ABSTRACT: This paper discusses the status of the Maglev-Cobra project for urban transportation. The project was previously discussed at the Maglev 2008 conference in San Diego, USA. Since that time, the levitation rail using permanent magnets has been optimized and built. The cryostats with HTS superconductors tested and a special linear induction motor designed and constructed. Initial tests supplying the linear motor with a power electronic inverter have been carried out. The vehicle design and a first module (wagon) constructed. The next steps moving towards a demonstration system will be discussed.

1 INTRODUCTION

The development of any engineering equipment can be broadly subdivided in four steps: small scale prototype (proof of concept); functional prototype (proof of technical viability); operational prototype (proof of daily operation) and industrialization. Each step represents a big challenge and requires engineering skills to be successfully accomplished.

The MagLev-Cobra technology proposes a magnetically levitated vehicle with multiple short units, allowing curves of small radius, ramps of 10% and velocities up to 70km/h. When these short units are connected, the vehicle resembles a ‘snake’ or ‘cobra’ in Portuguese. Since the noise level is low, the vehicle can run inside cities on elevated structures. The estimated construction costs are 1/3 of that necessary for subways. 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 industrialized or in commercial use. This levitation method is called Superconducting Magnetic Levitation (SML) and the technology is being also studied in China (Wang et al 2003) and Germany (Schultz et al 2005).

The MagLev-Cobra vehicle was originally conceived in 2000 (Nicolsky et al 2000) and a small scale prototype concluded in 2006 (Nicolsky et al 2000; Stephan et al 2004). The initial efforts for the construction of a full scale functional prototype were reported in 2008 (Stephan et al 2008a,b). The present paper describes the first tests with this prototype and gives some construction details. The rail of permanent magnets was optimized based on the simulation studies with a finite element software to give the required levitation force for a given configuration of superconductors (Motta et al 2008). The linear motor geometry contributes to the levitation force (Chabu, 2011). The wagon allows the silent transportation of five passengers per square meter comfortably.

2 TECHNOLOGY DEVELOPMENT

The development of new engineering products can be generally divided in four steps:
2.1 **Step 1: Proof of concept**

Usually a small scale prototype consolidates this step. Universities are probably the best place for this initial development.

2.2 **Step 2: Functional prototype**

Here a full scale prototype must be constructed and many engineering problems are already faced: the product design, the construction methods, the industrial partners, the financial support. This phase is prone of possibilities for patent applications.

2.3 **Step 3: Operational prototype**

The full scale prototype is not enough to prove the feasibility. The operational characteristics must be known and well tested. In other words, the equipment must be certified. In the specific case of a transportation vehicle, safety issues are a main concern: what happens if there is a brake failure, if there is a short circuit, if there is a storm, if the door does not close or open, if there are too many passengers, and many other questions must be answered.

**Step 4: Industrialization**

Finally, the series production and commercialization can start. This last step represents a big challenge and by no means a trivial one. In fact, the man force, the money, the difficulties, everything increases at each step.

These steps for the MagLev-Cobra technology are summarized in Figure 1.

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**Figure 1** The four phases of the MagLev-Cobra project.

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3 **THE MUCK-UP**

The muck-up is shown in Figures 2 and 3. The exterior presents a modern and aerodynamic view. The interior was planned for short distance travels. Passengers do not need really to sit and just a backrest is available. The inside design can be adjusted for other situations. Each module has a length of just 1.5 meters and a width of 2.4 meters, carrying comfortably 15 passengers.

Based on this muck-up, a full scale vehicle will be constructed with light fiber materials.
RELATIVE ADVANTAGE OF SML

The power required to levitate a vehicle based on electro magnetic attractive forces (ELM) is approximately 1.7 kW/t. As illustrated in Table 1, obtained from the data available in Table 5.36 of Schach et al (2006), at high speeds, for a 294 ton vehicle, this levitation power is comparatively small in relation to the power required for traction, pointing to long-distance calls, when high speed plays a leading hole. In the case SML, the power required for levitation is practically zero, however, the line of permanent magnets, necessary to promote the diamagnetic effect, is more expensive than the infrastructure of the option ELM. In urban transport predominates short distances between stations and low speeds, opening up here the niche for SML applications. As a result, the propose MagLev-Cobra for urban transportation of UFRJ is based on the technology SML. For high speed, the EDL and ELM methods are the most appropriate.

Table 1. Power consumption in the EML technology.

<table>
<thead>
<tr>
<th>Velocity</th>
<th>Traction</th>
<th>Levitation</th>
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<tbody>
<tr>
<td>70 km/h</td>
<td>90 kW</td>
<td>500 kW</td>
</tr>
<tr>
<td>450 km/h</td>
<td>10.000 kW</td>
<td>500 kW</td>
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</table>

5 NEXT STEP

The next step will be the connection of two blocks of the Center of Technology inside the university campus (CT1-CT2), as shown in Figure 4. They are just 200 meters apart but this short line will allow the daily operation and test of the proposed technology.

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Part of the equipment and material necessary is already available. Figure 5 shows a linear motor unit and its supply inverter on a test rig. Cryostats, superconductors and magnets are manufactured. The first full scale wagon can be seen in Figure 6. But funds for civil engineering infrastructure, certification, electrical equipment and control must still be raised. By 2013, at the time of the 22nd International Conference on Magnetically Levitated Systems and Linear Drives, this operational prototype will be probably opened for visits. The daily operation, transporting students, clerks and professors will give the necessary experience before the industrialization and wide spread application of the technology.
6 CONCLUSIONS

The magnetic levitation (MagLev) methods have implementation and operational advantages, justifying the prognosis of great expansion in the 21st century. Particularly, the MagLev-Cobra project of UFRJ represents a proposal:
- 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, this project fulfills all requirements of sustainability.

7 REFERENCES

Chabu, I., “Motor Linear Aplicado a Veículos de Transporte por Levitação Magnética”, Submitted Patent, INPI, Brazil.

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