb slopes that would be impassable to conventional steel-wheel systems (usually limited to 3-4 %). Hong Kong’s hilly terrain could benefit from this feature with reduced tunnelling and cut-and-cover construction.

(c) Less noise and vibrations -- With no wheel-rail contact, there is no characteristic 'clickety-clack' noise of conventional trains and vibration transmission to adjacent structures is significantly reduced. This makes Maglev particularly well suited for elevated guideways in densely populated areas [5], where noise complaints have historically limited rail expansion.

(d) Reduced construction costs for elevated alignments -- The supporting guideway structure can be made slimmer and less massive because maglev vehicles are lighter than conventional steel-wheel trains (because of distributed propulsion and the absence of heavy bogies). Industry estimates the cost of elevated maglev guideways at about 25% of the cost of comparable underground tunnel construction. This cost difference is very important for places like Hong Kong where underground expansion is becoming increasingly constrained.

(e) Lower maintenance load -- Contact between wheel and rail is also eliminated, as is the wear of these parts. No wheels to true, no rails to grind, no lubricant to put on. The maglev guideway must be aligned to a high degree of accuracy, and the control systems require sophisticated maintenance, but the total lifecycle maintenance cost is expected to be 30-40% lower than conventional rail systems.

2.4 Operational Experience in Mainland China

The above technical claims are not only theoretical but have been validated in several operational deployments in Mainland China.

(a) In 2016, China’s first homegrown medium-low speed maglev line, the Changsha Maglev Express, opened. The 18.55-kilometer line links Changsha Huanghua International Airport and Changsha South Railway Station, and it is expected to run at a maximum speed of 100 km/h and complete the journey in about 20 minutes. Since opening, the line has carried over 10 million passengers and has achieved reliability metrics comparable to traditional metro systems.

(b) The Beijing S1 Line (opened 2017) was the first medium-low speed maglev line to operate in a large metropolitan area. The 10.2-kilometer line connects several western Beijing suburbs and travels at speeds of up to 100 km/h. Of particular importance, the line crosses existing surface roads, demonstrating the technology’s capacity to adapt to dense urban fabric.

(c) Qingyuan Maglev Tourist Line (opened 2020) is a newer generation of medium-low-speed maglev technology. The 8.1 km line links Qingyuan’s city center with a major tourist attraction, demonstrating the technology’s suitability for specialised corridors that require high-frequency, medium-capacity service.

2.5 Gap Between Mature Technology and Local Application

However, the transfer of maglev technology to Hong Kong is not simple, despite the proven operational experience in Mainland China. There are some gaps to be filled in.

(a) Regulatory environment -- The Hong Kong railway standards, codified in the Railways Ordinance and administered by the Electrical and Mechanical Services Department (EMSD), are based on the conventional steel-wheel systems. Maglev technology does not fit neatly into existing regulatory categories and either requires regulatory adaptation or the creation of new safety certification processes.

(b) Working environment -- Mainland Chinese maglev systems are in temperate climates, but Hong Kong has its own environmental challenges: typhoon-force winds, high humidity, salt-laden air (especially in coastal alignments) and heavy rain. The effects of these conditions on electromagnetic systems and guideway accuracy must be carefully evaluated.

(c) Integration with the existing network -- Maglev systems cannot share track with conventional trains (due to incompatible propulsion and guidance systems) Any maglev line would then be a closed system and would have to interface with the MTR system at interchange stations, rather than through running.

(d) Public acceptance -- People in Hong Kong have become used to the MTR's high degree of reliability and frequency. No new technology can be accepted by the public until it has proved itself to be the equal of what has gone before.

3. The MTR's Constraints and Opportunities

3.1 Existing Network Characteristics

The MTR system has 11 heavy rail lines (not including light rail and airport express) serving 98 stations on Hong Kong Island, Kowloon and the New Territories. The network is marked by:

(a) High density -- Average interstation spacing of approximately 1.2 km in urban areas.

(b) Frequent service -- Headways of 2 minutes or less during peak times.

(c) High load factors -- Several lines are operating at or above design capacity in peak hours.

