The Maglev America Project: A 28,800 mile National Maglev Network for the United States

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ABSTRACT: A 300 mph National 2nd Generation Superconducting Maglev-2000 Network interconnecting 174 US metropolitan areas and full-scale component testing is described. The 28,800 mile Network transports passengers, roll-on/roll-off trucks, containers, autos, and passengers. 230 million people would reside within 15 miles of Network stations. Private investment would build and operate the Network without government funding. Transporting 1/3rd of intercity trucks would payback construction cost in 5 years. Network unique capabilities include: low construction cost, high-speed electronic switching, and Maglev travel inside metropolitan areas on adapted railroad tracks. Network construction would begin in 2015 and complete by 2030. The Network would greatly reduce oil imports, carbon dioxide and pollutant emissions, save thousands of lives annually, improve public health, and the economy.

1 MAGLEV AND FUTURE TRANSPORTATION

Transportation is absolutely critical to humanity's present standard of living. Without oil fueled cars, trucks, planes, trains, and ships, we would be back in the 1700's with horses, wagons, rafts and sails. What lies ahead if we continue to depend on oil fueled transport? The realities are pretty scary.

First Reality: Conventional oil will be extremely scarce and expensive in the coming decades. World oil production has plateaued at about 90 million barrels per day, and soon will start to decline. Oil demand from newly industrializing countries like China and India is rapidly increasing, making them compete very strongly for ever scarcer and more expensive oil. Today, American's consume on average 25 barrels of oil per year, while the rest of the 6.6 billion people in the World average only 3.6 barrels per year. If their consumption increases by 30% to 4.7 barrels per year, America's oil share would go to zero.

Second Reality: Synfuels from coal, oil shale, tar sands, etc., are the only way we can continue to use our oil fueled autos, trucks, airplanes, trucks and ships. Expecting biofuels to meet our liquid fuels need is not practical. Today, hundreds of millions of people go hungry because there is not enough arable land to feed them. By 2050 there will be 9 billion people in the World, not today's 6.6 billion.. Soil fertility is degrading, water tables are dropping, the ocean is acidifying, drought areas are increasing – we will be fortunate if we can avoid mass famine, let alone make biofuels. America has 300 million people and 300 million acres of farmland, approximately 1 acre per person for food production. We consume 600 gallons of gasoline and diesel fuel per person per year. To produce ethanol from corn with a net energy equal to the 600 gallons of fuel would require 7 acres per person, almost the entire land area of the continental 48 states. Biofuels can only supply a very small fraction of future transport fuel needs.

Hydrogen fueled cars and trucks? It takes enormous amounts of electric energy to make hydrogen to equal the fuel value of gasoline and diesel we burn today – 1,000 new nuclear reactors, each of 1,000 megawatts generation capacity. Hydrogen's safety and security problems are unsolvable. Imagine driving 70 mph in bumper to bumper traffic, with each car's hydrogen tank – either gaseous hydrogen at 5,000 psi, or liquid hydrogen at 420 degrees Fahrenheit below zero – having the explosive force of 500 pounds of TNT if it escapes in an accident, mixes with air, and detonates. Not only would the car explode, but also its neighboring cars. Further imagine a terrorist stealing a hydrogen fueled car, attaching a small penetrator device to the hydrogen tank that punches a hole in the tank, and detonates the resulting hydrogen-air mixture. The penetrator device could probably be bought on the black market. The terrorist could park the car in an underground garage, a shopping mall, or a busy city street.

Synfuels from coal, tar sands and oil shale are practical and affordable and have been produced in a number of countries for many years. For many years, Canada has produced one million barrels of syncrude daily from the tar sands in Alberta. World leaders call for an 80% reduction in global carbon dioxide emissions by 2050 AD. This is impossible if we continue with oil fueled transport. An 80% reduction corresponds to reducing the present World emissions of 25 Billion tons per year down to only 5 Billion tons annually. If the World transitions to synfuels, and its average per capita transport usage in 2050 AD is ½ that of today's value, transport emissions alone would be 60 Billion tons per year. If this happens, there will be no hope of stopping massive global warming, the ocean will acidify to the point that most marine life dies, and most of the World's species will go extinct.

Third Reality: The World must soon transition to electric transport, based on electric vehicles and 2nd generation Maglev. Electric autos and trucks would be used for short local trips. The new Chevy Volt automobile, for example, will be able to go 40 miles between recharges. 2nd generation Maglev can transport passengers, autos, trucks and freight for long distances, at high speeds to convenient, easily accessible stations near their final destinations. Autos and trucks will simply drive off the Maglev vehicle and go by highway to their destinations, while passengers will use public or private transit to reach their destinations.

High Speed Rail (HSR) is currently proposed as America's path for future long distance electric transport, but it will not meet U.S. needs. It requires massive government subsidies for construction and operation, and is very expensive for travelers. It cannot carry trucks, autos, and freight, only passengers. Today, the average American takes a round trip on Amtrak every 24 years. Even in countries like France and Japan with fully developed HSR service, it supplies only a small fraction of transport needs. Per capita HSR travel in France is only 400 miles annually, about 1 round trip per year. Per capita annual driving distance in France is 7,600 miles, 20 times greater than HSR travel distance. The average American drives 10,000 miles annually. Even if U.S. travelers were to equal the French HSR distance, which is unlikely given the much lower population density and much greater size of the

United States compared to France, HSR would do little to meet America's future transport needs.

To avoid the environmental damage from synfuels, America must soon begin to transition to electric autos and Maglev. To carry out this transition, we have proposed the National Maglev Network below. The necessary technology already exists, and the required materials and manufacturing methods are commercially available.

2 WHY A NATIONAL MAGLEV NETWORK FOR THE U.S.?

Present U.S. transport systems – highways, airways, and railways – operate as national networks that interconnect all regions and metropolitan areas in America. Building a highway between two cities that would not connect them with the rest of the country would be of very little use. Similarly, if aircraft could only fly between airports at New York City and Los Angeles, and the airports did not have flights to the rest of the country, transport efficiency would be virtually zero, and transport cost very high.

