Maglev-Cobra: An Urban Transportation Solution Using HTS-Superconductors and Permanent Magnets

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ABSTRACT: The Maglev-Cobra technology uses HTS-superconductors for levitation and guidance purposes. This paper describes the construction and operational advantages of this vehicle applied to urban transportation. The technology was tested with a small-scale prototype. Three steps for a full scale implementation will also be described.

1 INTRODUCTION

The need of efficient public transportation, non polluting and with competitive construction costs, is one of the priorities of the modern world, where great part of the population live in big cities.

The Maglev-Cobra technology proposes a magnetic levitated vehicle with multiple short units, allowing curves of 30 meters radius, ramps of 15% and velocities up to 70km/h. When these short units are connected, the vehicle resembles a 'snake' or 'cobra' in Portuguese.

The levitation technology is based on the flux pinning property of High Temperature Superconductor (HTS) blocks of Y-Ba-Cu-O and the magnetic field of Nd-Fe-B magnets. These materials were made available at the end of last century and until today there is no such system in full-scale or commercial use. Therefore, perspectives of innovation, originality and technical development can be foreseen.

A linear motor gives the traction. Since this propulsion method only needs electric energy, which is mainly generated by hydro power plants in Brazil, the Maglev-Cobra has low polluting effect.

Since the noise level in low, the vehicle can run inside cities on elevated structures. The estimated construction costs are 1/3 of that necessary for subways.

Moreover, the energy consumption and the maintenance costs are lower than that of a LRV (Light Rail Vehicle) since no mechanical contacts and rotational parts are necessary.

The proposed vehicle gives a futuristic view along its way, matching high technology, modern design, environmental restrictions and social requirements.

In this paper, the proposal advantages and the steps for its implementation will be described.

2 TECHNOLOGICAL ADVANTAGES

The advantages of a levitating vehicle for urban transportation embrace construction and operational aspects as will be highlighted in the following.

2.1 Construction Advantages

a) Distributed load: On traditional vehicles, the load is concentrated at the point of contact between wheel and rail. On the other side, for Maglev vehicles, the load is distributed. The efforts on the supporting structure are therefore reduced, as shown in Figure 1, implying a lighter and cheaper infra-structure.

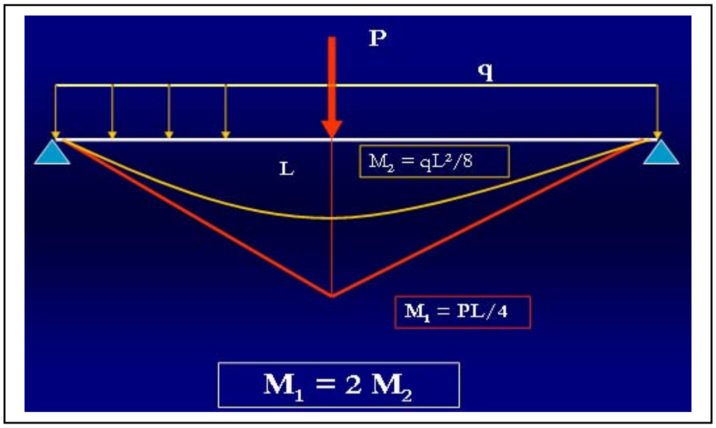


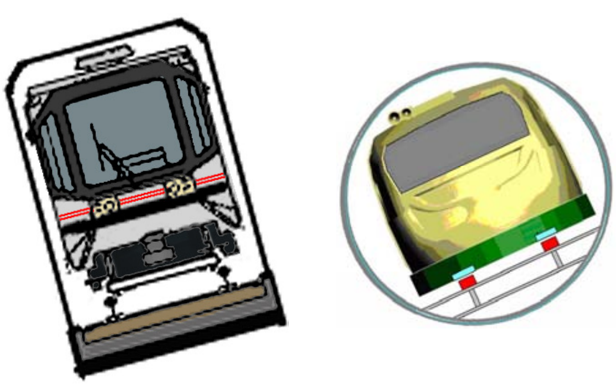
Figure 1. Moments for distributed and concentrated load.

b) Reduced weight: As the Maglev-Cobra vehicle do not need wheels, trucks and rotational motors, its weight is half the weight of a Light Rail Vehicle (LVR). Table 1 gives this estimation. Moreover, the iron rails, sleepers and stones necessary to the infra-structure of a LVR are heavier than the magnetic rail of the Maglev-Cobra system.

