The West Coast Maglev Network
Transport for the 21st Century

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January 20, 2010

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The West Coast Maglev Network

Executive Summary

The proposed West Coast Maglev Network would connect the metropolitan areas in California, Nevada, Oregon, and Washington State, plus the Vancouver, British Columbia area into a high speed Maglev network that would quietly transport many thousands of passengers, highway trucks, and personal autos six inches off the rails at speeds of 300 mph and one-fifth the cost of airline travel. 42 million persons in California, Nevada, Oregon, and Washington, 85% of the total population of 49 million in the 4 states, would live within 15 miles of their local Maglev station, from which they could reach any other station in the Maglev Network within a few hours. Another 1.3 million persons in the Vancouver area would be served by the Network, making the total population within 15 miles of a Maglev station equal to 43.3 million people. Total government funding is limited to $600 million over 5 years for upfront demonstration and certification activities. After that, freight capability enables building the entire network with private financing.

Typical trip times on the Maglev Network, compared to going by highway would be:

San Diego to Seattle	4 hrs 30 min vs 25 hrs 15 min
San Francisco to Los Angeles	1 hr 45 min vs 9 hrs 40 min
Portland to San Francisco	2 hrs 30 min vs 12 hrs 45 min
Los Angeles to Las Vegas	1 hr vs 5 hrs 30 min

In addition to much shorter trip times by Maglev, the cost of travel by Maglev would be significantly less for passengers, highway trucks and personal autos as compared to existing transport modes:

Passengers	3 cents per passenger mile (PM) on Maglev, compared to 40 cents per PM for driving by auto, 15 cents per PM by air and 50 cents per PM by High Speed Rail
Highway trucks	10 cents per ton mile by Maglev compared to 30 cents per ton mile by highway
Personal autos	30 cents per mile by Maglev transport compared to 40 cents per mile by highway

Traveling by Maglev, in addition to being much faster and cheaper than traveling by existing modes of transport – highway, air, and rail – is much better both personally and for the economy, society, and the environment. Among the benefits of the West Coast Maglev Network are:

- Creation of many thousands of new U.S. manufacturing jobs, both for domestic use of Maglev, and also for exports of Maglev equipment to other countries.
- A more efficient economy, due to the lower cost of transport and faster deliveries.
- Greatly reduced emissions of pollutants, micro particulates, and greenhouse gases that damage public health and the environment, including global warming.
- Significant reductions in highway deaths and injuries.

- Much less damage to the highways and reductions in highway repair and maintenance costs – one 18 wheeler highway truck does as much highway damage as several thousand autos, according to US DOT statistics.
- Much more reliable travel without delays due to congestion and bad weather. Maglev is not affected by bad weather and operates on schedule even when traffic flow is very high.
- Much more convenient scheduling – Maglev vehicles are self propelled and can operate as single units, not long trains of many cars, enabling shorter wait times for the next scheduled service.
- Less stressful travel – no engine or rail noise, and no vibration.

The West Coast Maglev Network would be primarily constructed on the rights-of-way alongside the I-5 and I-15 Interstate Highways. The I-5 corridor runs from San Diego northwards through Los Angeles, Sacramento, Eugene, Portland, and Seattle to the US/Canadian Border, where it transitions to the Canadian highway leading to Vancouver. The I-15 Corridor runs from Los Angeles to Las Vegas. I-5 has a total length of 1381 miles from the US/Mexico border South of San Diego to the US/Canada Border north of Seattle, while I-15 has a length of 275 miles from Los Angeles to Las Vegas. Side Maglev routes from the Maglev route along I-5 lead to other metropolitan areas in California, including San Francisco, Oakland and the Bay Area, San Jose, Santa Cruz, Modesto, Merced, Fresno, Hanford-Visalia, Bakersfield and Oxnard & Ventura. The I-15 corridor, besides serving Las Vegas, also serves San Bernardino, Riverside, and Ontario. Smaller communities, not listed here, along the I-5 and I-15 corridors and the side Maglev routes are also served (See Map)

Total high speed (300 mph) Maglev route mileage for the West Coast Maglev Network is 2,000 miles. In addition, Maglev-2000 vehicles, the Maglev system proposed for the West Coast Network, can also travel in the magnetically levitated and propelled mode on existing railroad tracks – both heavy, light, and commuter rail – that have had very low-cost aluminum loop panels attached to the RR cross ties. This unique capability allows Maglev-2000 vehicles to serve, at low cost, many stations that are conveniently located for quick access inside a given metropolitan area, using the existing rail infrastructure.

Travel speeds on the existing rail infrastructure inside the urban and suburban areas in the given metropolitan area are lower, on the order of 100 to 150 mph, than the 300 mph service between different metropolitan areas. The Maglev-2000 vehicles can electronically switch from one guideway to another without requiring movement of mechanical switches. This allows the Maglev vehicles to bypass off-line stations at high speed that they are not scheduled to stop at. As a consequence, vehicles can employ “skip-stop” service, and maintain high average speed even though the distance between stations is relatively small. In addition, because Maglev vehicles can accelerate and decelerate at the same rate as automobiles, and much more rapidly than conventional and High Speed Rail trains, the average speed of Maglev service is much greater than by highway or rail.