To be effective as a mode of transport, Maglev must function as a National Network that interconnects most of the U.S. population. A few isolated Maglev routes between large cities, e.g. New York to Washington, would not significantly benefit the U.S. – only the fortunate few who it would serve. That is the first constraint. The second constraint is that the National Maglev Network must satisfy a large fraction of U.S. travel needs not only for passengers who now travel by air or drive, but also intercity trucks. To achieve this, the cost of travel in Maglev should be less than by present modes, both per passenger mile and per truck ton mile.

U.S. highways and airways are increasingly congested, leading to more expensive and slower travel. Highway congestion is projected to greatly increase in coming decades as illustrated by Figure 1A and 1B, which compares 2002 AD with congestion with projections for 2035 AD.

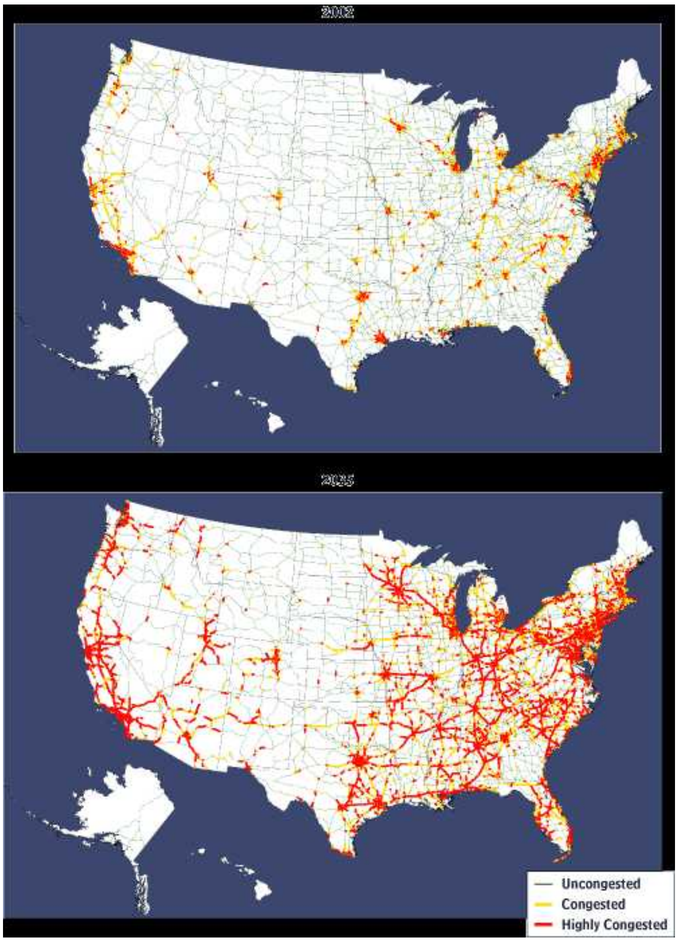

Figure 1A and 1 B Peak-Period Congestion on the National Highway System

In 2002 only a small fraction of the Interstates were highly congested (The Federal Highway Administration definition of highly congested is that the ratio of traffic flow to traffic capacity is greater than 95%, resulting in slow bumper to bumper movement). By 2035 AD, a large fraction of the U.S. Interstates in the more densely populated states will be highly congested. A major contributor to the increased congestion will be intercity trucks, as illustrated in Figures 2A and 2B.

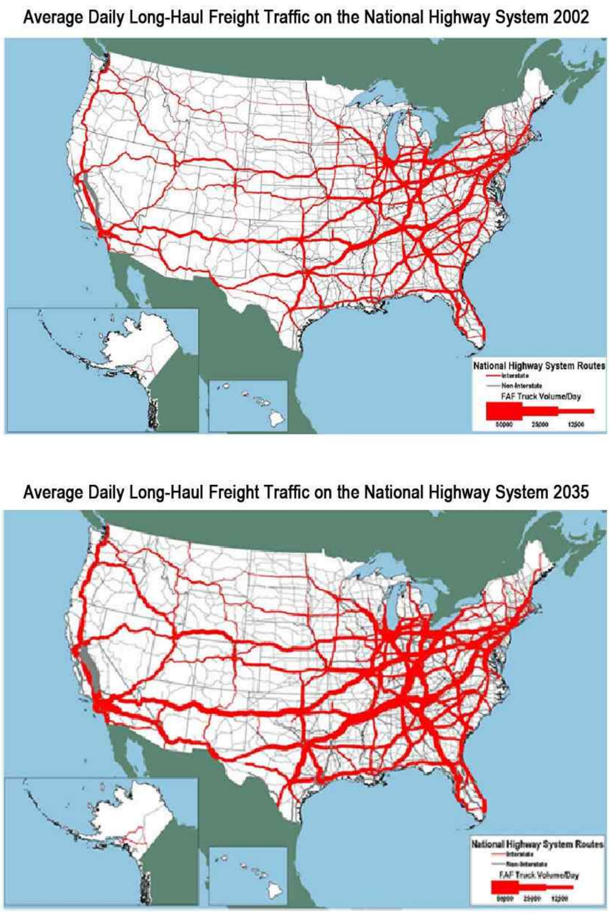

Figure 2A and 2B Average Daily Long-Haul Freight Traffic on the National Highway System: Comparison of 2002 with 2035

In 2002, there were only a few highway sections where the truck flow approached 20,000 vehicles per day. By 2035, due to the increase of 100 million in the U.S. population, and the increased GDP, there will be many highway sections where the truck flow is considerably greater than 20,000 vehicles per day. In some segments, truck traffic flow is approaching 50,000 vehicles per day. Think of 40,000 trucks per day on a 2 way highway. That's a truck every 2 seconds passing a given point of the highway. According to a Highway Research Board study, one legal heavy (40 ton) truck does as much damage to the highway as 9,600 automobiles.(1) 40,000 trucks per day in 2035 will do as much damage as 384 million automobiles would on a highway section. According to another DOT study (2), one heavy truck mile of travel costs $0.41 per year to repair the damage. In the U.S. in 2007, total heavy combination travel was 145 billion truck miles.(3) At 41 cents damage per truck mile, that's 60 billion dollars every year, just to fix the highway damage that trucks cause. In 2035, highway damage cost from trucks will exceed 100 billion dollars annually. Transport of trucks by Maglev will save many Billions of dollars per year in highway maintenance costs.

