Energy Efficiency and Economics of Maglev Transport*

by

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MAGLEV 2000

www.maglev2000.com

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The Message

- Oil Fueled Autos, Trucks, & Airplanes Dominated 20th Century Transport
- Electrically Powered Autos & Maglev Will Dominate 21st Century Transport

Overview

- 1st Generation Japanese & German Passenger Systems Operating
- 2nd Generation U.S. Danby/Powell Maglev-2000 System is Much Cheaper and More Capable
- Maglev-2000 Very Energy Efficient
  - -Uses Electricity, Not Oil
  - -Carries Passengers, Highway Trucks, Freight Containers & Personal Autos

- 25, 000 Mile National Maglev Network Connects Major U.S. Metropolitan Areas
- Between Cities, Maglev-2000 Uses Rights-of-Way of Interstate Highways
- In Urban/Suburban Regions, Levitated Maglev-2000 Vehicles Use Existing RR Tracks.
- Maglev-2000 Network, Plus Electric Autos, Eliminate Oil Imports

Maglev-The First New Mode of Transport Since the Airplane

What Maglev Is

- Magnetically Levitated Individual Vehicles Travel Above Guideways
- Magnetically Propelled By AC Windings In the Guideway
- 300 MPH Limited only By Air Drag

What Maglev Is Not

- No Mechanical Contact With Rails
- No Engines on Vehicles
- Not A Long Train of Many Cars
  - No Long Wait Until Next Train

What Maglev Can Transport

- Passengers
- Roll-On, Roll-Off Highway Trucks
- Freight Containers
- Personal Autos

Why Maglev Is Very Safe

- Superconducting Maglev Inherently Strongly Stable Cannot Contact Guideway
- If Propulsion Power Cuts-Off Levitated Vehicles Coast To A Safe Landing
- Vehicle Speed & Guideway Position Controlled By AC Propulsion Frequency

Why Maglev?

Energy Benefits

- No Oil – Electrically Powered
- Much More Energy Efficient Than Other Transport Modes
- With Electric Cars, Zero Oil Imports

Environmental Benefits

- Zero Emission of Greenhouse Gases
- Minimizes Land Use For Transport
- Reduces Environmental Damage From Oil Drilling & Shipping

Economic Benefits

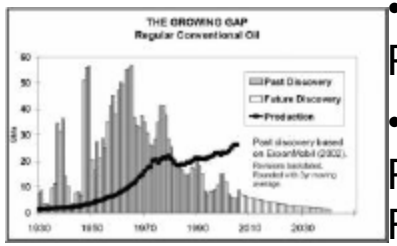
- Faster, Lower Cost Transport
- Increased Productivity & Global Competitiveness
- Major Industry – New Jobs & Reduced Trade Deficit

Quality of Life Benefits

- Saves Lives –Fewer Accidents & Less Damage to Public Health
- Fast, Comfortable, & Quiet Transport
- No Congestions and Weather Delays

The Realities For Future U.S. Transport

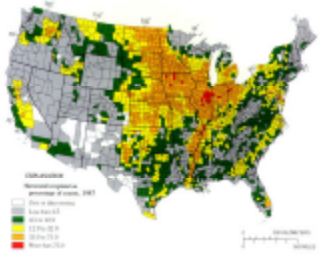
Conventional Oil Very Scarce & Expensive



- World Oil Production Peaking & Will Decline
- U.S.Uses 25 Barrels Per Person Per Year – Rest of World Only 4

- More Customers For An Ever Shrinking Pie

Supply of Biofuels is Small



- 1 Gallon of Ethanol = ¼ Gallon Gas (Net Energy)
- 20% of U.S. Corn Crop Supplies 1% of U.S. Transport Fuel Needs (Net Basis)

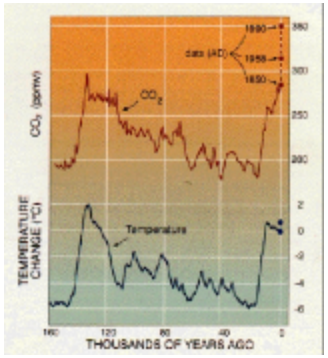
- Ethanol Production Drives Up Food Prices –World Is Already Short of Food

Hydrogen Fuel Is A Fantasy

- Making H2 Fuel Doubles Electrical Generation – From 4 Trillion KWH/Year to 8 Trillion KWH

- Serious Safety & Security Problems, One tank of H2=500# of TNT. Terrorists could Remotely Detonate H2 Autos in Cities.