Table 1. LRV x Maglev-Cobra

Especification	Unit	VLT	Maglev
Width	m	2,70	2,70
Height	m	3,80	2,70
Length	m	25,50	25,50
Mass of empty car	kg	37.000	10.200
Seated passengers	number	59	59
Total n. of passengers	number	254	254
Total mass	kg	54.780	27.980

c) Reduced cross section: Again the absence of wheels, trucks and rotational motors make the cross section of the Maglev-Cobra half the usual one and, moreover, practically circular (Figure 2). These characteristics represent a big advantage for the construction of tunnels.



(a) (b)

Figure 2. Cross section of LVR (a) and Maglev-Cobra (b).

d) Reduced radius: The Maglev-Cobra will be constructed with modules of just one meter length. Therefore, curves with 30m radius are acceptable, as Figure 3 illustrates.

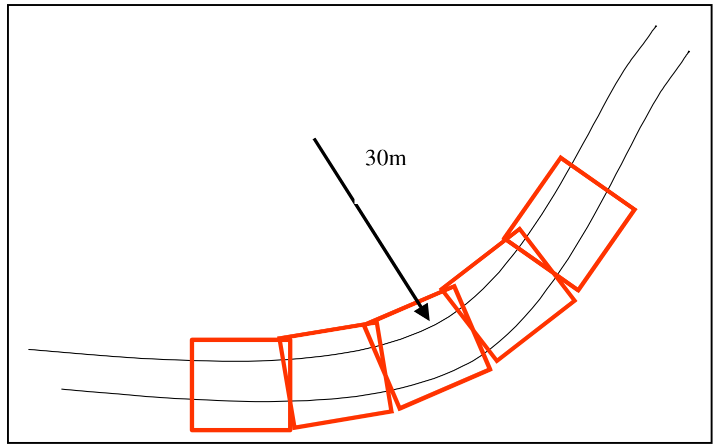


Figure 3. Curves with small radius.

e) Higher declivity: When based on friction, the maximal declivity of a track is 4%. The linear motor traction of Maglev vehicles allows declivities of 15%, just limited by the comfort of passengers.

2.2 *Operational Advantages*

a) Reduced energy consumption: The energy to levitate the Maglev-Cobra vehicle is just that necessary to refrigerate the YBCO superconductors with liquid Nitrogen. These superconductors are arranged inside cryostats and, therefore, the consumption is extremely low, representing an advantage when compared with the electromagnetic (EML) or electrodynamic (EDL) levitation methods. For the traction, as the resistance is limited to the air friction (there is no drag force or Coulomb friction) and the velocity is low (<70km/h), the mean consumption of energy is approximately 2.7Wh/pkm. This is half the energy required by a LVR and many times lower in comparison with buses and cars.

b) Reduced CO_2 emission: As the Maglev-Cobra needs less energy and is supplied with electric energy, that in countries like Brazil comes mainly from renewable sources, the CO_2 emission is extremely low (approximately 10% of that produced by a car to transport the same number of passengers).

c) Reduced noise: Without friction and running at low speeds, the noise produced is negligible and the vehicle do not disturb the city life, being appropriate to run on elevated lines or along rivers or channels at ground level.

c) Easy of switch: As reported in [1], the change of direction can be achieved with electromagnets, substituting the traditional slow mechanical solution.

d) Easier maintenance: The linear motor used for the traction do not have moving parts, making the maintenance easier than that of cylindrical motors with bearings and mechanical wear. The magnetic rail can be protected, as shown in Figure 4, also requiring less maintenance than the usual rail system with dormant and alignment procedures.