Of the 37,000 highway traffic fatalities in the U.S. in 2008, 4,200, or 11%, were killed in crashes involving large trucks. An additional 90,000 people were injured in the crashes.(4) Besides the human costs of these deaths and injuries, there are enormous economic costs. Adding the costs of highway transport, highway damage, and deaths and injuries, the total cost of highway trucks is approximately 700 billion dollars annually. And that doesn't include the cost of health damage from the pollutants and micro particulates emitted by Diesel trucks. Studies estimate that people living in high truck traffic areas suffer extensive health problems – lungs, hearts, etc. – with their lives shortened by as much as 2 years. It is difficult to quantitatively project these health costs, but they clearly are enormous, many more billions of dollars. So, America pays a high cost for truck transport – approaching a trillion dollars per year, today, and well over a trillion dollars annually by 2030 AD, as measured in today's dollars.

We must have very large amounts of truck freight transport to sustain our standard of living. Even though railroad costs per ton mile are 1/10th of that of truck transport, America spends 10 times as much on trucks for freight hauling as it spends on railroad freight. Unless we find a practical way to get a large portion of truck traffic off the highway, in 2030, America will spend an enormous sum on truck operating costs and highway damage, along with a great cost in fatalities, injuries, and illnesses of its population. Moreover, the greatly increased congestion delays and its costs, which are not included above, will cripple our national productivity. There is a way to accomplish this goal – transport of highway trucks by Maglev on the National Maglev Network. Transport costs will be much less and highway damage, fatalities, injuries, and health problems will be greatly reduced. Moreover, our oil imports will be greatly reduced, and greenhouse gas emissions curtailed.

3 UNIQUE CAPABILITIES OF THE 2ND GENERATION MAGLEV 2000 SYSTEM

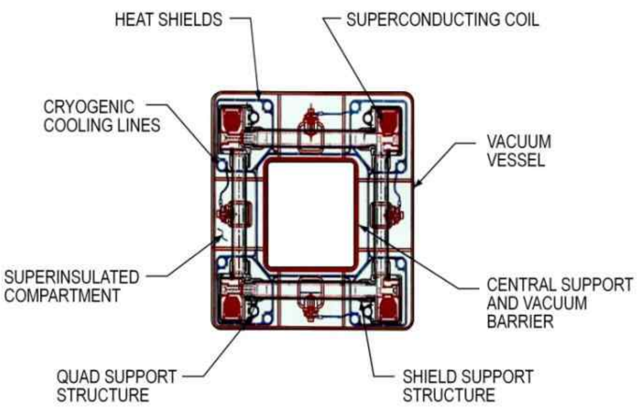

Figure 3 Cross-Section of Quadrupole Magnet

Figure 3 shows a cross section of the Maglev 2000 superconducting quadrupole magnet, the unique heart of the Maglev 2000 system. The M-2000 quadrupole magnet module has 2 superconducting loops of width W, separated by the distance W. The 2 loops carry oppositely directed superconducting currents, resulting in 4 magnetic poles, alternating as one proceeds around the circumference of the quadrupole. The 2 loops can be separate electrical circuits, or be connected together to form a single circuit. The 4 pole feature enables the superconducting quadrupole to magnetically interact with aluminum guideway loop panels positioned vertically on the sides of a monorail guideway beam, using the magnetic pole from the vertical face of the quadrupoles, or they can interact with aluminum guideway loop panels positioned on a planar guideway beneath the Maglev vehicle, using the magnetic pole from the bottom surface of the quadrupole as depicted in Figure 4.

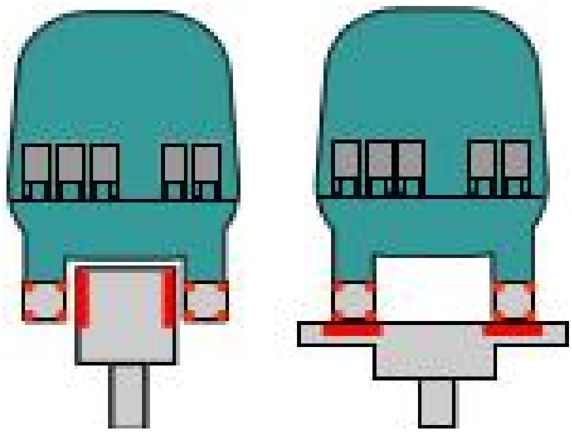

Figure 4 Maglev 2000 Vehicle on Monorail and Planar Guideway Using Quadrupole Magnets

Figure 5 Artist's Drawing of Maglev 2000 Passenger Vehicle on Monorail Guideway

Maglev 2000 vehicles can smoothly transition between the 2 types of guideway, from monorail to planar, and back to monorail. For high speed operation on most of the route (90% or more), vehicles travel on elevated monorail guideways (Figure 5). They are lower in cost, safe at high speeds, visually more attractive, and easy to erect. At locations where switching to off-line stations is scheduled, vehicles would transition to a planar guideway holding 2 lines of planar guideway loops. Initially closely overlapping, the 2 lines would gradually diverge laterally with the straight ahead line of loops being the main high speed guideway, while the laterally diverging line of guideway loops leads to the off-line station.

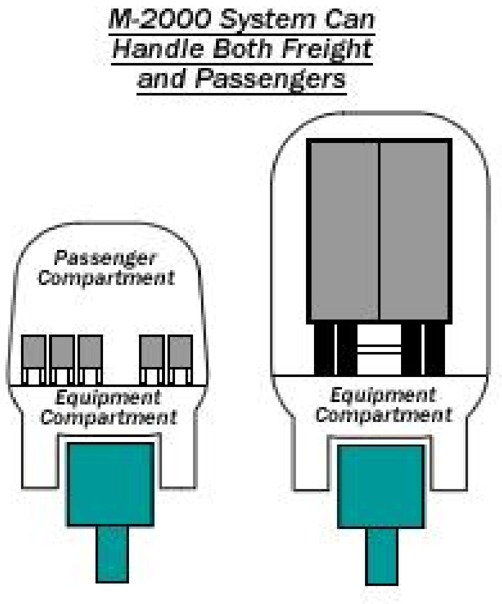

Figure 6. Maglev 2000 Passenger and Truck Carrier Vehicles on Guideway

Figure 6 shows passenger and truck carrying Maglev vehicles on the same monorail guideway. They can access separate off-line stations for unloading/loading operations.

Figure 7. Drawing of levitated Maglev 2000 vehicles traveling on conventional RR track to which aluminum loop panels have been attached to the cross ties.

