General Atomics Urban Maglev Test Track Status

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Abstract This paper discusses the status of the construction and testing on the General Atomics Urban Maglev test track located in San Diego, California. The status of the project was previously discussed at the LDIA 2003 conference in Birmingham, England. The test track is full-scale, 120 meters in length, with a 50-meter radius curve. The test vehicle consists of a single 5-meter chassis unit (a complete vehicle is comprised of two 5-meter chassis units). The levitation system is of the electrodynamic type, consisting of permanent magnets arranged in a Halbach Array configuration. Propulsion is achieved by the use of a permanent magnet linear synchronous motor. Initial dynamic testing of the chassis was performed at speeds up to 7 m/s at the end of 2004. This paper discusses the test track construction, summary of testing performed, and next steps in the program.

Keywords : Maglev, Permanent Magnet, Halbach Array

1. INTRODUCTION

The Urban Maglev program is administered by the Federal Transit Administration (FTA). The Urban Maglev team led by General Atomics has developed an Urban Maglev system using a passive, permanent magnet levitation system with a linear synchronous motor (LSM) powering the guideway to provide propulsion and guidance. Among the advantages of the approach is the simplicity provided by the passive levitation and propulsion systems on the vehicle. The system has been designed for driverless operation with a throughput of 12,000 passengers per hour per direction, with two minute headway between vehicles. It is envisioned to be elevated, and when combined with the enabling features of maglev technology (quiet operation, and steep grade capability) results in a system which provides urban planners great flexibility, with corresponding savings in capital and maintenance costs. Depending on the alignment, the elimination of tunneling itself can result in substantial system cost savings.

Figure 1. The General Atomics Urban Maglev System

Levitation is achieved by using un-powered arrays of permanent magnets beneath the vehicle. When the train is in motion, the magnetic field from these permanent magnets generates “eddy currents” to flow in the electrically conducting track. These induced currents are in a direction, which interact with the applied magnetic field of the permanent magnets, to produce forces, which levitate the vehicle. The track is made up of conductors assembled in an array that resembles a ladder with close-packed rungs. Many of the details of the technology development were published in previous conferences, including the LDIA 2003 conference [1-8].

2. TEST TRACK CONSTRUCTION

In November 2002 we initiated the construction of a maglev test track at the General Atomics Electromagnetics Systems facility in San Diego, California. The test track has a total length of 120 meters, with 50-meter radius curve to demonstrate the guidance system. It is built at-grade, and consists of a loading ramp for the vehicle, a small test chassis access pit, electrical room, and control room. In March 2003, GA broke ground at its San Diego facility on the full-scale test track, which features both straight and curved (50-meter radius) sections. In June 2003, a test vehicle consisting of a single, full-scale chassis unit (a mass transit vehicle has two chassis units) was completed The vehicle chassis is composed of upper and lower Halbach arrays, additional Halbach magnet arrays for the propulsion system, auxiliary wheels, and secondary suspension components. The test vehicle chassis is equipped with water tanks for varying the weight during the test. Initial testing of the propulsion systems were conducted on the first 15 meters of the test track. The entire 120-meter track was completed in September 2004. Figure 2 shows the installation of one of the 15-meter long guideway modules, which contains the linear synchronous motor, and the levitation track on the concrete foundation. Figure 3 shows the completed test track and the GA Urban maglev team, September 2004. Views of the enclosed control room and electrical room adjacent to the track are seen in Figure 4. Figure 5 shows the rectifier and the IGBT-based inverter in the electrical room. The inverter was built by General Atomics, and provides variable frequency 3-phase voltage to the LSM, being used for vehicle propulsion.

Figure 2. Installation of a 15-meter guideway module.

Figure 3. Completed test track and team.

Figure 4. Test track control and electrical rooms.

Figure 5. Electrical room interior view.

The completed chassis unit on the test track, is seen in Figure 6.

The test chassis has many unique features, specifically focused at being able to vary magnet configurations and gaps, and making changes in the secondary suspension spring constant and damping rates. Variable level water tanks can be mounted on the chassis to simulate the correct center of gravity corresponding to a passenger-carrying vehicle, and the associated shifts in passenger loading.

Figure 6. Completed chassis on the test track.