Oil From Coal Speeds Global Warming

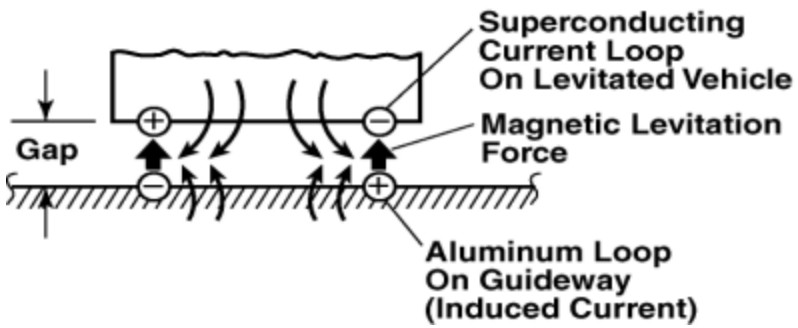


- Each U.S. Auto Emits 10 Tons of CO2 /Year
- Oil From Coal Doubles Emission to 20 Tons

Increasing World Transport And Oil From Coal will Double World CO2 Emissions/Year.

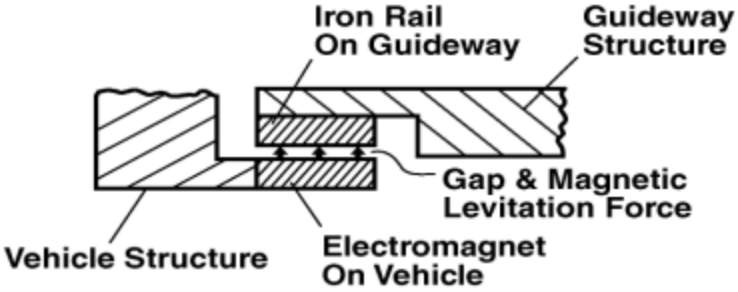
Maglev—How It Works

SUPERCONDUCTING MAGLEV



- Invented by Danby-Powell in 1966
- Basis for 1st Generation Japanese Maglev System
- Levitation is Inherently Strongly Stable
- Large Gap Between Vehicles & Guideway (4 to 6 inches)
- New, Lower Cost & More Capable 2nd Generation System Has Been Developed by Powell & Danby

ELECTROMAGNETIC MAGLEV



- 1st Generation German Maglev System (Transrapid)
- Levitation is Inherently Unstable
- Electromagnet Current is Servo-Controlled to Prevent Crashes (Functions on Millisecond Time Scale)
- Small Gap (~3/8th Inch) Between Vehicles and Guideway
- Very Precise & Expensive Guideway

Present Status of Maglev Systems

1st Generation – Japan

- Passenger Vehicles Operate in Yamanashi, Japan
- Carried Over 50,000 Passengers at Up to 360 MPH
- Plan 300 Mile Maglev Route Between Tokyo and Osaka – 2000,000 Passengers Daily
- Cost ~ 60M$ Per Mile

1st Generation – Germany

- Passenger Vehicles Operate on 21 Mile Route in Shanghai.
- Thiessen-Krupp & Siemens Have Withdrawn Support
- Proposed Projects Cancelled
- Cost ~60 M$ Per Mile

2nd Gen–D-P Maglev 2000

- Full-Scale Hardware (Magnets, Guideway Loops & Beam, Vehicle) Successfully Fabricated.
- Next Step is Testing on Guideway – w/Gov't Funding
- Projected Cost ~ 20 M$/Mile

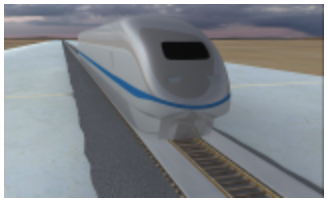
Unique Capabilities of 2nd Generation Maglev-2000 System