The guideway panels can also be mounted on the cross-ties of existing RR tracks (Figure 7), enabling levitated travel of Maglev 2000 vehicles along the RR tracks. The panels do not interfere with conventional trains, which can still use the tracks for bulk freight transport, with appropriate scheduling. Maglev 2000 vehicles traveling as individual units allow much more frequent and convenient passenger service, rather than long trains of many RR cars. Also, because Maglev loads are distributed along the vehicle and not concentrated at wheels, local track loading is much less than with conventional trains, greatly increasing track life and reducing maintenance.

The 2nd generation Maglev 2000 System also is unique in its capability to mass produce prefabricated guideway beams, piers and vehicles at large factories and ship them to the construction site, where they can be quickly erected onto pre-poured concrete footings at very low cost, using conventional cranes.

As an alternative to manufacturing the Maglev components in the U.S., they could be manufactured abroad, and transported by container ship to the U.S. One large container ship could transport 20 miles of prefabricated elevated monorail guideway, piers, vehicles, etc. to seaports near the Maglev construction site, at low cost, on the order of 1 million dollars per 2-way mile (Table 1). After unloading at the seaport, the prefabricated beams and piers could be quickly transported by highway trucks to the Maglev construction site, again at low cost, there to be quickly erected by conventional cranes onto pre-poured concrete footings. The jobs? Almost all abroad. Cost of the Maglev system? Somewhat less than if manufactured in the U.S., because of much lower labor costs abroad.

How much raw materials are required for the 2nd generation Maglev 2000 guideway per 2-way mile, and how much do they cost? Table 1 shows the amounts required and their 2010 costs. Amounts of material are based on detailed 3-D computer analyses and fabrication of a full-scale prototype beam. The total of $4,360,000 does not include the additional costs of manufacturing labor, operating cost of manufacturing equipment; electronic power switches for the Linear Synchronous Motor Propulsion System, pre-poured concrete footings, and erection of the beams and piers by conventional cranes at the

Maglev construction site. A significant portion of this additional cost is manufacturing labor. If manufactured in the U.S., adding the above material costs, to the labor cost, switch cost, etc., and emplacing them on the rights-of-way of the Interstate Highways, the projected cost per 2-way mile is 25 million dollars, roughly 10 times the cost of materials.

Table 1 Material Amounts and Costs Per 2-Way Mile for the 2nd Generation Maglev 2000 Guideway System.

Basis: 100 foot long Guideway beams; 106 beams per 2-way mile 30 foot average pier height; piers use ½ of beam materials used in a 100 foot beam. The beam uses 30 cubic yards of concrete, 1.6 tons of stainless steel rebar, 3.1 tons of aluminum conductor, and 4 cubic yards of polymer concrete.
Note: 1 ton =2,000 pounds = 0.9 metric tonne; 1 metric tonne = 1,000 kg.

Guideway Beams and Pier Materials

Amt/2-Way Mile	**Unit Cost**	**$ Cost/2-Way Mile**
Beam – 3,000 cubic yds concrete	$100/cubic yd	$300,000
Pier – 1500 cubic yds concrete	$100/cubic yd	$150,000
Beam – 420 cubic yds polymer concrete	$800/cubic yd	$340,000
Beam – Stainless Steel Rebars – 170 Tons	$4500/ton	$760,000
Piers – Stainless Steel Rebars – 85 Tons	$4500/ton	$380,000
Beam – Aluminum Loops – 330 Tons	$2,200/ton	$730,000
	Total Materials Cost	**$2, 660,000**
Transportation Cost		
Import/Export using Container Ship –10,600 tons	$100/Ton (5,000miles@$0.02 per ton mile	$1,060,000
Truck Transport for 200 miles in	$0.30/Ton Mile	$640,000
	Total Transport Cost	$1,700,000
	Total Cost, Materials + Transport	**$4,360,000**

However, the best strategy would not be to buy 2nd generation Maglev systems from abroad, but instead, manufacture them domestically, for their application in the U.S., together with exporting them to other countries. This would create millions of new domestic jobs, plus reducing the U.S. trade deficit.

4 DESCRIPTION OF THE U.S. NATIONAL MAGLEV 2000 NETWORK

The National Maglev 2000 Network is laid out in 4 phases, with each phase taking 5 years. The first phase completes the development and certification of the 2nd generation Maglev 2000 system. No technology breakthroughs are needed. The materials and manufacturing methods for the various components of the Maglev 2000 system have been developed and are suitable for large scale production. Assembly and testing of full-scale prototype vehicles at operational conditions is needed to certify safety and reliability, so that implementation of the Network can begin. The feasibility of superconducting Maglev has already been proven. The next step is engineering improvements for greater capability and lower cost.

Phase 1 would be completed by December 2015 assuming a start in 2011. Planning for the construction phases 2, 3, and 4, obtaining environmental and regulatory approval, arrangements with private investors, who would fund the construction of the Maglev Network, etc., would proceed in parallel with the testing and certification in Phase 1.

Phase 2, the “First Maglev Wave”; would be built in 5 years, starting in 2016. Figure 8 shows the East and West Coast Networks built in the first Maglev wave. It would serve 26 States in the lower 48 Continental U.S., plus Vancouver, Montreal, and Toronto in Canada. Total population served is 227 million, with 146 million living within 15 miles of a Maglev Station, and able to reach any other station in the Network in a few hours. A total of 6,230 Maglev route miles is built in the first wave, directly serving

Figure 8: First Maglev Wave to Be Built 2016 to 2020 AD

Table 2 Population and States Served in First Wave

Maglev Network	States In Network	Population of States in Network (millions)	Population Living Within 15 Miles of Maglev Stations (millions)	Route Miles in Network
East Coast/Midwest Network	45 MN, WI, IL, IN, OH, PA, NY, MA, VT, NH, MN, ME, RI, DE, MD, VA, DC, NC, SC, GA, FL plus Toronto & Montreal	175.8 (includes Toronto, Montreal)	102.9 (includes Toronto, Montreal)	4,224
West Coast Maglev Network	CA, NV, OR, WA & Vancouver, Canada	50.9 (includes Vancouver)	43.5 (includes Vancouver)	2006
Total for First Maglev Wave (Both Networks)	26 States Plus Toronto, Montreal & Vancouver	226.7	146.4	6230
65 % of population in States Served by the Networks live within 15 Miles of a Maglev Station				

25,000 people per route mile who live within 15 miles of a Maglev station. At 25 million dollars per 2-way route mile, the construction cost per person directly served is only $1,000 dollars. This is extraordinarily attractive. The Maglev riders do not pay for the Maglev routes – they will be privately financed – but they will save at least $1,000 dollars per year in transport costs by riding Maglev. Over a 30 year period, they will save $30,000 and not have to subsidize the Maglev Network. A High Speed Rail Network would serve fewer and its riders would pay much more than other modes. Plus, all U.S. taxpayers would subsidize the HSR Network, even though most could not use it, which is very unfair.