(d) Extensive underground alignment -- About 60% of the network is underground in tunnel, reflecting the constraints of surface space in the built environment of Hong Kong.

3.2 Identified Constraints on Further Expansion

There are several factors which are increasingly constraining the MTR's ability to expand its network with conventional technology.

(a) Geological and geotechnical limitations -- The bedrock of Hong Kong is mainly granitic and volcanic rocks, covered by varying depths of decomposed material. Tunnelling can be done, but it is costly and time consuming. More importantly, many of the potential alignments pass through areas already occupied by underground utilities such as water mains, gas pipes, power cables and telecommunications infrastructure within the available subsurface space. In places like Kwun Tong, where the original population estimate of 60,000 has been exceeded by over 400,000 residents, the subsurface is effectively full.

(b) Constrained land acquisition -- Land will be needed for surface rail alignments and land in Hong Kong is at a premium and expensive. Raised structures take less land than at-grade alignments. However, support columns and station structures encroach upon road space and pedestrian walkways.

(c) Noise and vibration issues -- Conventional systems with steel wheels produce considerable noise and vibration especially on elevated alignments. In Hong Kong's dense urban environment, noise complaints have led to operating hour restrictions on certain elevated sections and made some alignments politically untenable.

(d) Escalation of costs -- MTR expansion unit costs have grown substantially over the past 20 years. The Sha Tin to Central Link (completed in 2022) was hit by a massive cost overrun, with the final bill far exceeding the original estimates. These overruns were due to several factors, but the primary driver was the inherent complexity of underground construction in challenging urban geology.

3.3 Specific Corridors Identified for Maglev Potential

Transportation planners and engineers have identified several corridors where the special attributes of maglev technology could overcome constraints that block conventional rail expansion.

(a) Kwun Tong to Kai Tak -- The corridor, which was first proposed for maglev consideration in 2017, exemplifies the kind of alignment where maglev has unique advantages. The route would run through an area of extreme population density (Kwun Tong district now has a population of over 400,000, far more than original design capacity). The underground is crowded with utilities, and the surface road network is already full. An elevated maglev guideway could be strung above existing roads, supported only by thin support columns, with stations built into the podium levels of existing buildings. And the Kai Tak development area would be an anchor destination with planned commercial and residential density. The length of the corridor (about 5-6 km) is well within the performance envelope of medium-low speed maglev.

(b) Kwun Tong to Kowloon Bay Exhibition Center -- It is suffering from poor public transport access; the Kowloon Bay International Trade and Exhibition Centre rely on infrequent shuttle buses from Kowloon Bay MTR station. An extension of the maglev line from Kwun Tong across Kowloon Bay to the Exhibition Centre would serve the commuter and event-trip markets alike.

(c) Northern Metropolis Links -- The Northern Metropolis development, which covers areas near the Shenzhen border, is expected to accommodate 2.5 million residents and create 650,000 jobs. Standard MTR extensions (such as the Northern Link) are planned, but Maglev might offer more connectivity, especially on routes with tight curves or steep gradients to traverse the hilly terrain of the area.

(d) Cross-border links to Shenzhen -- Experts have suggested cross-border maglev links between Hong Kong and Shenzhen and other GBA cities. A cross-border maglev at least connecting Hong Kong with Shenzhen, and even to other cities in Guangdong would help to achieve the half-hour living circle between Hong Kong and Shenzhen and the "one-hour living circle" with other GBA cities. Such a line would be able

to run at speeds of 160-200 km/h, higher than urban maglev, but on the same basic technology platform.

4. Opportunities Presented by Maglev Adoption

4.1 Economic Opportunities

(a) Lower capital expenditure -- The strongest economic case for maglev in specific Hong Kong corridors is for construction cost. The estimated cost of constructing maglev guideways is about one quarter of that of underground tunnel construction, as discussed in Section 2.3. An elevated maglev system might cost HKD5-6 billion for a 5-kilometre corridor where underground construction would cost HKD20-25 billion. Some of these differentials may be offset by the need for specialised vehicles, control systems and maintenance facilities but the capital cost advantage is still considerable.