Prefabricated Monorail Guideway

•One Container Ship Exports 20 Miles Guideway

•Prefabricated Guideway Beams & Piers & Attached Loops Trucked to Site
•Erected By Conventional Cranes
•Low Cost Fabrication & Erection
•300 MPH on Elevated Guideway

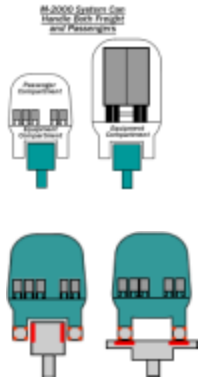
Levitated Travel Along Existing RR Tracks



•Low Cost Aluminum Loop Panes on Cross Ties Enable Levitated Travel of Maglev Vehicles on RR Tracks.
•4 M$/Mile for Panels

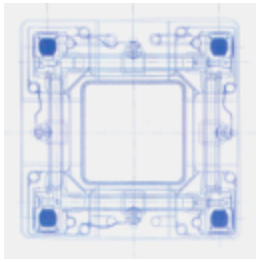
•Maglev-2000 Vehicles Can Use Existing RR Tracks Without Disrupting Existing Infrastructure.

Unique Transport Capabilities



•M-2000 Guideway can Carry Passengers Highway trucks, Freight Containers and Personal Autos
•M-2000 Vehicles Electronically Switch At High Speed From Main Guideway to Off-line Stations for Unloading/Loading

Maglev-2000 Superconducting Magnet



•M-2000 Quadrupole Magnet Can Travel on Both Monorail and Planar Guideways
•High Speed Electronic Switch
•Much Greater Load Capability
•Magnetic Fringe Fields at Earth Ambient Level

Energy Efficiency by Transport Mode
In Barrels of Oil or Oil Equivalent Per 10,000 Passenger Miles

Basis: Transportation Energy Data Book, 25th edition; Stacy Davis and Susan Dregel, Center for Transportation Analysis, Oak Ridge National Laboratory, ORNL-6874 (2006)