Figure 9: Second Maglev Wave completed in 2021-2025 AD

Table 3 Population and States served in Second Wave

Maglev Network	States In Network	Population of States in Network (millions)	Population Living Within 15 Miles of Maglev Stations (millions)	Route Miles in Network
First Wave Plus Second Wave	45 (Iowa, Nebraska & S. Dakota not in Network) plus Toronto, Montreal & Vancouver	310 (includes Toronto, Montreal & Vancouver)	210 (includes Toronto, Montreal & Vancouver)	18,630
74 % of population in States served by the Network live within 15 Miles of a Station				

Figure 9 shows the second Maglev Wave, built starting in 2021 and proceeding through 2025. Three transcontinental routes would connect the East and West Coast Maglev Networks, plus 5 North-South routes. 45 states would be in the National Maglev Network, plus Vancouver, Toronto, and Montreal in Canada. 310 million people would live in the States and Canadian cities served by the Network, with 210 million people living within 15 miles of a Maglev station. 12,600 Maglev route miles would be added the second Wave bringing the total to 18,600 miles.

Figure 10 shows the third Maglev Wave, which would be built from 2026 to 2030. A 4th transcontinental Maglev route would be built along U.S. I-40, plus various routes to provide more efficient interconnections between the routes built in the 1st and 2nd Maglev Waves. The 48 U.S. States, plus Vancouver, Toronto, and Montreal, would be served by the 28,800 mile National Maglev Network, with a total population of 315 million people. 232 would live within 15 miles of a Maglev station.

Figure 10: Third Maglev Wave completed in 2026-2030 AD

Table 4. Population and States Served in Third Wave

Maglev Network	States In Network	Population of States in Network (millions)	Population Living Within 15 Miles of Stations (millions)	Route Miles in Network
First, Second and Third Waves Completed	48 plus Toronto, Montreal & Vancouver	315 includes Toronto, Montreal & Vancouver	232 includes Toronto, Montreal & Vancouver	28,800
74% of population in States live within 15 Miles of a Station				

The smaller Metropolitan areas, with a few hundred thousand people will have 1 or 2 Maglev stations. The larger areas, e.g. Seattle, Dallas, Chicago, Los Angeles, New York, etc., will have multiple stations with the number of stations depending on the size of the metropolitan area. Each station will connect to all of the other Maglev stations in the high speed intercity Maglev Network. The Network will interconnect all of the 174 metropolitan areas in the continental United states having a population of 250,000 or more persons, with 300 mph Maglev service.

Inside a given metropolitan area, Maglev will also provide local transport service, using existing RR trackage adapted for Maglev travel. The adaptation consists of attaching thin panels containing loops of ordinary aluminum conductor to the RR cross ties. Maglev vehicles can magnetically levitate above, and be propelled along the existing RR track to serve local stations in the metropolitan area. Conventional trains can still use the RR trackage, with appropriate scheduling. The cost of adaptation– only about 6 million dollars per 2-way mile. Existing RR tracks can be quickly adapted for Maglev travel without disrupting existing conventional train service and existing infrastructure.

The Maglev 2000 guideway beams are prefabricated in large factories, and shipped to the construction site by truck, rail, or along an already operating guideway. The 100 foot long beams have aluminum loop panels and other equipment attached to them at the factory prior to shipment. At the construction site, pre-poured concrete footings for the support piers for the guideway beams are already in place. The prefabricated beams and piers arriving at the construction site are quickly erected by conventional cranes onto the pre-poured footings, and the various electrical connections between the beams made.

Maglev 2000 routes can be rapidly constructed. Based on 2 hours to place a guideway beam on a pier, and 4 construction teams at the construction site, with each team having a crane, a 2 shift per day schedule could construct 2 miles per week of 2-way Maglev 2000 guideway, corresponding to 100 miles per year. The first Maglev wave of 6,800 miles over a 5 year construction period would have an average construction rate of 1,240 miles per year. 12 construction crews could do the whole job. Because of the desire to engage local construction companies, there probably would be more construction crews. In any case, field construction requirements will be modest, in cost, and personnel. At 25 million dollars per 2-way mile, the projected cost for the Maglev 2000 monorail guideway, the construction cost of the first Maglev Wave would be $150 billion dollars, about 30 billion $ per year. The U.S. consumes approximately 180 billion gallons of gasoline and diesel fuel annually. 30 billion dollars is equivalent to only 16 cents a gallon – a real bargain, considering Maglev travel will be much cheaper than driving.

The above construction cost does not include the cost of the intercity Maglev 2000 stations. The amortization cost of the Maglev 2000 vehicles is included in operating costs since the number of vehicles depends on traffic volume.

When the 3rd Maglev 2000 Wave is completed, total guideway construction cost of the 28,800 mile National Maglev Network will be approximately 700 Billion dollars. All 174 metropolitan areas in the 48 continental U.S. states are served. Assuming 2 Maglev stations per metropolitan area – many areas will only need 1 station – and conservatively estimated cost of 20 million dollars per average station, stations would cost about 60 billion dollars, bringing total system cost to about 760 billion dollars. The 760 billion dollars would be funded by private investment. Taxpayers would not provide any of the invested capital.