The I-5 corridor is already congested, with very high traffic flows, which are projected to increase greatly by 2035. The following table shows data on the I-5 Corridor, as given by the US DOT.

Vehicle Flows and Congestion Along the I-5 Corridor

Traffic Flow on Corridor				
	2007		2008	
	Avg	Max	Avg	Max
Vehicles/Day	71,000	300,000	150,000	~600,000
Trucks/Day	10,000	35,000	22,000	~70,000
Urban Segments,* % Congestion	65%		95%	
Rural Segments, % Congestion	31%		85%	
*(550 miles of 1381 mile total length are urban segments)				

Based on the above data, a Reference Case for the average traffic flow on the West Coast Maglev Network was assumed, with

- 5000 Trucks Per Day (2 per Maglev Vehicle)
- 30,000 Passengers per day (100 per Maglev Vehicle)
- 20, 000 personal autos carried on Maglev per Day (10 per Maglev vehicle)

The above traffic flows on Maglev are a significant fraction of the 2035 traffic flow, but could be increased substantially if demanded.

For the Reference Case described above, travels by Maglev results in major savings in transport cost, as given below:

	Maglev Travel (B$ per year)	Existing Mode of Travel (B$ per year)
Passengers	0.64 B$	6.6 B$ (Highway & Air)
Autos w/Passengers	4.7 B$	5.8 B$ (Highway)
Highway Trucks	7 B$	21 B$
Total	12.3 B$	33.4 B$
Savings by Maglev = 21B$ per year		

The annual energy consumption savings are also very large as given below:

	Maglev Travel (KWh/year)	Existing Mode of Travel (KWh/year)
Passengers	2.2 Billion	36 Billion
Autos w/Passengers	14 Billion	24 Billion
Highway Trucks	23 Billion	32 Billion
Total	39.2 Billion	92 Billion
Savings by Maglev = 53 Billion KWh per Year		

The savings in carbon dioxide (CO_2) emissions enabled by Maglev are also very large. [Maglev has 0 emissions, because its electric power will primarily come from non-fossil fuel power plants in the next 20 years.]

	<u>Maglev Travel</u> (Million Tons of CO_2/yr)	<u>Existing Mode of Travel</u> (Million Tons of CO_2/yr)
Passengers	0	11
Autos w/Passengers	0	7.4
Highway Trucks	0	9
Total	0	27 million tons
Savings by Maglev = 27 million tons of CO_2 per Year		

The West Coast Maglev Network can be in full operation by 2019, given an aggressive program with adequate funding.

Construction ground breaking would start in 2015, following a 5-year program to demonstrate and certify the various types of Maglev vehicles – passenger, auto w/passengers carrier, and highway truck carrier on a test guideway at commercial operating conditions. Planning activities, environmental permits and startup of guideway production plants would also be carried out in parallel with the testing of commercial type vehicles.

The Network would be constructed over a 4 year period by simultaneously carrying out construction of 9 segments of the 2000 mile network. Each segment would run between major metropolitan areas on the Network, e.g. San Diego to Las Angeles would be one segment, Anaheim to Las Vegas another segment, and so on. Each segment of the Network would have one or more guideway beam and pier manufacturing plants. At each plant, conventional reinforced concrete box beams and piers would be manufactured. The construction rate would be well within existing concrete plant capabilities; for example, the average construction rate for a plant would be only 16 beams per day.

The beam plant would attach the guideway aluminum loop panels and other Maglev equipment to the sides of the beams (the panels and equipment would be mass produced and shipped to the beam plant). The finished Maglev guideway beams would then be trucked to the construction site and quickly erected by conventional cranes on piers that had been previously set on pre-poured concrete footings. The piers would be segmented and their height adjustable so that the final elevated monorail guideway remained flat and level, even if the local terrain was rolling, i.e., had hills and valleys.

At a construction rate of 16 guideway beams (each 100 feet in length) per day, each end of the extending segment of completed 2-way guideway would lengthen at a rate of 400 feet per day, equal to 28 miles per year. In 1 year, counting both ends, the guideway would extend by a total of 56 miles. Over a 4 year construction period, the 13 beam & pier plants involved in the construction of the West Coast Maglev Network would construct over 2000 miles of elevated monorail guideway.

The projected construction cost is on the order of 50 Billion dollars, based on an average unit cost of 25 million dollars per 2 way mile. Amortization of the construction cost plus maintenance costs are expected to be very small, since there is no mechanical contact or friction, and the loads on the beam are distributed and low, in contrast to the large point loads under the wheels of trains, trucks, and cars.

The unit Maglev transport costs for passengers, autos w/passengers, and trucks, include amortization and maintenance of the guideway (10% per year of construction cost), vehicle amortization and maintenance (10% of vehicles capital cost per year), vehicle propulsion power at a cost of 10 cents per KWh, and operating personnel. The very large savings in transport costs compared to existing modes of transport, 21 Billion dollars per year, make the West Coast Maglev Network very attractive for private financing. There appears to be no need for government funding and operation of the Maglev Network, once the Maglev-2000 system has been demonstrated and certified by the government. The projected cost for demonstration and certification is 600 million dollars over a ~5 year period, equal to about 12 hours of the cost of imported oil at 100 dollars per barrel. From that point on, private financing will build and operate the West Coast Maglev Network.

