Maglev Trains

Prepared by:
- Abhijeet Ballani
- Aman Chadha
- Bhavana Vishnani
- AbhishekJain
- Akhil Bhavnani
- Akshay Malkani
INTRODUCTION
Transportation is a product of the social link and relationship of people. Revolutionary changes have occurred in the field of transportation since human beings learnt to communicate and locomote. The major development has taken place in the trains which are today the most widely used modes of transport worldwide. From the ancient steam engine progressing on to the electricity and steam powered engine, electricity powered engine, bullet trains and now the recent research and development of maglev trains is enough to prove that trains have indeed come a long way.

Today we students from second year EXTC A1 are here to present our report titled ‘MAGLEV TRAINS’. Far from our imagination, these trains with extremely high speeds, without friction, controlled by computers and almost flying on rails are now a reality. It is our sincere hope that this report brings you closer to this magnificent creation of science.
EVOLUTION OF MAGLEV
Concept of magnetically levitated trains was first identified in early 1900s.

August 14, 1934 ➔ Germany received a patent for magnetic levitation of trains.

1966 ➔ USA propose the first practical system for magnetically levitated trains.

1971 ➔ FMC and SRI were awarded for analytical and experimental development of EMS and EDL.

1975 ➔ Federal funding for high-speed maglev research in USA was suspended.

1991 ➔ inclusion of 300-km long superspeed maglev system route in Germany.
1996 → Yamanashi Maglev Test Line opened in Japan.

1997 → Running test of MLX01 started in YMTL.

2000 → Prince and Princess of Japan experienced maglev trial ride.

2001 → Construction of Shanghai Transrapid Maglev.
Principle of Maglev
MAGLEV is the principle used in working of Maglev Trains.

MAGLEV – Derived from MAGnetic and LEVitation.

Property- Force between two magnetized bodies is inversely proportional to their distance.

Suspension of objects in mid-air through the combination of magnetic attraction and repulsion forces.
Basic Functions of Maglev Technology

The Maglev Technology operates on three basic functions:

- Levitation
- Propulsion
- Guidance

In most current designs, magnetic Forces are used to perform all three functions, although a nonmagnetic source of propulsion could be used.
Based on the nature of the magnetic levitation system employed, there are two technologies empowering today’s Maglev trains-

1. **Electro-Magnetic Suspension (EMS) System**
   
   Electromagnets in the train repel it away from a magnetically conductive track.

2. **Electro-Dynamic Levitation (EDL) System**
   
   Electromagnets on both track and train are used to push the train away from the rail.
Electro-Magnetic Suspension (EMS) System

- Commonly known as *Attractive Levitation*.
- Based on the elementary idea of attraction of unlike magnetic poles.
- Magnet-guideway geometry is used to attract a direct-current electromagnet towards the track.
- EMS levitates the train about one-third of an inch above the guideway.
- Suitable for low and high-speed passenger carrying vehicles and a wide range of magnetic bearings.
- The German Transrapid (Emsland) works on EMS.
Commonly known as *Repulsive Levitation*

Based on the induction of Eddy currents in conducting materials.

Eddy currents are generated by a superconducting coil operating in persistent current mode and as per Lenz’s law, they create a magnetic field and oppose the magnetic field created by traveling coil.

This interaction produces a repulsive force on the moving coil, thus uplifting the vehicle.

EDL levitates the train about 4 inches (about 10 cm) above the guideway.

The Japanese JR- Maglev MLX01 works on EDL.
In EMS systems, the train levitates above a steel rail while electromagnets, attached to the train, are oriented towards the rail from below.

In EDS systems, both the rail and the train exert a magnetic field, and the train is levitated by the repulsive force between these magnetic fields.

A major advantage of the attractive (EMS) maglev systems is that they are naturally stable, hence narrowing the distance between the track and the magnets.
## Comparison between EMS and EDS

<table>
<thead>
<tr>
<th>Technology</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EMS</strong></td>
<td>Magnetic fields are weaker than EDS. Commercially available technology that can attain very high speeds (500 km/h). No wheels or secondary propulsion system needed.</td>
<td>Separation between the vehicle and the guideway needs constant monitoring with the help of computer systems to avoid collision. Due to the system's inherent instability, vibration issues may occur.</td>
</tr>
<tr>
<td><strong>EDS</strong></td>
<td>Onboard magnets and large margin between rail and train enable the technology to achieve highest recorded train speeds (581 km/h). Recent demonstrations prove successful operations using high temperature superconductors.</td>
<td>Strong magnetic fields onboard the train tend to raise safety concerns for passengers with pacemakers or magnetic data storage media such as hard drives and credit cards. Limitations on guideway inductivity limit the maximum speed of the vehicle.</td>
</tr>
</tbody>
</table>
TECHNOLOGY AND COMPONENTS OF MAGLEV
Maglev Vehicle

- Comprise a minimum of two sections, each with approx. 90 seats on average.

- Can act as dedicated cargo trains (payload up to 15 tons per section).