What are the revenues and benefits of the National Maglev Network? First, the revenues. U.S direct transport costs are about 1,500 billion dollars per year, or 30 trillion dollars over a 20 year period to 2030 AD. This is 40 times greater than cost to construct the National Maglev Network. However, the actual cost will be much greater if we continue to rely on oil fueled autos, trucks, planes, and trains. First, the U.S. population will increase from today's (2010) population of 304 million people to 373 million people by 2030. Second, the cost of fuel will be much greater as world supplies dwindle, and countries like China and India get a bigger share of the shrinking oil pie. Third, the *real* U.S. Gross Domestic Product (GDP) per capita – the measure of our average standard of living – will hopefully grow. The real U.S. GDP per capita in 1990, 20 years ago, was $32,000 per person, measured in 2005 dollars. Today, again measured in constant 2005 dollars, real GDP per capita is $43,000 per person, a gain of 1.5% per year. If that the real standard of living grows by 1.5% over the next 20 years to 2030 AD, the real GDP per capita will increase to $58,000, in constant 2005 dollars. What does the increasing population and GDP per capita mean for transportation outlays? In the last year of data from the U.S. Statistical Abstracts, 2001, the U.S. spent 309 billion dollars on intercity truck transport. As the population grows from 285 million people in 2001 to 373 million in 2030, and as their real GDP per capita grows from $39,800 in 2001 to $58,000 in 2030, the intercity truck outlay will grow from $309 billion in 2001 to $590 billion assuming the use of oil fueled trucks in 2030. The actual intercity truck outlay will be much greater than $590 billion, due to the escalating cost of diesel fuel and gasoline.

If in 2030 the 28,800 mile National Maglev Network carried only intercity highway trucks no passengers, autos, or railroad freight containers, what would be the annual U.S. transport savings in constant 2005 dollars? For diesel fueled intercity highway trucks the operating costs, including maintenance, amortization, energy, personnel, traffic scheduling, etc., are about 30 cents per ton mile. Trucks carried on the National Maglev Network would have operating costs of about 10 cents per ton mile. The annual savings in intercity truck transport outlays would be 20 cents per ton mile; for the U.S. the annual savings would be 390 billion dollars! Deducting a 10% return on investment (ROI) to the private investors the net savings in U.S. truck transport outlays would be 314 billion dollars annually. Additional revenues for the National Maglev Network include passengers that would otherwise fly or drive, passengers with their autos, and freight containers, providing over 200 billion dollars of additional revenue per year.

The above projections assume 100% of the long distance transport of trucks, passengers, autos, and freight containers in 2030 AD is on the National Maglev Network. While this will not be the case, the lower cost, faster travel, greater convenience, and environmental benefits, make it likely that the percentage of U.S. long distance travel on the Maglev Network will be high, say in the range of 70 to 80 percent. At a 75% utilization, the net transport savings from the National Maglev Network would be over 300 billion dollars annually, about $1,000 per person per year.

The societal and environmental benefits of the National Maglev Network are even more important than the economic benefits. First, safety and health. Maglev travel will be much safer than by highway. Today, over 5,000 deaths per year and 100,000 serious injuries are due to trucks. Highway deaths and injuries will soar in the years ahead as the roads become much more congested. Transporting trucks and autos by Maglev will save many thousands of lives and serious injuries per year. Moreover, the health damage by pollutants and micro particulates in heavily traveled areas will be greatly reduced. The many Billions of dollars now spent annually because of these deaths, injuries, and damaged health will be avoided. Second, the linked areas of national security and economic productivity. The National Maglev Network will substantially reduce oil imports – 70% of U.S. oil consumption is currently used for transport. Building the National Network will provide millions of new U.S. jobs, for both domestic and export application of Maglev. Reducing transport cost and enabling more efficient, faster delivery of people and goods inside the U.S. will increase economic productivity and make exports more competitive. Third are the environmental benefits. Maglev emits no pollutants and greenhouse gases, is much more energy efficient than current modes of transport, and is very quiet with no rail, braking or engine noise.

5 STATUS OF 2ND GENERATION MAGLEV 2000 TECHNOLOGY

The principal components for the 2nd generation Maglev-2000 System have been fabricated as full scale prototypes and successfully tested. (5) These include the Superconducting Quadrupole Magnet, the guideway aluminum loop assemblies for levitation, stability, and propulsion, the encapsulation of the aluminum loop assemblies into polymer concrete panels, and the fabrication of a 22 meter long, monorail guideway beam that would support a fully loaded Maglev 2000 vehicle.

Figure 11. NbTi Superconductor Loop for Maglev 2000 Quadrupole

Figure 12 shows one of the two wound superconducting loops used for the Maglev 2000 quadrupole. The loop has 600 turns of NbTi superconducting wire. At the design current of 1000 Amps in the NbTi wire, the Maglev 2000 quadrupole has a total of 600,000 Amp turns in each of its 2 superconducting (SC) loops. The SC winding is porous, with small gaps between the NbTi wires to allow liquid Helium flow to maintain their temperature at 4.2 K, and to stabilize them against flux jumps and micro movements.

Figure 12 shows the SC loop enclosed in its stainless steel jacket. Liquid Helium flows into the jacket at one end and exits at the end diagonally across from the entrance providing continuous Helium flow through the SC winding. Before insertion of the SC loop into the jacket, it is wrapped with a thin sheet of high purity, aluminum (5,000 residual resistance ratio) to shield the NbTi superconductor from external magnetic field fluctuations. After closing the jacket, a second layer of high purity aluminum is wrapped around it for additional shielding.

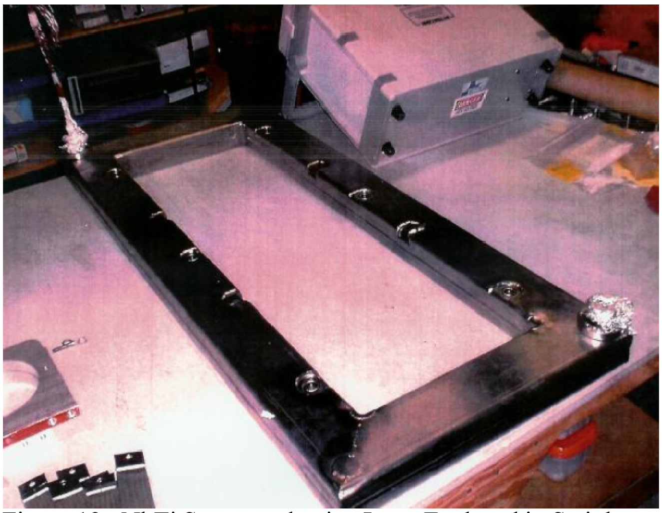

Figure 12. NbTi Superconducting Loop Enclosed in Stainless Steel Jacket

Figure 13. Assembly of Maglev 2000 Superconducting Quadrupole

Figure 13 shows the SC loops, support structure, and cooling currents for the Maglev 2000 quadrupole being assembled in Maglev 2000's facility on Long Island. The SC loops have a 10K thermal shield, which is cooled by Helium exiting from the jacket holding the SC loop. The SC quadrupole structure is then enclosed by an outer layer of multi-layer insulation (MLI) consisting of multiple alternating layers of glass fiber and aluminum foil. A second thermal shield encloses the SC quadrupole, and maintained at ~70 K by the helium out-flow from the 10 K primary thermal shield.

