Aerodynamics of Magnetic Levitation (MAGLEV) Trains

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Track Arrangement

The track arrangement that is receiving the most consideration in the US is elevated as shown.

Elevating the Maglev guideway provides adequate clearance over existing Interstate bridges and other structures.
Magnetic Suspension Systems

The different systems that have been proposed have a large influence on vehicle configuration design.
German Test Vehicle

There are ongoing test vehicle programs in Germany and Japan.
Japanese Test Vehicle
Proposed Japanese Designs

The Japanese have developed new designs to minimize aerodynamic forces, noise and tunnel entry/exit problems.

Double Cusp Style
Proposed US Designs

There are several US designs that have been proposed.
Grumman Designs
Lockheed Design for AMT
Need for Wind Tunnel Studies

+ There is little relevant data in the literature

+ The analytical estimates for drag vary widely

+ CFD is unreliable and very expensive for 3D flows with separated regions
Wind Tunnel Tests of Maglev Vehicles

+ Model ground effect of track with a moving belt

+ Model clearance between elevated track and ground (approx. 3 diam.)

+ Parallel, uniform incoming flow to model accomplished with proper shrouding

+ Reynolds number simulation with a "trip" strip
Moving Belt System

+ Use in VT 6 ft. X 6 ft. Wind Tunnel

+ Accommodate 6 ft.(long) X 1 ft.(diam.) model

+ Maximum belt speed

SHROUDING NOT SHOWN
Incoming Flowfield Verification

+ Hot-wire measurements at various locations above and around the belt

+ Mean-flow and turbulence profiles
Northrop/Grumman Model in the Wind Tunnel with Moving Track
Experimental Methods

+ Force and Moment balance
+ Tuft surface flow observations
+ Hot-wire flowfield surveys
+ Surface pressure distributions
+ Skin friction gages
Typical Flowfield Surveys

Velocity Contours Aft Of Tail

Turbulence Contours Aft Of Tail
Wind Tunnel Data

Drag Comparison

- Grumman IGE
- Grumman OGE
- Lockheed IGE
- Lockheed OGE
- EDS IGE
- EDS OGE

Re

0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

Cd

200000 300000 400000 500000 600000 700000 800000 900000 1000000 1100000
Wind Tunnel Data

Lift Comparison

- Grumman IGE
- Grumman OGE
- Lockheed IGE
- Lockheed OGE
- EDS IGE
- EDS OGE
Design Considerations

♦ Aerodynamics
♦ Structures
♦ Control
♦ Propulsion
♦ Cost
♦ Transportation utility
MultiDisciplinary Design

Aerodynamics

- Low Drag, Lift and Moment
- Low noise
- Cross winds
- Passing
- Tunnel entry/exit
MultiDisciplinary Design

Structures

- Load-bearing skin (like an airplane, not like a train)
- Weight
- Construction/materials
- Impact loads
- Unsteady aero loads
MultiDisciplinary Design

Cost/Shape

- Weight
- Shape complexity and tolerances
- Construction/materials
- Conventional rail cost info NG
- Some MAGLEV cost info available
- Use small transport plane cost info