(b) Fast delivery of projects -- Maglev's lighter guideway structure means the modular construction approach allows for faster deployment than conventional rail. The normal MTR line takes 7-10 years from planning to opening, but a maglev line on a suitable corridor could be delivered in 4-6 years. The economic value of this acceleration lies in both earlier realisation of benefits and less disruption during construction.

(c) Less maintenance costs -- There is no wheel-rail contact and therefore no wheel truing, rail grinding and associated maintenance activities. The MTR Corporation now spends hundreds of millions of dollars a year on track maintenance. Maglev may bring new maintenance needs (precise guideway alignment, electromagnet replacement, control system calibration) but the overall maintenance burden should be lower.

4.2 Operational Opportunities

(a) Possible of more frequent -- Because of their ability to accelerate and decelerate quickly (high power-to-weight ratios), Maglev systems can have shorter headways than conventional systems. Without the constraints of wheel-rail adhesion, maglev vehicles can brake harder without the fear of wheel slip. This feature is especially useful for corridors where peak period demand exceeds the conventional line capacity.

(b) Improved operational dependability -- Magnetic levitation is less sensitive to environmental conditions [6] than wheel-rail adhesion. Electromagnetic levitation and propulsion are not affected by rain, leaves or light snow on the running surface which can diminish adhesion and delay conventional systems. That reliability is a big plus in Hong Kong, where heavy rain during typhoon season can cause wheel slip on steep slopes.

(c) Improved passenger experience -- There is no contact between wheel and rail, and therefore none of the vibration and less of the noise typical of conventional train travel. Maglev vehicles are said to move "with a lightness like a breeze". This added comfort may improve mode choice relative to road-based alternatives for corridors serving business travellers or tourists.

4.3 Environmental Opportunities

(a) No direct emissions -- Maglev systems are electric and produce no direct carbon emissions. When charged from Hong Kong's electricity grid (which is gradually decarbonising), the

lifecycle carbon footprint is much lower than road-based alternatives (private cars, buses, taxis) and comparable to conventional electric rail. But maglev's lower rolling resistance gives it a slight efficiency edge over steel-wheel systems.

(b) Less noise pollution -- As we said, maglev systems are much quieter than conventional rails. In dense population areas where alignments are elevated, that noise reduction could be the difference between politically possible and not. For example, the Beijing S1 line has operated close to residential buildings without the noise complaints that have plagued some conventional elevated lines.

(c) Less visual impact -- The slim guideway structure required to support maglev has a lower visual impact than traditional elevated rail viaducts. In heritage-sensitive areas (e.g. near the Kai Tak runway, or along waterfront promenades), this reduced visual impact may ease approvals.

4.4 Strategic Opportunities

(a) Positioning Hong Kong as the innovation centre -- And with China continuing to pursue ambitious maglev plans, including a proposed 600 km/h high-speed maglev link between Shanghai and Hangzhou, Hong Kong has an opportunity to become a hub of maglev expertise. Hong Kong can also gain economic benefits from knowledge transfer by introducing maglev technology on a local corridor and through research partnerships with Mainland institutions that contribute to the refinement of the technology.

(b) Enhancing GBA integration -- The vision of a "Greater Bay Area on Rails" would become a reality with the development of maglev links. Hong Kong is already linked to the GBA network by high-speed rail, but maglev could provide more frequent and flexible connections for shorter and medium distance journeys where high-speed rail is over-specified. Maglev can realise a half-hour living circle between Hong Kong and Shenzhen.

(c) Displaying teamwork under "one country, two systems" -- A maglev project co-developed by Hong Kong institutions and Mainland enterprises would showcase the practical benefits of cross-boundary co-operation. The Hong Kong branch [7] of the National Rail Transit Electrification and Automation Engineering Technology Research Centre (CNERC-Rail) [8] is already well positioned to promote such cooperation.

