Basic Comparative Study on Magnetically Levitated Highways and Magnetically Levitated Railways Focused on Space Performance

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Abstract

The authors have conducted research on magnetically levitated highways (roads) where automobiles are loaded on pallets and magnetically levitated to travel at high speed. A magnetically levitated highway is personal transportation consisting of a system that loads individual automobiles on separate magnetically levitated pallets. This research is a comparative study of basic aspects of magnetically levitated roads and magnetically levitated railways in the medium high speed range of 200km/h focusing on their space performance in the passenger flow in order to achieve the above goal.

1 Maglev Development

1.1 Outline

Systems of every kind are the product of historical development. Maglev appeared as a way to break through the speed limit on railway trains running on steel wheels, and the focus of discussions of Maglev has been its ability to apply its high-speed performance to compete with airlines that are another form of high volume transportation.

But the core technologies of a Maglev system are its magnetic levitation technology and linear motor. Its magnetic technology and propulsion technology can be used not only for mass transportation systems, but through the use of pallets, for personal transportation systems.

To take automobile tires as a historical example, they were not developed as part of automobile development from first starting. Rather, Dunlop developed them for use on bicycles, and they were used on automobiles later.

If such a process is based on its historical record, if the advanced technologies of subsystems are good and applicable, they will transcend the barriers between transport modes. Consequently, if present challenges facing automobile transport can be overcome, neither of the sub-technologies, magnetic levitation and linear, will be limited to railway use.

And if a form such as this is used, it will be possible to clarify their role on roads in order to contribute to ordinary automobile transport.

1.2 Change of purposes

Applying Maglev to automobiles transforms its basic purpose. Because applying it to automobile transportation means that they must be carried with ordinary window shields unless they are inside capsules, the initial target speed will probably be about 200km/h. In this sense, achieving high speed is the first goal, but because it will not be necessary to drive automobiles, they will normally be driven automatically, creating the new benefits of an automated expressway. And because this can radically resolve the problems of sound and vibration, these are also principal goals of the introduction of Maglev.

In brief, railway mode Maglev was developed mainly to achieve super high speed equal to that of aircraft. But although automobile mode Maglev will, of course, be developed to provide speed, its purposes will be changed to apply to many other challenges now facing automobile transport: simplifying driving, reducing noise and vibration, lowering environmental load, and preventing accidents. Consequently, when considering a project, it is extremely important to evaluate cost-performance in line with its purposes.

2 Considering the form of magnetically levitated highway

2.1 Reasons for comparison

A magnetic levitation technology has been applied mainly to railways as a result of the way it has been developed, its application to road transportation is a new frontier. However, considering the fact that automobile transportation is the leading form of modern transportation, it is expected that Maglev technology will eventually be applied to automobile transportation.

The application of Maglev to automobile transportation is broadly categorized into two forms. One approach is to build the Maglev and linear motor units into automobiles and drive them on special Maglev lanes. The other is to manufacture separate Maglev and linear motor units instead of altering automobiles to separate them so they can only be operated on designated lanes. The benefit of the former approach is that automobiles could be driven directly onto a designated Maglev lane without modification, but because only designated automobiles could use the system, introducing such a system would be very difficult because its success would depend on how many people would buy these automobiles that would unavoidably be extremely expensive. Because leaving motor vehicles unmodified and separately providing Maglev units and linear motors would require no modification of automobiles as in the former method, present automobiles could use the system. Therefore, the latter is the only realistic method.

Considering legal issues, although the situation differs between countries, in Japan, such a method is a moving road that comes under the Road Law. A moving road for pedestrians is technologically a horizontal elevator, but if it is classified based on categories, it is a moving walkway that is, as a public system, classified as a sidewalk. Similarly, it will be called a moving road for use by motor vehicles.