Quadrupole magnetic levitation and propulsion forces were measured using DC current in the aluminum loop guideway assembly beneath the quadrupole as a stand-in for the induced currents. The quadrupole operated at its full design current of 600,000 Amp turns. The magnetic forces between the quadrupole and the guideway loop assembly were measured as a function of vertical separation and lateral displacement from the centered position, and longitudinal position in the direction of movement along the guideway. The measured forces agreed with 3D computer analyses. Since the Maglev 2000 quadrupole tests, high temperature superconductors and are being commercially produced. Using YBCO high temperature superconductor wire, Maglev 2000 quadrupoles would be much simpler to construct, with much easier refrigeration.

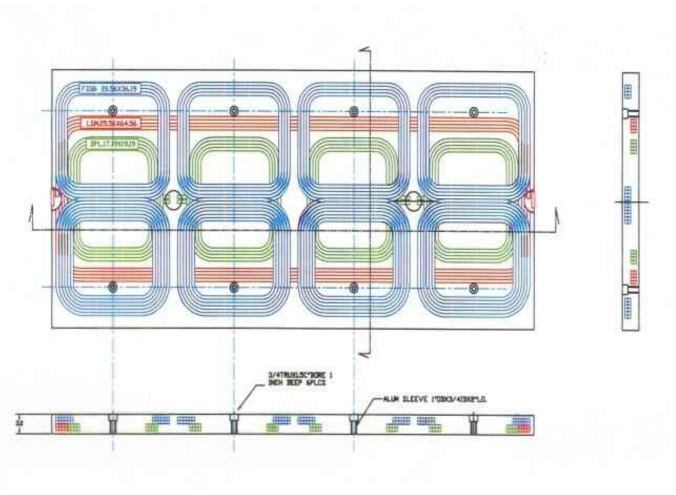

Figure 14. Drawing of aluminum loop guideway panel providing vertical lift and stability, lateral stability, and linear synchronous propulsion

Figure 14 shows a drawing of the Maglev 2000 aluminum wire loop guideway panels. It has 3 sets of multi-turn aluminum loops: 1) a sequence of 4 short independent Figure of 8 loops; 2) a sequence of 4 short dipole loops; and 3) 1 long dipole loop. When the panels are mounted on the vertical sides of the monorail guideway beam, the Figure of 8 loops provide levitation and vertical stability. The dipole loop on each side of the beam are connected together into a null flux circuit that maintains the vehicle in a centered position on the beam – when centered, no current flows in the aluminum null flux circuit, when an external force (wind, curves, etc.) acts to push the vehicles away from its centered position, a magnetic force develops that opposes the external force. The long dipole loop is part of the Linear Synchronous Motor (LSM) propulsion system, in which the loops on a sequence of panels are connected in series to form an energized block along which the Maglev vehicles travels. The energized block is typically on the order of 100 meters in length; as the vehicle leaves an energized block, its AC propulsion current is switched into the next block that the vehicle is entering. For the planar guideway, the same panel design is used, with the panel laid flat on the planar surface beneath the line of quadrupoles on the moving vehicle. The Figure of 8 loops now provide lateral stability, generating magnetic restoring forces if an external force acts to displace the vehicle from its centered position on the guideway. The dipole loops act individually, with inductive currents that levitate and vertically stabilize the vehicle as it passes overhead. The LSM loops function in the same way as they do on the monorail guideway. The planar guideway panel configuration can also levitate and propel Maglev vehicles along existing RR tracks, with the panels attached to the cross-ties of the RR tracks.

Figure 15 shows a completed guideway loop panel with all of its 9 loops. The completed panel is then enclosed in a polymer-concrete structure for handling and weather protection. (Figure 16) Polymer concrete – a mixture of aggregate, cement and plastic monomer – can be cast into virtually any form as a slurry. When the monomer polymerizes (the rate of polymerization is controlled by the amount of added promoter), the resulting concrete-like structure is much stronger – a factor of 4 or greater – than ordinary concrete and not affected by freeze thaw cycles, salt, etc.

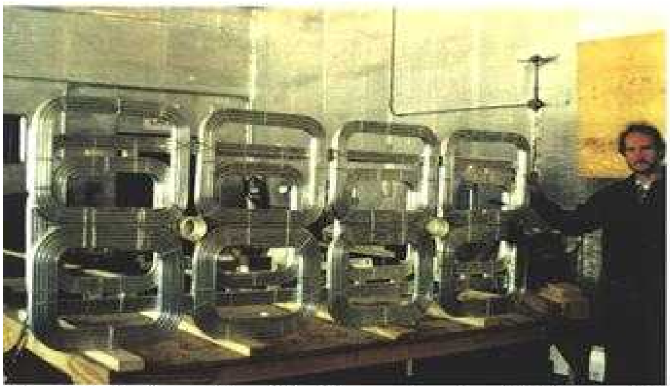

Figure 15. Completed Guideway Panel with Figure of 8 Dipole, and LSM Propulsion Loops