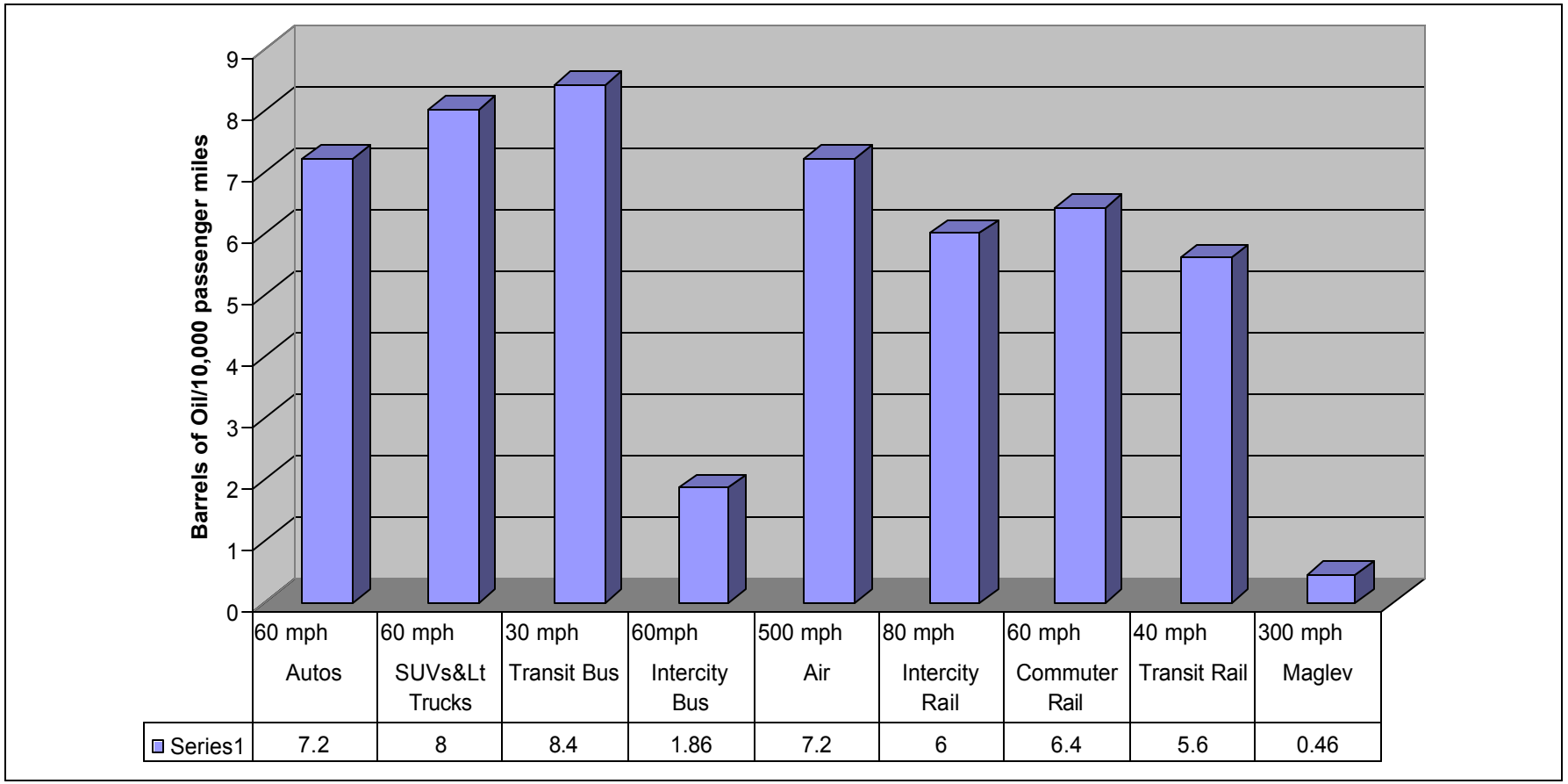


Table 1

Propulsion Power and Energy Requirements for High Speed
Intercity Maglev Vehicles as a Function of Speed

Basis:
100 Passenger Maglev Vehicle
11 m^2 Frontal Area
0.22 Effective Drag Coefficient
90% Efficient LSM Propulsion
10 cents/kWh(e)
$4/Gallon Gasoline, 60 mph, 20 mpg Automobile
1 kWh = 3.6 Mega Joules (MJ)

Speed (mph)	Air Drag Power KW(e)	I^2R Drag Power KW(e)	Total Drag Power KW (e)	Total Drag Power/LSM Eff KW (e)	Energy Per Passenger Mile kWh(e)/PM	Energy Cost/PM $/PM	Energy/PM MJ/PM	Energy for Auto MJ/PM	Auto Gas Cost/M $/P
300	3720	300	4020	4460	0.149	$0.015	0.54	7.0	0.2
250	2150	300	2450	2720	0.109	$0.011	0.39	ditto	ditto
200	1100	300	1400	1550	0.078	$0.008	0.28	ditto	ditto
150	465	300	765	850	0.057	$0.006	0.20	ditto	ditto

Table 2

Propulsion Power and Energy Requirements for Moderate Speed
Urban/Suburban Maglev Vehicle as a Function of Speed