5. Challenges and Barriers to Implementation

5.1 Technical Challenges

(a) Guideway accuracy requirements -- Maglev levitation systems need guideway alignment tolerances at the order millimetres. Conventional rails also must be precisely aligned, but the penalties for misaligned wheels are less severe; conventional trains can roll over slightly uneven tracks, but with more wear and vibration. A maglev vehicle with an 8-10 mm levitation gap cannot tolerate guideway deviations of similar magnitude. In Hong Kong, the temperature variation and ground settlement are not insignificant, and it is a technical challenge to achieve and maintain the required precision.

(b) Power supply needs -- Maglev propulsion depends on a continuous supply of high-quality power for levitation. The levitation electromagnets can be powered by onboard batteries

for short periods of time, but any long-term power outage would cause the vehicle to sit down on mechanical back-up supports. To support a maglev line, a major reinforcement of MTR's existing power supply infrastructure would be required.

(c) Resilience to typhoons -- One of the biggest challenges for any coastal rail infrastructure in the GBA is typhoon resilience. Maglev systems with their narrow levitation gaps and open guideway surfaces may be more susceptible to wind-blown debris than conventional rail. The guideway would be elevated (to avoid surface obstruction) and would be exposed to higher wind speeds than at-grade or underground systems. The Guangzhou-Shenzhen-Hong Kong Express Rail Link has already developed mature anti-typhoon measures, but whether these can be applied to maglev still needs to be proved.

(d) Marine environment corrosion -- Because Hong Kong is on the coast, any elevated guideway will be subject to salty air. Electromagnetic components are susceptible to degradation due to corrosion. Protective coatings [9] and stainless-steel components can help to mitigate this risk, but lifecycle implications in terms of maintenance and replacement need to be carefully assessed.

5.2 Economic Challenges

(a) Higher vehicle purchase price -- Maglev vehicles are manufactured in smaller numbers than conventional metro vehicles today and the technology employs more sophisticated electronics (levitation controllers, gap sensors, power converters). Thus, the procurement costs per unit are higher compared to equivalent conventional stock rolling. As production scales increase this differential may decrease but for the near term it represents a financial barrier.

(b) Specific maintenance requirements -- Maglev reduces several maintenance items (wheels, rails, bearings) but introduces new items such as the need for accurate measurement of guideway alignment, reconditioning of electromagnets, calibration of control systems, and specialised training of maintenance personnel. The MTR Corporation would have to develop new maintenance capabilities either through in-house training or service agreements with Mainland suppliers.

(c) Fees for transfer stations -- Maglev systems do not run on the same tracks as conventional trains, so interchange between maglev and MTR lines would require dedicated transfer stations. These stations would need to provide easy, barrier-free transfers without requiring maglev vehicles to operate on MTR tracks and vice versa. The cost of these stations (including vertical circulation, fare control integration and passenger circulation space) needs to be incorporated into the project economics.

5.3 Regulatory and Institutional Challenges

(a) Hong Kong maglev standards absent -- Maglev technology [10] is currently not within the railway safety regulatory framework in Hong Kong. The Electrical and Mechanical Services Department (EMSD) would have to either develop new safety standards or adapt standards from Mainland China (where GB/T standards for maglev exist) or international standards. This process would necessarily extend the schedule for the project.

(b) Integration with MTR concession system -- The MTR Corporation has certain rights and obligations for railway development and operation under a concession agreement with the Hong Kong SAR Government. Any maglev line built by MTR would have to be compatible with this framework. Alternatively, a maglev line could be developed by a separate entity (e.g. Airport Express, operated by MTR but owned by the government), but this would add additional coordination complexity.

(c) Interoperability with Mainland systems -- Interoperability with potential Mainland Chinese maglev systems would be required for cross-border maglev links. Technical interoperability (track gauge, power supply, signalling) is possible, but operational interoperability (fare integration, cross-border passenger processing, emergency coordination) would need new agreements between Hong Kong and Mainland authorities.

5.4 Social and Political Challenges

(a) Public acceptance of new technologies -- The MTR is very reliable, and Hong Kongers are used to that. Any suggestion that a new technology might be "less proven" could trigger public opposition. Advocates would have to carefully manage expectations, perhaps through demonstration projects or public education campaigns.