- Neither the length of the vehicle nor the payload affect the acceleration power.
The Operation Control System
The Maglev Track

- Levitation and guidance coil
- Propulsion coil
- Wheel support path
- Beam
The power supply in the guideway is activated only in the section where the vehicle actually is.
PROS AND CONS
PROS

Safety

► The trains will not crash on the track even when the electric power is cut-off on the guideway.

► Train movements are computerized.

Maintenance

► Maintenance is very less.
Comfort

- The ride is smooth even at high speeds and hence is very comfortable.

Economic Efficiency

- The initial investment is similar to other high speed rail roads.
  (Magliff is $20-$40 million per mile and I-279 in Pittsburg cost $37 million per mile 17 years ago.)
- Operating expenses are half of that of other railroads.
- The linear generators produce electricity for the cabin of the train.
Speed

- The train can travel at about 300 mph.
- For trips more than 500 miles, total travel time is equal to a plane.

Environment

- It uses less energy than existing transportation systems.
- For every seat on a 300 km trip with 3 stops, the gasoline used per 100 miles varies with the speed.
  - At 200 km/h - 1 litre
  - At 300 km/h - 1.5 litres
  - At 400 km/h - 2 litres
- This is 1/3 the energy used by cars and 1/5 the energy used by jets per mile.
The tracks have less impact on the environment because:

- The elevated models (50ft in the air) allows all animals to pass
- Low models (5-10 ft) allow small animals to pass
- Use less land than conventional trains
- Can handle tighter turns.
Noise Pollution

- Very less noise = city traffic

![Noise Emission Graph]

Pass-by Level in dB(A) at a Distance of 25 m (82 ft)

- Suburban Train: 80, 73, 82, 85 dB(A)
- Transrapid 07: 80, 90, 92, 89 dB(A)
- ICE 1+2: 80, 90, 92, 89 dB(A)
- TGV-A: 80, 90, 92, 89 dB(A)

Speeds:
- 80 km/h (50 mph)
- 200 km/h (125 mph)
- 300 km/h (185 mph)
- 400 km/h (250 mph)
The magnetic field created is low, therefore there are no adverse effects.
► Faster trips, High speed, Less time.

► Eliminates the need for overhead wires compared to conventional trains.

► Average cost is 4 cents per passenger mile as compared to 13 cents per passenger.

► Access to Maglev station is much easier than airports.

► Maglev schedule will not be disturbed due to bad weather.
CONS

- Large initial capital investment.
- Lack of human experience with Maglev technology.
- Designing of tracks.
IMPLEMENTATION
### Emsland Maglev

<table>
<thead>
<tr>
<th>Info</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Locale</td>
<td>Emsland, Germany</td>
</tr>
<tr>
<td>Transit type</td>
<td>Maglev</td>
</tr>
<tr>
<td>Number of lines</td>
<td>1</td>
</tr>
<tr>
<td>Number of stations</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Began operation</td>
<td>1984</td>
</tr>
</tbody>
</table>

| Operator     | Transrapid International |

<table>
<thead>
<tr>
<th>Technical</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System length</td>
<td>31.5 kilometers</td>
</tr>
</tbody>
</table>
Construction began in 1980 and was completed in 1984.

 Runs between Dorpen and Lathen.

 The total cost of project was 1 billion $. 
► Uses EMS mechanism.

► Current working model-TR07.

► Fare is $25 for a two way tour.
# Shanghai Maglev

<table>
<thead>
<tr>
<th>Info</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Locale</td>
<td>Shanghai</td>
</tr>
<tr>
<td>Transit type</td>
<td>Maglev</td>
</tr>
<tr>
<td>Number of lines</td>
<td>2</td>
</tr>
<tr>
<td>Number of stations</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Began operation</td>
<td>January 1, 2004</td>
</tr>
<tr>
<td>Operator(s)</td>
<td>Shanghai Maglev Transportation Development Co., Ltd.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System length</td>
<td>30.5 km (19.0 mi)</td>
</tr>
</tbody>
</table>
Double-track project started on March 2001.

Connects the Pudong International Airport and the Longyang Road Station.

The total cost of the project is about 10 billion Yuan.

Takes 7 mins 20 seconds to complete the ride.
► Uses EDS mechanism.

► Noise level less than 60 decibels at 300 km/h.

► The service operates once every 15 minutes.

► Of all the world's Airport Rail Links, the *Demonstration Operation Line* is by far the fastest.
Route of Shanghai Maglev

**FACTS:**
- Record speed: 311 mph, 12 November 2003
- Travel time: 7 min 20 sec/ 8 min 10 sec
- Maximum speed: 268 mph/190 mph
- Reaches 220 mph in 2 minutes
- 19.0 mile long track
- Ridership: 20% capacity
- ¥ 50 one way ticket cost
- ¥ 40 reduced fare with plane ticket
- Project cost: ¥ 10 Billion Yuan over 2.5 years

**Stations:**
- Longyang Road Station
- Maintenance Facility
- Pudong International Airport

**Shanghai Maglev Transportation**
# Linimo Maglev, Japan

<table>
<thead>
<tr>
<th>Info</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Locale</td>
<td>Nagoya, Japan</td>
</tr>
<tr>
<td>Transit type</td>
<td>Maglev</td>
</tr>
<tr>
<td>Number of lines</td>
<td>2</td>
</tr>
<tr>
<td>Number of stations</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Began operation</td>
<td>January, 2004</td>
</tr>
<tr>
<td>Operator</td>
<td>Aichi Rapid Transit Co., Ltd.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>System length</td>
<td>8.9 km</td>
</tr>
</tbody>
</table>
Built for the 2005 World Expo in Nagoya Japan.