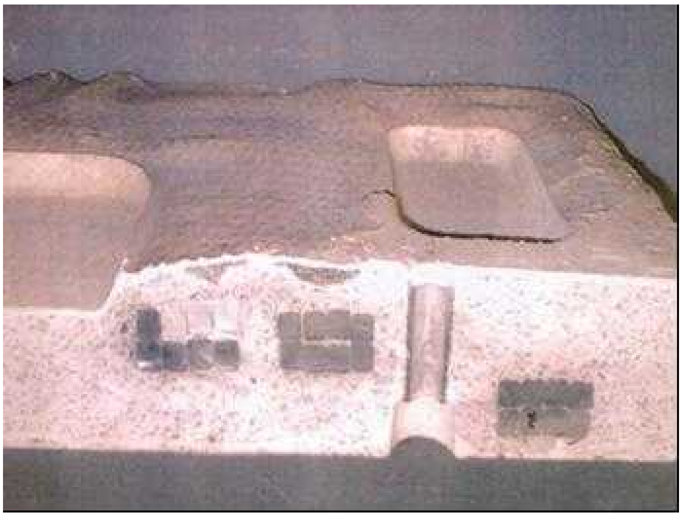

Figure 16. Guideway Loop Panel Enclosed in Polymer Concrete Matrix

Figure 17 shows a completed polymer concrete panel left outside of the Long Island facility for 2 years. It was subjected to a wide range of weather conditions and multiple freeze-thaw cycles over the 2 year period, without any degradation. After being fabricated at the Maglev factory, the guideway panels would be attached to the sides of the monorail or the surface of planar guideway beams to be shipped to a construction site for an elevated guideway, or transported to existing RR trackage that was to be modified for use by Maglev 2000 vehicles.

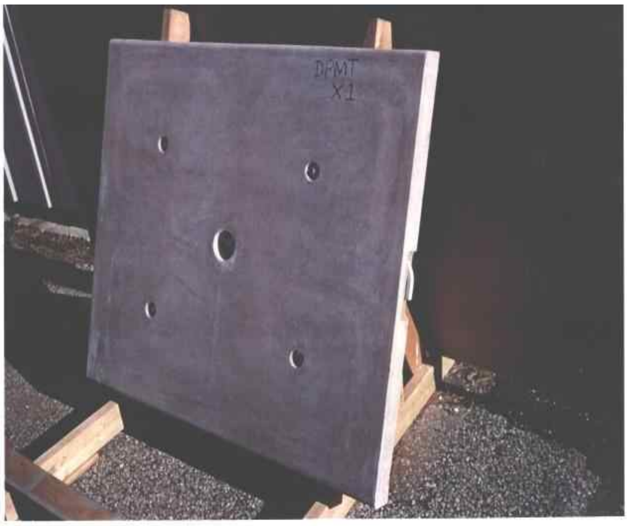

Figure 17. Polymer Concrete Panel with Enclosed Aluminum Loop Exposed for 2 Years to Outdoor Environment with Multiple Freeze-Thaw Cycles

Based on fabrication experience at Maglev 2000's facilities on Long Island and Florida, using hand operated tooling, the 9 loops for a 2.2 meter long guideway panel can be fabricated in less than 1 week by one person. At $25 per hour, fabrication would then cost less than $1,000 per loop. Per mile of 2-way guideway (2,800) this amounts to less than 2.8 million dollars if made by hand. With automated tooling, the fabrication cost of the aluminum loops can be brought down considerably, to the order of 1 million dollars per mile. At $4 per kg for the aluminum conductor and $1 per kg for polymer concrete, the cost of the materials for the monorail guideway panels would be approximately 5 million dollars per 2-way mile.

The monorail guideway beam is a hollow box beam made with reinforced concrete. Beam length is 22 meters and weight is 34,000 kg. It uses post tension construction, which allows the tensioning cables in the base of the beam to be re-tightened if some stretching were to occur. The beam is tensioned to have a 0.5 cm upwards camber at the midpoint of the beam when it is not carrying a Maglev vehicle. When the Maglev vehicle is on the beam, the beam flattens out to a straight line condition, with no vertical dip or camber along its length.

Figure 18. Photo of 72 Foot Long Monorail Guideway Beam Delivered to Maglev 2000 Facility in Florida from Fabrication Site in New Jersey

Figure 18 shows a photo of the fabricated beam after transport by highway truck from the manufacturing site in New Jersey to Maglev 2000's facility in Florida. No problems in transport by highway were encountered.

6 SUMMARY AND CONCLUSION

The National Maglev Network will create America's new "Interstate Highway" system for the 21st Century that will be faster, cheaper and environmentally much better than our present Interstate Highway System. It will drastically reduce our dependence on foreign oil imports, substantially reduce greenhouse gas emissions, save many thousands of lives now lost on the highways every year, prevent hundreds of thousands of serious injuries, improve public health by eliminating pollution and micro particulates from cars and trucks, and brake dust from commuter and light rail operations, reduce congestion and eliminate delays due to adverse weather. Plus, it will be much more comfortable to travel by Maglev – no road, rail, braking, or engine noise, no bumpiness and lots of very comfortable sitting room for the traveler. It will save many hundreds of hours of commuting time, be extremely reliable, and much less stressful than traveling on our existing transport systems. On the National Maglev Network, people will travel at high speeds to convenient, easily accessible stations near their final destinations. Autos and trucks will simply drive off the Maglev vehicle and go by highway to their destinations; passengers will use public or private transit.

There are only two transport options for America in the decades ahead. Either we continue with our present oil fueled transport vehicles, using synfuels from coal, tar sands, oil shale, etc., or we transition to electric transport with the National Maglev Network. Synfuels will lead to environmental catastrophe, maybe not within the lifetimes of America's older citizens, but very likely within the lifetimes of our young children. Hopefully, America and the rest of the World does care, and will chose to transition to electric transport before it's too late. In choosing electric transport, besides ensuring a sustainable society and avoiding environmental disaster, there will be major economic, social, and personal benefits in doing so, with the benefits far outweighing the transition costs.

How soon can the 28,800 mile National Maglev Network be built? Described is a practical 20 year program to build the 28,800 mile National Maglev Network, with all segments completed by 2030 AD. On an emergency basis it could probably be built faster, probably in half the time. The important thing is to start now.

7 REFERENCES

1. Highway Research Board, NAS, 1962. http://www.saferoads.org/issues/fs-trucks.htm
2. "Comparison of Cost for Maintaining Highway and Waterway Freight Transport Systems" U.S. DOT, April 9, 2001
3. Table 1-32 "U.S. Vehicles miles, Research and Innovative Technology Administration," Bureau of Transportation Statistics
4. National Highway Traffic Safety Administration (2008);http://www.nrd.nhtsa.dot.gov/pubs/811162pdp
5. Maglev Transportation Technology: Final Report to Florida Dept. of Transportation and Federal Railway Administration" Maglev 2000 of Florida. Final Report (April 2002)