Basis = Same As Table 1, except 60 passenger Vehicles, & 200 KW(e) I^2R Power

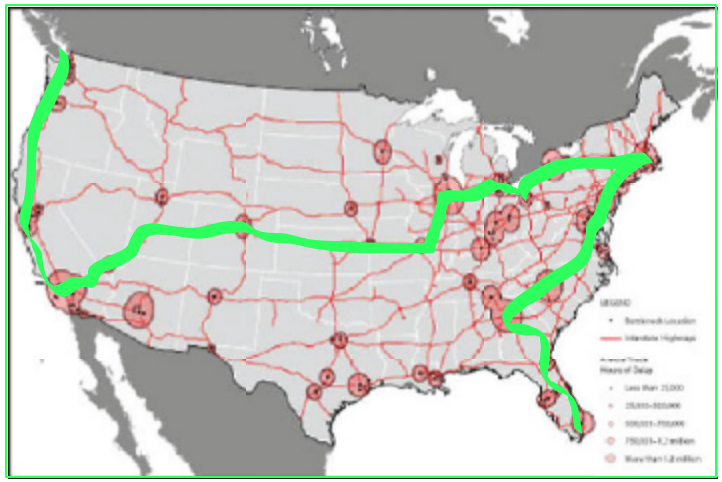
Speed (mph)	Air Drag Power KW(e)	I^2R Drag Power KW(e)	Total Drag Power KW (e)	Total Drag Power/LSM Eff KW (e)	Energy Per Passenger Mile kWh(e)/PM	Energy Cost/PM $/PM	Energy/PM MJ/PM	Energy for Auto MJ/PM	Auto Gas Cost/M $/P
150	465	200	665	740	0.082	$0.008	0.29	7.0	$0.20
100	140	200	340	380	0.063	$0.006	0.23	ditto	ditto
75	66	200	260	240	0.064	$0.006	0.23	ditto	ditto

Table 3

Propulsion Power and Energy Requirements
For Maglev People Mover

Passenger Capacity	30
Average Speed	30 mph
I^2R Drag Power [100% LSM Eff]	100 KW(e)
I^2R Drag Power [90% LSM Eff]	110 KW(e)
Kinetic Energy of Vehicle [10,000 kg, 30 mph]	900 Kilojoules
Air Drag Power	Negligible
Nominal Travel Distance and Trip Time	500 meters & 40 seconds
Nominal Station Stop Time	60 seconds
Average Speed Including Station Stops	12 mph (5.4 m/sec)
Energy Consumption Per Passenger Mile with Full Recovery of Kinetic Energy	
1. Levitated @ station	0.30 KWH/PM
2. Not Levitated @ station (mech.support)	0.12 KWH/PM
Energy Consumption Per Passenger Mile With No Recovery of Kinetic Energy	
3. Levitated@Station	0.33 KWH/PM
4. Not Levitated@ Stations (mech. Support)	0.15 KWH/PM

The National Maglev-2000 Network



First Phase: Golden Spike Project

- 6000 Miles of Routes Connects East & West and North-South Coasts
- Ready By May 2019, 150th Anniversary of the Transcontinental Railroad