Connects Bampaku-yakusa station to Fujigaoka station.

The total cost was $100 million per km.

Uses EMS mechanism.
Designed by the Chubu HSST Development Corporation.

Runs at average speed of 100 km/h.

The line serves the local community.

Able to carry 4000 passengers in each direction every hour.
Route of Linimo Maglev
Maglev Bullet Train (Shinkasen)

- Being tested on a test track in Yamanashi prefecture.
- Developed by JR Central and Kawasaki Heavy Industries.
- Proposed to connect Tokyo to Osaka.
► Use superconducting magnets.

► Uses EDS mechanism.

► Achieved a world record speed of 581Km/h on December 2, 2003.
Route of Shinkasen Maglev

- Osaka
- Kyoto
- Shin-Osaka
- Tokyo
- Omiya
- Takasaki
- Joetsu
- Shinkansen
- Tokyo
- Echigo-Yuzawa
- Hakutaka
- Uozu
- Naoetsu
- Toyama
- Kanazawa
- Thunder Bird
- Fukui
- Osaka

Shin-Osaka
Advantages over Linimo Maglev

- Uses higher speed potential.
- Uses repulsive system than attraction system.
- Provides larger air gap.
- Thus, accommodates the ground motion experienced in Japan's earthquake-prone territory.
Major Hindrances for Shinkasen Maglev

- The design of Japan's repulsion system is not firm.
- Very expensive
Maglev Test Line, Yamanashi

- Connects Sakaigawa and Akiyama of Yamanashi Prefecture.

- Total length of 42.8km.

- Built to perform confirmation to obtain a final perspective of Maglev feasibility.

- The Test Center was officially opened on July 1996, to start on the program of test runs and complete the developmental activities.
Route of Yamanashi prefecture
Yamanashi Maglev Test Line
Major test items to take place

► Confirmation for possibilities of safe, comfortable, and stable run at 500 km/h.

► Confirmation of reliability and durability of the vehicle, wayside facilities, and equipment as well as the Superconducting Magnets.

► Confirmation of structural standards including the minimum radius of curvature and the steepest gradient.

► Confirmation of center-to-center track distance for safety of trains passing each other.
Confirmation of vehicle performance in relation to tunnel cross-section and to pressure fluctuations in the tunnels.

Confirmation of performance of the turnout facilities.

Confirmation of environmental impact.

Establishment of multiple-train operation control systems.

Confirmation of operation and safety systems and track maintenance criteria.

Establishment of inter-substation control systems.

Pursuit of economic issues, construction and operation costs.
ACCIDENTS
1. The Miyazaki Fire incident

The MLU002 (Japan) test train was completely consumed in a fire in Miyazaki in October 1991.

Water being sprayed to extinguish the fire
Engineers checking the cause of the fire
2. FIRE ON SHANGHAI TRANSRAPID

- **Date-**
  August 11, 2006

- **Place-**
  Shanghai Transrapid, shortly after leaving the Longyang terminal.

- **Reason-**
  First accident on commercial line. No casualties were reported. Caused due to fire on onboard batteries.
LATHEN ACCIDENT

Date and Time-

Place –
- About 0.6 miles (1 km) away from Lathen, Germany.

The Accident-
- Transrapid maglev train collided with a maintenance vehicle.
- First fatal accident. 10 people were seriously injured, 23 people were killed.
- Reason – lack of communication between operators.
Collision with maintenance vehicle
Emergency workers tried to rescue passengers from the train, but were hindered by it balancing on the elevated track.
CONCLUSION
Use magnets to levitate and propel the trains forward.

Frictionless.

Top speed with people aboard is about 350 mph.

The main obstacle is its high expenses.

Earthquake proof.

No wastage of energy.

Safe way to travel.

The governments have mixed feelings about the development of these systems.
Proposed Systems

Many maglev systems have been proposed in various nations of North America, Asia, and Europe..

1. Mumbai – Delhi, India

- Between Mumbai and Delhi.
- If successful, then between Mumbai Central and Chhatrapati Shivaji International Airport.
- The State of Maharashtra has also approved a feasibility study for a Maglev train which plans to connect the developed area of Mumbai and Pune with Nagpur via underdeveloped hinterland via Ahmednagar, Beed, Latur, Nanded and Yavatmal.
2. Los Angeles, Southern California – Las Vegas, United States

3. Baltimore – Washington, D.C., United States

4. London – Glasgow, United Kingdom

5. Melbourne maglev proposal, Australia

6. Tokyo — Nagoya — Osaka, Japan

Thus, maglev trains are soon going to change the transportation scenario worldwide.