2.2 Two types of moving road

This latter approach can be further categorized basically as pallet and capsule methods. A characteristic of the pallet method is that thin pallets can be manufactured so that the mode change step—loading and unloading an automobile—can be done without raising it very high, lowering costs. But because it cannot provide automobiles with protection from aerodynamic force, its speed limit would be approximately 200km/h. [1]

A capsule type can withstand very high speeds and can be equipped with vacuum tubes if the capsule is strengthened, permitting its use at speed comparable to that of aircraft. But providing capsules that occupy far more space than a pallet would greatly increase costs. And in the super high speed range, the distances between stations would naturally be correspondingly long, lowering its significance as a form of personal transportation. Considering these facts, it is clear that developing a capsule form of personal transportation is an unrealistic project. The best approach is, therefore, pallets that occupy little space during mode changes in order to preserve the personal transportation aspect of automobile transportation.

3 Comparison of a maglev highway with a maglev railway

In a railway case, the primary goal of Maglev is to achieve super high speed unobtainable on steel wheels, but considering the above, adequate speed on a magnetically levitated road is about 200km/h. A comparison with a super high speed magnetically levitated railway running at between 400km/h and 500km/h is not very significant, because the systems are too different and their target speeds also differ. Therefore, a conventional railway, automobile transportation, and a magnetically levitated railway designed to run at about 200km/h are compared.

3.1 Fundamentals

Before the comparison is explained, the basic items are described.
Before comparing objects, it is important to decide what kinds of items will be compared. In the case of transportation systems, the important considerations when planning a project are its performance as a system and the required cost. Not matter how well a system performs, if its cost is extremely high, a system development project is unfeasible. Performance can be broadly categorized as transportation performance, structural performance, and space performance. Costs include construction cost, operating cost, and maintenance cost. These are not completely independent, rather they are linked in organically close relationships. Generally, good design creates good cost-performance. But no matter how good the cost-performance obtained by good design, if the public does want the system, a project to create it cannot be undertaken. In a case where a concept for a product has already been accepted by the public, and the product is developed by applying technology to refine the concept to create an even higher quality product, the public's needs are already apparent. Therefore, the technology may be developed in line with the public's requirements. But because if a concept has not been fully accepted by the public, the public's needs have not become apparent, its requirements are vague and it is difficult to develop technology that will satisfy them. For this reason, if technology development simply to achieve technological potential is carried out, but the public does not consider it very attractive and does not want the completed technology, it will be difficult to undertake a project to create it. Considering this fact, the best approach is to clarify the public's future needs, establish the broad outline of the process from the research and development to the project stage, organize the framework of the basic concept and the framework of the project, and when the prototype has been completed without any error in critical key elements, it will be a project that will respond to latent needs and be welcomed by future generations. This report selected spatial performance for special study from among traffic performance, structural performance, and spatial performance.

3.2 Spatial Performance

Space performance refers to how effectively space is utilized. This is a concept that has rarely been debated in relation to a transportation system. But considering the future population explosion and the rapid advance of motorization, and worldwide acceleration of the concentration of populations in giant cities, it will be necessary to utilize space even more effectively than now. It will be an era when systems must be compact. If the system is not compact, it will naturally occupy a lot of space, and in the centers of cities in particular where space is limited, the cost will soar, effecting the entire project. And if the spatial performance is poor on regional roads between cities that are far from city centers, the size of structures will also be effected. This means that as the weight increases, it will be impact the load, and this in turn will increase wind load and seismic load. So in this case, it will be extremely important to conduct studies to clarify how to design compact systems.

3.2.1 Basic considerations

The following is a consideration of magnetically levitated roads focused on space performance. First, a comparison of basic section drawings shows that a magnetically levitated road will be extremely compact because it will handle only passenger cars. The section of a railway or a magnetically levitated railway is much larger. The basic reason for this difference is that a magnetically levitated road will be designed so that people sit in ordinary passenger cars. This means that because people will board a magnetically levitated road system seated in their automobiles, people will not walk into coaches as they do when riding a train. But because basically people walk into railway cars, more space is necessary. And railway cars must have corridor or aisle space, because if they do not, people will be unable to move around inside them. The next step is a study of their side sections. With an aerodynamic resistance coefficient of approximately 0.3～0.4, passenger cars basically feature an extremely good aerodynamic resistance design that suits them for use on a magnetically levitated road. In the case of a railway on the other hand, when cars are linked to form a train, only the lead car is shaped to reduce aerodynamic resistance, so individual cars are only constructed to reduce aerodynamic force when linked to form a train. Figure 1 compares the volume of interior space per person of an ordinary passenger car, the volume of interior space per person of a high-peed railway[2] (In this case a Japanese Shinkansen train (bullet train), and its value is estimated by the diagrams).