(b) Concerns about the visual impact -- Elevated maglev guideways have a smaller visual footprint than traditional elevated rail, but they're not invisible. Nearby residents may object to proposed routes because of the intrusion on views or what is seen as a shadowing effect. Such concerns need to be addressed through careful choice of alignment and, where necessary, mitigation measures.

(c) Competing with traditional rail investments -- MTR Corporation has a long-term investment programme for the expansion and renewal of conventional rail. If we invest capital in a Maglev demonstration project, that money will be taken away from these traditional investments unless the government puts in extra money. The investment in Maglev must be assessed transparently as an opportunity cost.

6. Existing Research and Institutional Infrastructure

6.1 CNERC-Rail (Hong Kong Branch)

The focus of maglev research in Hong Kong is at the National Rail Transit Electrification and Automation Engineering Technology Research Centre (CNERC-Rail) Hong Kong Branch, which was established at The Hong Kong Polytechnic University in 2015. Being "the only national engineering technology research centre in Hong Kong dedicated to the research and application of railway operation safety technology", CNERC-Rail has been researching the following frontiers:

(a) Intelligent maglev control -- Advanced control algorithms have been developed at the Centre to ensure stable levitation under different load and environmental conditions. This study, in collaboration with Tongji University and Hunan Maglev Corporation, has enhanced the operation of maglev systems.

(b) Maglev health monitoring -- CNERC-Rail has deployed sensor networks on maglev guideways to monitor alignment, vibration and component condition. Contributes to predictive maintenance capabilities.

(c) UAV-enabled hazard detection -- The centre has integrated unmanned aerial vehicle (UAV) technology with maglev monitoring to enable quick inspection of guideway infrastructure.

The centre's 2025 annual report specifically lists "breakthroughs in intelligent operation and maintenance, noise-control technologies...progress in UAV-enabled geological hazard mitigation, obstacle detection, and intelligent maglev control".

6.2 Academic Research

Other Hong Kong institutions have added to the maglev knowledge base other than that of CNERC-Rail. The 2001 master's thesis on maglev prospects at the University of Hong Kong, although dated, provides baseline economic and operational analysis. PolyU and Shenzhen University have also jointly set up the "Guangdong-Hong Kong-Macao Greater Bay Area Modern Rail Transportation Collaborative Innovation Center" to promote cross-institutional research on advanced rail technologies including maglev.

6.3 Policy Discussions

Several key events have influenced the policy discourse on maglev in Hong Kong:

(a) 2019 -- The first GBA maglev seminar at PolyU attracted 100 experts in the Mainland and Hong Kong. At the event, Professor Ni first proposed the idea of a cross-border maglev connection, saying: "I hope we can have a cross-border maglev...at least from Hong Kong to Shenzhen, and even to other Guangdong cities".

(b) 2024 -- The second GBA maglev seminar was co-hosted by PolyU, Tongji University and other partners [11]. The urgent need for new rail transportation technologies in Hong Kong, in particular, in the Northern Metropolis.

(c) July 2024 -- The HKSAR Chief Executive's Policy Unit visited CNERC-Rail for "in-depth discussions on the potential development of maglev transport in Hong Kong, such as how Hong Kong can serve the national planning and development of maglev rail transit".

(d) September 2025 -- A technical seminar jointly organised by China Hong Kong Railway Institution had speakers from CRRC Changchun and China Railway Siyuan to share detailed technical characteristics of medium-low speed maglev systems.

6.4 Mainland Collaboration Partners

Several Mainland institutions have established collaboration relationships with Hong Kong counterparts, thus facilitating knowledge transfer.

(a) CRRC Changchun Railway Vehicles Co., Ltd is the leading manufacturer of high-speed EMUs, railway locomotives and urban rail transit vehicles in China has achieved "full product coverage in all urban rail vehicle types" including maglev. Mr Yu Qingsong, Deputy Chief Engineer of the company, is the Director of the Maglev Research Institute.

(b) China Railway Siyuan Survey and Design Group Co., Ltd. undertook China's first medium-low speed maglev line (Changsha) in EPC model and subsequently delivered Qingyuan line.