The levitation, propulsion, and guidance systems are seen in the end-view of the vehicle and guideway module in Figure 7. The linear synchronous motor (LSM) windings are three-phase and interact with the field generated by the permanent magnet propulsion magnets on the vehicle, with a peak force capability of ~50 kN for a complete vehicle system (~25 kN for the test chassis, which represents ½ length of a full vehicle). The propulsion magnets also provide guidance by interacting with the LSM iron lamination rails.

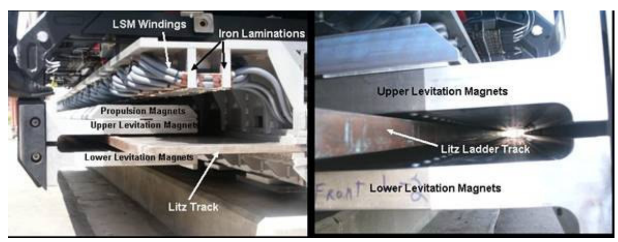

Figure 7. End view of chassis showing levitation and propulsion components.

3. INITIAL TESTING

Initial testing of the levitation, propulsion and control systems was conducted at the end of 2004. Most of this testing focused on the check-out of the power electronic, data acquisition, and control systems. We achieved the first levitated run in October 2004. Measured gaps are in the 30-35 mm range, for chassis weights of about 8,000 kg (a complete vehicle consists of two chassis sections). Take-off speeds, depending on weight, occur at about 5 m/s. To-date, we have tested up to a maximum speed of 7 m/s. The maximum speed, due to the short length of the track, is limited to 10 m/s. Current activities on the test track involve optimization of the motor control system, and all supporting equipment including the vehicle location encoder. Additional discussion of these initial tests is presented in another paper at this conference [9]. Further extensive testing during 2005 will test the capabilities of the system up to a speed of 10 meters/second, and will validate the ride quality, detailed take-off and landing characteristics, control system and automatic train protection system operation, as well as projected system efficiencies. The test track will also continue to be used to test the reliability of both mechanical and electronic components. Figure 8 below shows the chassis during testing operations with the water tanks installed.

Figure 8. Testing the chassis with water tanks installed.

4. PLANNED DEMONSTRATION SYSTEM

The purpose of the test track is to validate integrated levitation, propulsion, and guidance. Upon successful completion of trials, we hope to construct a demonstration system at California University of Pennsylvania (CUP) in California, Pennsylvania, located about 60 miles southwest of Pittsburgh. When completed, this system will be a 7.4 km system with three stations and multiple vehicles, connecting the upper and lower campus via a 7% grade, serving the main campus, the Borough of California, and student housing on the upper campus. Initially, it will be used to demonstrate the all weather, grade climbing, and excellent ride quality capabilities of a maglev system. An artist's rendition of the maglev system connecting the upper and lower campuses is seen below.

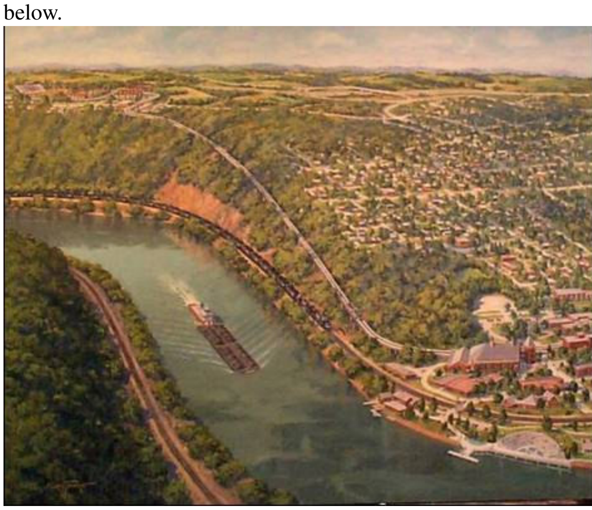

Figure 9. The CUP demosntration system

5. CONCLUSIONS

Significant progress has been made in completing the construction of the test track, and demonstration of initial levitation and propulsion. The goal of the test track initially will be to complete the development and refinement of the levitation, propulsion, and guidance systems. Prior to building the demonstration system at CUP, we plan to use the test track for refining all the system support equipment. This includes block switches, inductive power pick-up, automatic train protection (ATP), second chassis with articulation, non-optical location encoder, and car body. Testing during the remainder of 2005 and 2006 will start some of these activities.

Acknowledgements

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