Aerodynamics of Magnetic Levitation (MAGLEV) Trains

Joseph A. Schetz
and
James F. Marchman III
Virginia Tech
Blacksburg, VA

Transportation Beyond 2000: Engineering Design for the Future

September 26-28, 1995
Track Arrangement

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

There's ample clearance on rural Interstates for Maglev construction along the median or the right of way.

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
Wind Tunnel Data
MultiDisciplinary Design

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