(c) Tongji University and Hunan Maglev Corporation are designated main partners of CNERC-Rail in maglev research.

7. A Strategic Pathway for Phased Deployment

Against the above opportunities and challenges, this article outlines a strategic approach for maglev deployment in Hong Kong in three phases.

7.1 Phase 1: Demonstration and Capacity Building (2026-2028)

(a) Objective -- Build technical capability, regulatory framework and public acceptance.

(b) Main activities:

(i) Feasibility study of Kwun Tong-Kai Tak corridor -- Detailed engineering, economic and environmental assessment of a 5-6 km maglev line for the identified corridor. The study shall include alignment options, station location analysis, cost estimates and ridership forecasts.

(ii) Creating a regulatory framework -- In Hong Kong, there are no draft safety standards for the operation of Maglev, which should be developed in consultation with EMSD and the Mainland standards bodies. The process should be based on GB/T standards as far as possible and be adapted to the specific requirements of Hong Kong.

(iii) Public engagement and education -- Launch an information campaign explaining what maglev technology is, what its benefits are, and its safety record. Engage community stakeholders along potential alignments to identify concerns and develop mitigation measures.

(iv) Talent development -- Organise training programs for engineers and technicians in the design, construction, operation and maintenance of maglev. This could include secondments to Mainland operators (Changsha, Beijing, Qingyuan) and specialised modules in existing transport engineering programmes at Hong Kong universities.

(c) Success criteria -- Positive feasibility study results; safety standards developed; community support documented; pool of trained personnel identified.

7.2 Phase 2: Pilot Deployment (2028-2032)

(a) Objective -- To build and operate a first phase maglev line on a chosen corridor.

(b) Main activities:

(i) Kwun Tong Line Construction at Kai Tak -- If Phase 1 feasibility is confirmed, move on to detailed design, procurement and construction of the first maglev line. The line should be designed for future expansion, but operable as a stand-alone system.

(ii) Integration with MTR system -- Construct transfer facilities at the Kwun Tong MTR station (for connection to the Kwun Tong line) and at Kai Tak (for connection to the future Kai Tak station on the Tuen Ma line or Shatin to Central Link). Seamless Octopus fare integration.

(iii) Trial operation -- Protracted testing and commissioning, with a supervised operational trial period. Monitor measures of reliability, safety and passenger satisfaction.

(iv) Performance Documentation -- Systematic approach to document construction costs, schedule performance, operational reliability, maintenance requirements, and environmental impacts. This documentation will inform future maglev projects in Hong Kong and elsewhere.

(c) Success criteria -- Safe, reliable operation to defined performance metrics, positive passenger feedback, cost and schedule within planned ranges.

7.3 Phase 3: Network Expansion (2032-2040)

(a) Objective -- To extend the maglev network to new corridors, including potential cross-border links.

(b) Main activities:

(i) Kwun Tong extension to Kowloon Bay and further -- Extend the pilot line north to serve the Kowloon Bay Exhibition Centre and possibly link up with new developments in the former airport area.

(ii) Northern Metropolis Maglev network -- Build a maglev network to the Northern Metropolis development to provide all-weather connectivity at high frequencies in this new growth area.

(iii) Interconnection to Shenzhen -- Build a maglev link from Hong Kong (possibly via Lok Ma Chau or Huanggang) to Shenzhen's transport network, pending cross-border agreements. This link would be built to higher speeds (150-200 km/h) to meet the "half-hour living circle" target.

(iv) Technology transfer and knowledge export -- Position Hong Kong as a regional centre of expertise in maglev, providing consulting, training and technology services to other cities considering the deployment of maglev.

(c) Success criteria -- Increased ridership on the network in line with forecasts; successful cross-border operation; evidence of economic benefits to HK.

8. Conclusion and Recommendations

8.1 Summary of Findings

This article has examined the prospects of magnetic suspension (maglev) technology in the Hong Kong Mass Transit Railway (MTR) system. The analysis gives several key findings.