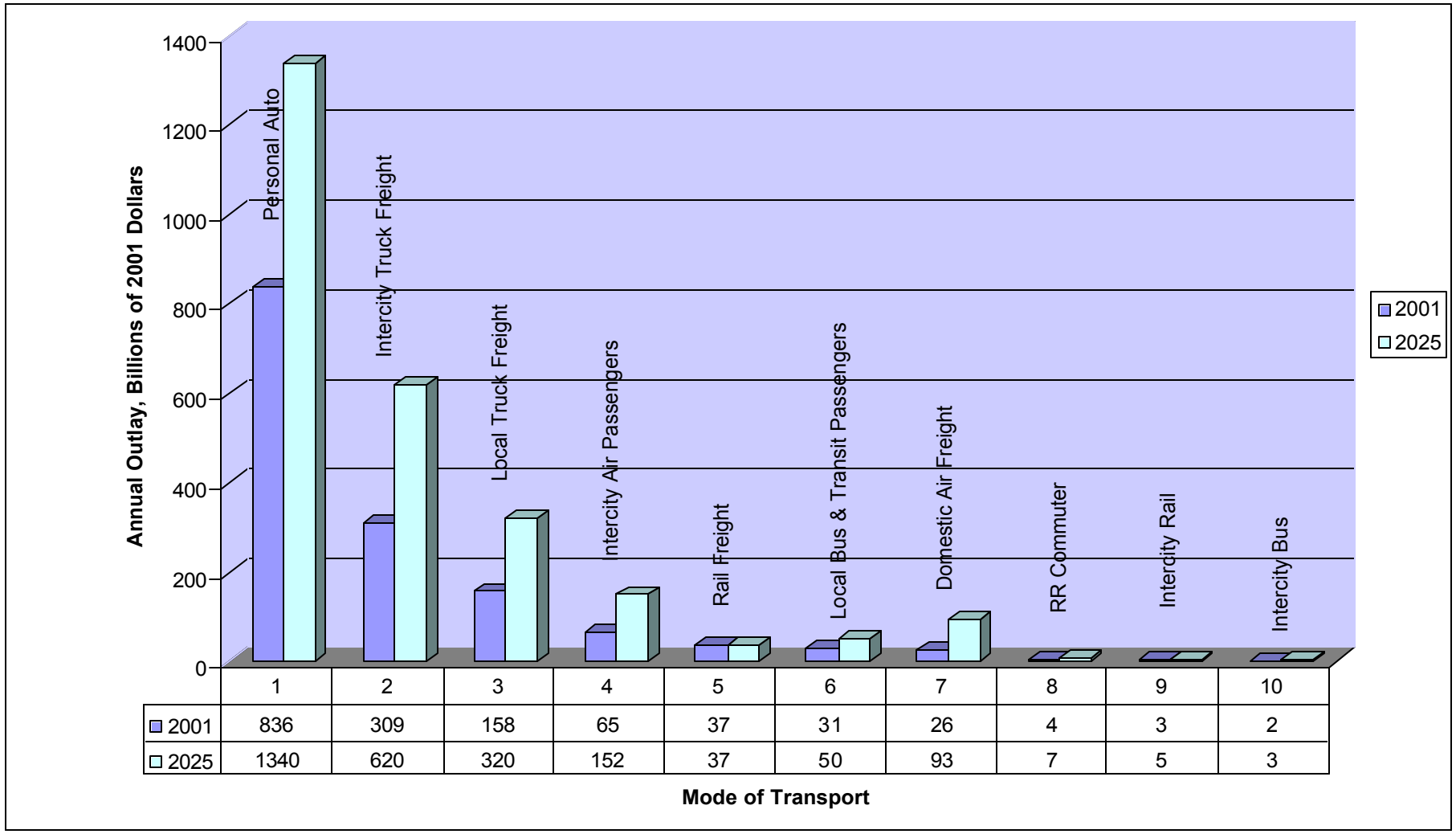
National Maglev-2000 Network

- 25,000 Mile National Network Completed By 2030 AD
- Connects All Major Metropolitan Areas
- 70% of Population Lives Within 15 Miles of a Station on the Network
- Maglev Network + Electric Autos Eliminates Oil Imports
- Network Cost Paid Back in <5 Years By Carrying Highway Trucks

Annual Outlays, Current and Future, for US Transport Modes

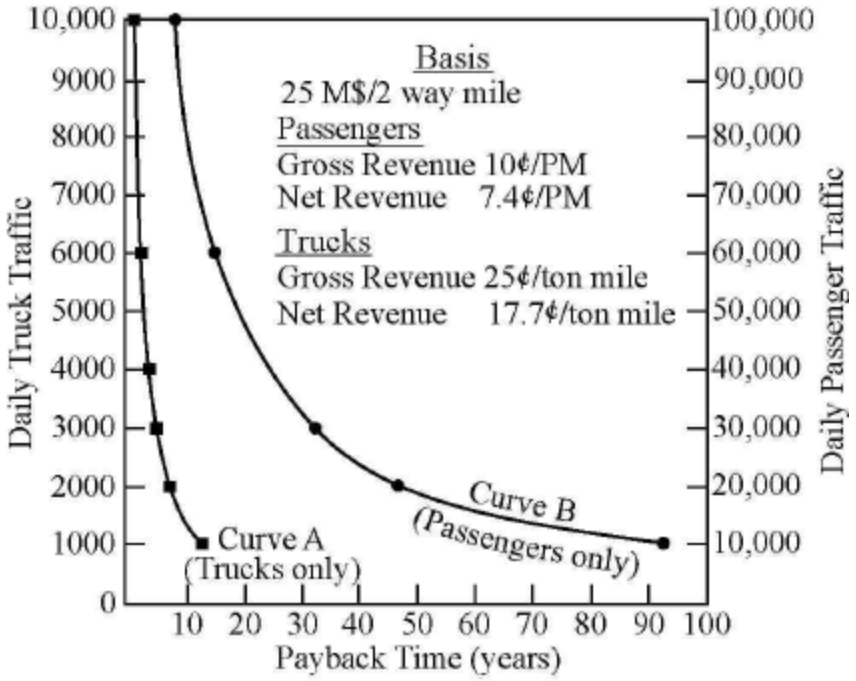
(Billions of Dollars)