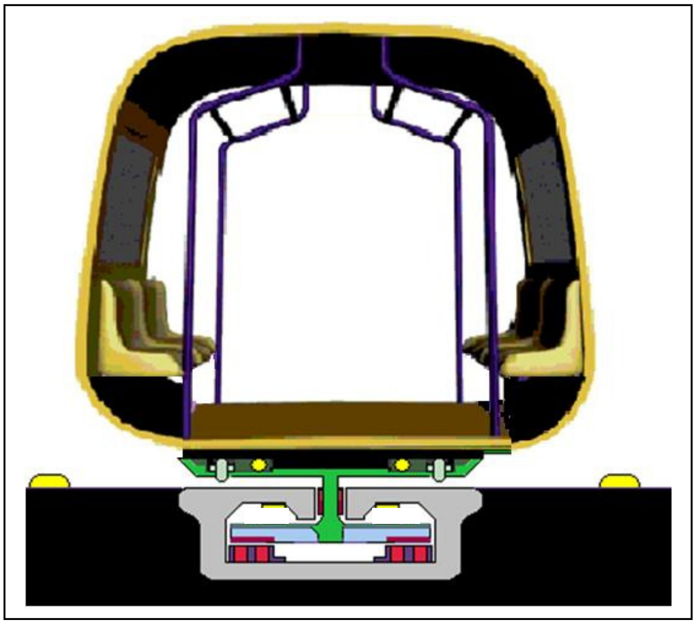


Figure 4. Rail protection.

3 IMPLEMENTATION STEPS

Following the construction of the first full scale module, reported elsewhere in this conference [2], three implementation steps are planned.

3.1 Step 1 (2009-2010)

A line of 114m, with two curves of 30m radius and a ramp of 15%, as shown in Figure 5, to verify the technical characteristics of the system. The line will be constructed inside de university campus. The vehicle will be a full scale one consisting of 4 modules, each 1m long (Figure 6).

The Brazilian industry was called to take part of this innovation and industries like WEG (electric motors), EMBRAER (vehicular technology) and NUCLEP (mechanical construction), beside the research centers CEPEL and IFW, and the universities UFRJ (Federal University Rio de Janeiro) and USP (University of São Paulo) agreed to participate with the additional support of 3M US$ from BNDES (Brazilian Bank for Economic and Social Development). The final decision of the bank will be known by the end of this year.

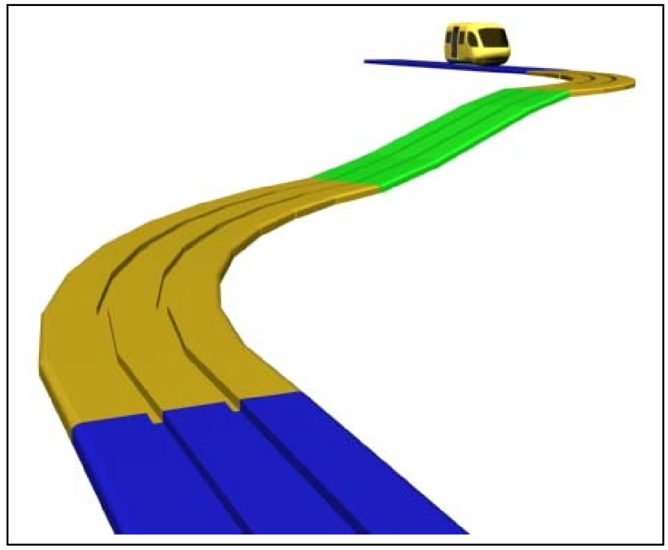


Figure 5. Line of 114m in perspective.

