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MAGNETIC LEVITATION SYSTEM

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March 2004

Project report submitted in partial fulfillment
Of the requirements for the
Diploma in Mechanical Engineering

Abstract

The Magnetic levitation System, called *Maglev*, is designed as an alternative to all conventional guided transportation systems. Advantages include major reductions in travel time, operating cost, capital cost, noise, and energy consumption. Van or small-bus size vehicles operating automatically with headways of only a few seconds can be operated in platoons to achieve capacities of more than 12,000 passengers per hour per direction. Small vehicles lead to lighter guide ways, shorter wait time for passengers, lower power requirements for wayside inverters, more effective regenerative braking and reduced station size. The result of the design is a system that can be built for about $20M per mile, including vehicles but excluding land acquisition.

The design objectives were achieved by taking advantage of existing technology including improved microprocessor-based power electronics, high-energy permanent magnets, precise position sensing, lightweight vehicles, a guide way matched to the vehicles and the ability to use sophisticated computer aided design tools for analysis, simulation and optimization. The vehicles have arrays of permanent magnets to provide suspension and guidance forces as well as provides the field for the Linear Synchronous Motor (LSM) propulsion system. Feedback-controlled currents in control coils wound around the magnets stabilize the suspension. The LSM windings are integrated with the suspension rails and excited by inverters located along the guide way.

This report focuses on urban applications with baseline vehicles designed to carry 24 passengers seated with room for 12 standees at times of peak load. The LSM is designed to provide speeds up to 45 m/s (101mph) and acceleration and braking up to 2 m/s^2 (4.5 mph/s) without onboard propulsion equipment. Installation and operating cost are predicted to be lower than for any competing system and average travel times are reduced by more than a factor of 2. Environmental advantages include a factor of 2 reduction in energy consumption, smaller guide way cross-section with reduced visual impact, and greatly reduced noise. For some applications it is desirable to use smaller vehicles with lower top speeds or larger vehicles with higher top speeds. Both of these options are possible with the same guide way and suspension system. The only changes necessary are in the size of the power system used for propulsion. A 12 passenger vehicle with a top speed of 30 m/s (67 mph) is discussed in this report as an option when the application requires shorter trips with lower capacity and the reduced cost is an important advantage. An articulated vehicle with 36 seats is a possible option for speeds up to at least 60 m/s (134 mph).

March 2004

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ACKNOWLEDGEMENTS

In the name of Allah, the most gracious, the most merciful.

All praise to Allah, the almighty and salawat and salam to the prophet Muhammad S.A.W, his families and companions R.A. Alhamdulillah, by the will of Allah, we are able to complete this project report.

This project report was made possible by the contributions and assistances rendered to us by lecturers and our companions. We would like to take this opportunity to thank most of all, our supervisor for this project Mr. Rosley bin Jaafar. Without his advises and comments, this project might never been completed. Also we would like to thank our Head of Programme, En. Rozalee bin Abu Hassan.

Last but not least, we wish to extend our profound gratitude to everyone whose involves in the process of realizing this project report.

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MAGLEV SCENARIO

In the last 35 years maglev has changed from an engineering curiosity to the basis for commercial systems now being built in the U.S., China and Japan. German and Japanese efforts over many years have demonstrated maglev's potential for safe, fast and economically viable transportation but potential users have not been impressed enough to install a major commercial system until very recently. The lack of commercial support has been partly due to emphatic statements by critics from academia, industry and the government that maglev is too expensive in comparison with other types of guided transportation. Unfortunately, maglev enthusiasts have not helped the cause by often focusing more on the technology than on what it can deliver to the user.

A principal problem with past maglev efforts has been an excessive emphasis on speed and technology without taking a system approach to solving a transportation problem. With this in mind, our report has stressed the system approach and examined all aspects of the problem of providing high quality and cost effective transportation with maglev by taking advantage of recent advancements in enabling technologies. For their applications we believes a key market for maglev today is in the low and middle speed region now dominated by light rail, rapid transit, commuter rail and all versions of Automated People Movers (APM).

A fundamental property of magnetic structures, called *Earnshaw's Theorem*, is that no static configuration of magnets can be levitated so as to be stable in all degrees of freedom. It is possible to be stable in all but one dimension, so it is possible to have a magnetic suspension stable in the vertical direction but then it must be unstable in a lateral direction. Such structures have been proposed but they tend to be heavier and more complex than if electronic control is used to stabilize the suspension in the vertical direction. The vertical stabilization approach to ElectroMagnetic Suspension (EMS) design has now been proven to be suitable for operation over a wide range of speeds. For example, the new Shanghai Transrapid maglev installation uses this approach and has been carrying passengers at speeds up to 430 km/h (267 mph), 43% faster than the fastest high-speed trains in operation today.

This report gives a description of maglev as it exists at this time. Although the design is expected to evolve over the next few years it is unlikely to change in any major way. We believe this report can be used to assess the potential merits of maglev for specific applications.