Source: Statistical Abstracts of the US for 2006 (US Census) & The Changing Face of Transportation (US DOT Bureau of Transportation Statistics (2002)



	1	2	3	4	5	6	7	8	9	10
2001	836	309	158	65	37	31	26	4	3	2
2025	1340	620	320	152	37	50	93	7	5	3

Payback Time for Maglev-2000 Guideway



Payback Time for Maglev-2000 Guideway

Table 1: Vehicle O&M Costs

5 M $ vehicle cost; 10 year Amortization; 5%/year maintenance; 100 passenger or 30 ton capacity; 80% load factor; 12 hours op/day; 250 mph average speed; 3 MW propulsion power for passenger vehicles, 4 MW for trucks; 6 cents/KWH

Revenues & Costs	Passengers (cents/pm)	Trucks (cents/ton mile)
Gross Rev	10	2.5
Energy Cost	1.2	4.0
Am& M Cost	0.9	2.8
Personnel Cost	0.5	0.5
Net Rev.	7.4	17.7

Why Don't We Have Maglev In the U.S.?

Maglev Initiative	U.S. Government Response
Modern Maglev Invented By Danby-Powell in 1966	U.S. DOT Decides Autos & Airpanes Are Sufficient Into the Far Future
Germany & Japan Develop 1st Generation Maglev System	No Action
Senator Moynihan Proposes 750 M$ U.S. Maglev Program in 1990	Passes Senate But Killed In House By Existing Transport Interests
U.S. Maglev Deployment Programs Starts in the Late 90's	7 Routes Selected for Study •6 Routes propose German Transrapid Systems •Florida Proposes 2nd Generation U.S. Maglev-2000
Down Select From 7 to 2 Routes.	2 Routes Propose German Transrapid •No Plan to Build – Just More Study
Maglev-2000 Proposes Developing 2nd Generation U.S. Maglev Systems	No Action
Conclusion: Unless U.S. Acts Soon, 2nd Generation System Will Be Developed Abroad & Exported to the U.S. One Container Ship Can Carry 20 Miles of Guideway	

Implementing the National Maglev Network

- Maglev-2000 Has Successfully Fabricated and Tested The Full-Scale Components for the 2nd Generation 2nd Generation Maglev 2000 System
- Next Step is to Test Assembled Maglev-2000 Vehicles on an Operating Guideway
  - 3 Phase, 5 Year Testing Program Proposed
  - Test Passenger & Truck Carrier Levitated Vehicles at Speeds on Elevated Guideway and Existing RR Tracks
  - Speeds Up to 300 mph on Elevated Guideways
  - Long Term Running Tests for Commercial Certification
  - 600 M$ Program With Government Funding
- Implementation as National Maglev Network Will Be Privately Financed
  - Fast Payback Time (<5 years)
  - No Government Subsidies
- 6000 Mile Golden Spike Sections Operating by 2019, Full 25,000 Network Completed by 2030 AD

Summary and Conclusions

- Maglev Transport Offers Many Major Benefits, Including
  - Very High Energy Efficiency, Low Cost Transport
  - Does Not Use Oil, Helps Curb Global Warming
  - New U.S. Industry with Many Thousands of Jobs & Billions of Dollars in Exports
- 1st Generation Passenger Only German and Japanese Maglev Systems Too Expensive -- Steel Wheeled HSR Systems Too Limited
- 2nd Generation U.S. Maglev-2000 System Much Lower in Cost and Much More Capable Than 1st Generation Systems.
  - Can Carry High Revenue Highway Trucks, Freight Containers, & Personal Autos
  - Levitated Travel on Existing RR Tracks in Urban and Suburban Areas
  - Payback Time <5 years
- 25,000 Mile National Maglev Network and Electric Cars Will Eliminate Oil Imports By 2030
- U.S. Can Be World Leader in Maglev, But Must Act Now.