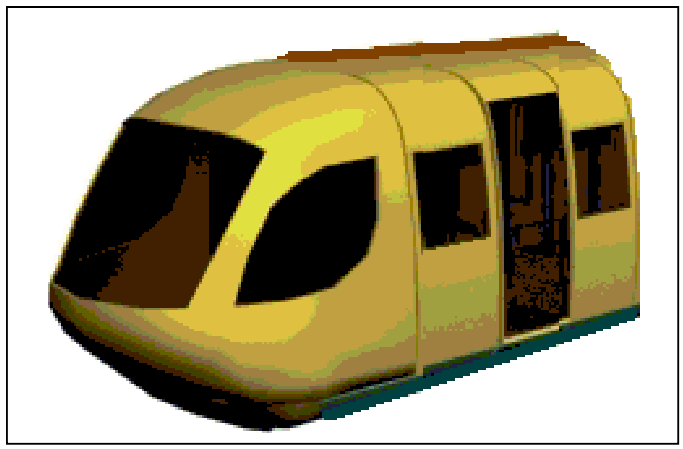


Figure 6. Four modules of the Maglev-Cobra Vehicle.

3.2 Step 2 (2011-2012)

Based on the experience of step 1, the next move will test the operation of the vehicle in every day use. For that, a line of 3km connecting centers and units of the Federal University of Rio de Janeiro has been planned as shown in Figure 7. The funds necessary for this construction will be raised by PPP (Public Private Partnerships). The present bus service will be substituted by this environmental friendly system giving the opportunity to students, professors and clerks prove the new transportation. This project was already foreseen in 2006 [3].

Figure 7. Line of 3 km..

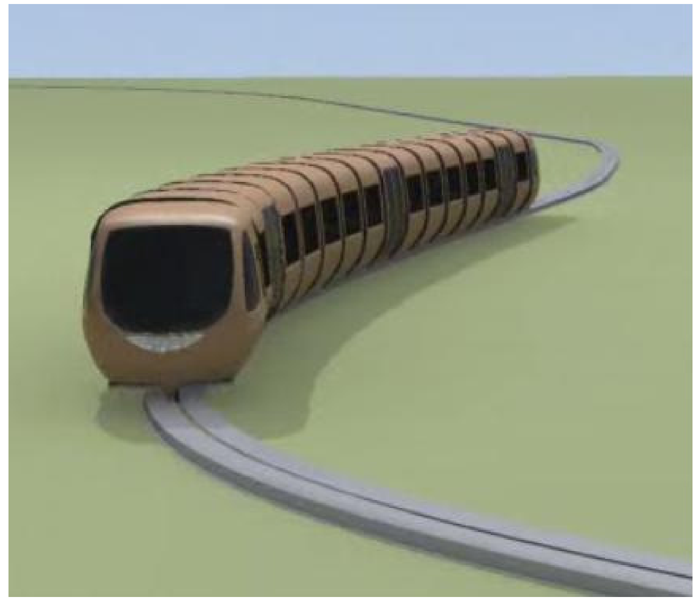


Figure 8. Artistic drawing of the Maglev-Cobra.

3.3 Step 3 (2013-2015)

After the improvements that will result from the experience of step 2, this line will be extended to the north and to the south, connecting the two main airports of the city of Rio de Janeiro, two bus stations, the ferryboat station and a subway line. This sums 25km that will change the face of a 10 million people city and open the door for the technology Maglev-Cobra solve the urban transportation problem of big cities.

An artistic drawing of the Maglev-Cobra vehicle crawling silently along a green field is finally shown in Figure 8.

4 CONCLUSIONS

This paper showed that the Maglev-Cobra technology for urban transportation is:

-Ecologically correct, due to the lower noise and lower energy consumption.

-Economically correct, because of the lower implementation and maintenance costs.

-Technically correct, since the levitation method for low speed applications is better than EDL or EML.

-Socially correct, because solves the urban transportation system of large cities.

Therefore, the efforts and costs to implement this technology are justified.

5 REFERENCES

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ACKNOWLEDGMENT

To CNPq, CAPES, FAPERJ and DAAD for the financial support.