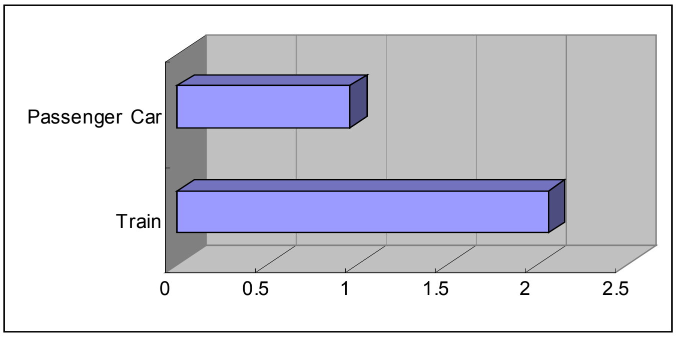

Figure 1. Comparison of the Volume of Interior Space Per Person （m^3）

3.2.2 Management considerations

Next, space performance is considered from the perspective of tracks or guide way control. The major parts of a magnetically levitated road system that are controlled are the guide way, mode interchanges, and the pallets. An automobile that is a vehicle with a superior aerodynamic resistance coefficient of 0.3 is controlled by the user so it is not a burden on the road manager. But on a magnetically levitated railway, not only the tracks, but the railway cars must also be controlled. This places a burden on the implementation of a magnetically levitated railway project.

3.2.3 Considering energy and other effects

Railway cars are much heavier than passenger cars. This is because trains were developed from steam powered vehicles, so that the vehicles were originally heavy, and if they were too light, there was a danger that the effects of the wind would derail them because they were tall. Therefore, to maintain their safety, they had be quite heavy. But because Maglev trains are mechanically protected from derailment by their guide ways, there is no danger of this happening. Therefore they can be designed structurally slender because there is no danger that reducing their weight will effect their structures.
And if pallets are used, it will be possible for the added weight to be far lower than it would be using capsules, and this will also reduce the quantity of energy consumed to accelerate and decelerate.
Considering the spatial aspects in this way reveals that it is an extremely important matter with repercussions on its transport performance and structural performance.

4 Conclusions

This report focused on space performance that has hitherto not been discussed in the transportation field to comparatively study magnetically levitated roads and magnetically levitated railroads by clarifying basic differences between them. The results have revealed the following facts.

[1] Focusing on space performance, on a magnetically levitated road, pallets that need to provide only storage space for one vehicle are more realistic because they are far less expensive than a system in which capsules enclose automobiles.

[2] If capsules were introduced, the system would have to operate at super high speed in order to take advantage of its benefits, but this would require long distance transport between fixed points. This would reduce the benefits of personal transport by users of separate vehicles.

[3] Because riders in passenger cars will not stand up to get on and off a magnetically levitated road, these systems will occupy extremely compact spaces, and this is also benefits their aerodynamic resistance.

[4] A comparison of the volume of interior space per person shows that on a magnetically levitated road it is approximately 1 m^3, that is much more compact than on a high speed railway or on various kinds of magnetically levitated railways. It can maintain the comfort of users because while it is compact, it is also personal space.

[5] Generally, transporting automobiles on pallets might seem to be very wasteful at first consideration, but because the guide way is compact and it is not necessary to control the vehicles, it is a system that will be easier to introduce.

[6] The evaluation of spatial performance is an important matter with repercussions on its transport performance and structural performance.

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Reference:

1. Motoyuki Minakami, Mike McDonald: *'Basic Developmental Scenario for the Maglev Highway – Maglev Highway as Future of Transport'*, Malgev 2002. September, Swiss,2002

2. Sato Yoshihiko *: High Speed Train in the World* ,Grampri Shuppan. Japan, 1998