(a) A technical feasibility is proved -- The medium-low speed maglev technology has been verified in commercial operation in Mainland China (Changsha, Beijing, Qingyang) and attained reliability indexes like traditional urban rail. The technical features of maglev, such as better geometric adaptability, excellent climbing capability, and reduced noise are particularly well suited to Hong Kong's dense, hilly, and congested urban environment.

(b) There are strong cases of specific corridors -- The Kwun Tong to Kai Tak corridor, where utility congestion precludes underground expansion and surface space is limited, is a strong candidate for maglev deployment. There is also more to play for with Northern Metropolis development and potential cross border links to Shenzhen.

(c) Economic viability must be assessed on a case-by-case basis -- Maglev has advantages in construction cost for elevated alignments (around one quarter of underground tunnel costs), but these must be balanced against higher vehicle procurement costs and the cost of transfer stations. For corridors where conventional rail would require extensive tunnelling, maglev is likely to be cost-competitive; for corridors where at-grade or existing elevated alignment is possible, conventional rail may retain an advantage.

(d) Challenges are not easy, but they can be managed -- The lack of a regulatory framework for maglev in Hong Kong, the

need for specialised maintenance capabilities, and the need for public acceptance are challenges that can be addressed through deliberate planning and capacity building. The existence of CNERC-Rail and established Mainland collaboration partners provides a basis for addressing these challenges.

(e) Timing is a question of timing -- Given the increasing policy interest in GBA rail integration, the HKSAR government's commitment (as demonstrated by the Chief Executive's Policy Unit visit to CNERC-Rail) and the operational data from Mainland maglev systems, the conditions are ripe for Hong Kong to seriously consider maglev deployment.

8.2 Recommendations

The following recommendations are made to policy makers:

(a) Conduct a complete feasibility study on maglev -- The HKSAR government should collaborate with MTR Corporation and CNERC-Rail to finance a comprehensive feasibility study for the implementation of maglev on the Kwun Tong-Kai Tak line. This study should include engineering design, cost estimation, ridership forecasting, economic analysis and environmental assessment.

(b) Create a regulatory working group for maglev -- EMSD in consultation with CNERC-Rail and Mainland standards bodies should set up a working group to develop standards and certification processes for safety of maglev technology in Hong Kong.

(c) Support maglev research and talent development -- The Research Grants Council and Innovation and Technology Commission should prioritise funding research on maglev, including control systems, guideway monitoring and typhoon resilience. Universities should offer training modules in maglev technology.

The following research priorities are recognised by researchers:

(d) Quantitative economic modelling -- Develop detailed cost-benefit models for maglev deployment on specific Hong Kong corridors, covering construction costs, operating costs, travel time savings, environmental benefits, and broader economic impacts.

(e) Typhoon resilience assessment -- Physically and numerically model maglev system performance in typhoon conditions, including wind loading, debris impact and saltwater exposure.

(f) Design optimisation of transfer station -- Study best practices for design of maglev-conventional rail interchange to reduce transfer time and improve passenger convenience.

(g) Life-cycle assessment comparison -- Conduct a rigorous life-cycle assessment comparing maglev and conventional rail systems across environmental, economic, and social dimensions.

8.3 Conclusion

The MTR has been a good servant to Hong Kong for almost half a century. The constraints that made sense in the 1970s and 1980s, deep tunnels, heavy trains, conventional steel-wheel technology, are not necessarily optimal for the

2030s and beyond. As Hong Kong grows and evolves, so must its rail network.

Maglev technology is a real alternative in certain corridors where traditional rail has reached its limits. It is not a substitute for the present MTR network, but a complementary tool for solving problems that conventional tools cannot solve. In the case of Hong Kong, the question is not whether maglev is better than conventional rail, but whether, situations, the unique characteristics of maglev can provide solutions that would not be possible otherwise.

The answer to that question, based on the evidence reviewed in this article, is increasingly yes. With strategic planning, careful implementation and continued research support, Hong Kong can be a showcase for the deployment of urban maglev, demonstrating to the world how a mature, dense and demanding city can integrate advanced rail technology to serve its citizens and enhance its regional position.

There is a ‘urgent need for new rail transportation technologies in Hong Kong, especially in the Northern Metropolis’. It is time to start meeting those needs.

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