In addition to transporting passengers, highway trucks,, personal autos, and freight containers at speeds of 300 mph on the West Coast Maglev Network, the 2nd generation Maglev-2000 technology can also be used to store large amounts of electrical energy from variable power sources, e.g. wind and solar, so that it can be supplied to the electric power grid when it is needed to meet demand. The MAPS (MAglev Power System) stores electric energy by moving heavy, e.g. 100 ton blocks uphill on a Maglev guideway to an upper storage yard. To meet electric power demand, the blocks are moved downhill to a lower storage yard to generate energy. The Maglev propulsion system operates in the motor mode, converting electric input energy to potential energy of the blocks as they climb. To retrieve the stored energy, the Maglev propulsion system operates in the generating mode, converting the stored energy in the blocks back to electric energy as they descend.

The MAPS system is similar to conventional pumped hydro, except that it is much more efficient – 95% of the input electric energy is returned to the grid, compared to only 60% for pumped hydro. Moreover, the cost to store electric energy using the MAPS system is only 2 cents per KWh, compared to about 10 cents per KWh by pumped hydro. Finally, the environmental impact of MAPS is much less than pumped hydro, and there are many more potential sites for MAPS. Other modes of energy storage – batteries, flywheels, etc., are too expensive and limited in storage capability to be practical for large scale storage of electric energy.

Another major application of 2nd generation Maglev-2000 technology is the long distance transport of fresh water to water scarce regions. The Maglev-2000 Water Train can deliver Billions of gallons of water per day over distances of hundreds of miles at a cost of only 1$ per 1000 gallons – a much lower cost than by pipeline.

Low cost transport of large amounts of fresh water is very attractive for Nevada and California. Low cost storage of large amounts of electric energy is also very attractive for wind and solar farms in all 4 states on the West Coast Maglev Network – California, Nevada, Oregon, and Washington.

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1. Introduction

Features of the West Coast Maglev Network

- Transports Passengers, Highway Trucks, Freight Containers, & Personal Autos
- Cheaper than Flying, Driving, or Rail
- 300 mph Travel – Seattle to San Diego in 4 Hrs (20 Hours by Highway)
- Removes Trucks From I-5 Highway – Much Less Congestion, Accidents, & Highway Damage
- Network Connects All 4 States on West Coast
- Privately Financed

85% of the 49 million people in California, Oregon, Washington, and Nevada, will live less than 15 miles from a Maglev station, and travel to any other Network station within a few hours. They can drive their personal auto onto a Maglev auto carrier and travel with it, at lower cost and much faster than by highway, comfortably, with no traffic congestion, no accidents, and no weather problems.

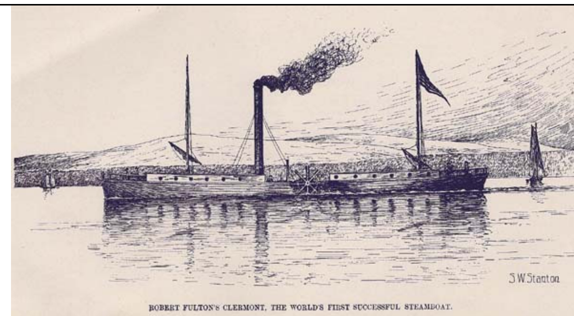
The West Coast Network, privately financed with revenues from carrying long distance highway trucks, will not be subsidized by taxpayers.

The West Coast Maglev Network, and the Maglev-2000 System that makes it technically and economically practical, are described later.

Very important is the question, who will lead the World in Maglev transport, which will be the dominant mode of transport in the 21st Century transport?

Maglev based industries – superconducting magnets, vehicles, guideways, and other equipment will create millions of high paying jobs and many Billions of dollars per year in exports. Will it be America or some other nation to receive these benefits? To help answer this question, let's take a quick trip through history.

2. America the World Leader in Transport – Past Triumphs

<table>
<tr><td>The Erie Canal</td><td>Steam Boats on the Hudson</td></tr>
<tr><td></td><td>
</td></tr>
<tr><td>• 363 miles, Albany to Buffalo
• Hand Dug, 40 ft Wide, 4 ft deep
• Built in 8 years (1817 to 1825)</td><td>• First Trip in World By Steamboat
• Robt. Fulton's "Clermont"
• NYC to Albany on August 17, 1807</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>The Transcontinental Railroad</td><td>The Panama Canal</td></tr>
<tr><td></td><td></td></tr>
<tr><td>• First Railroad Across America
• Built in 6 Years (1863 to 1869)
• 7 Day's @ 65 mph to Cross America</td><td>• Fast, Safe Trips, Atlantic to Pacific
• No More Trips Around Cape Horn
• Built in 12 Years (1902 to 1914)
• 15,000 Ships Thru Canal in 2008</td></tr>
</table>

America the World Leader in Transport – More Past Triumphs

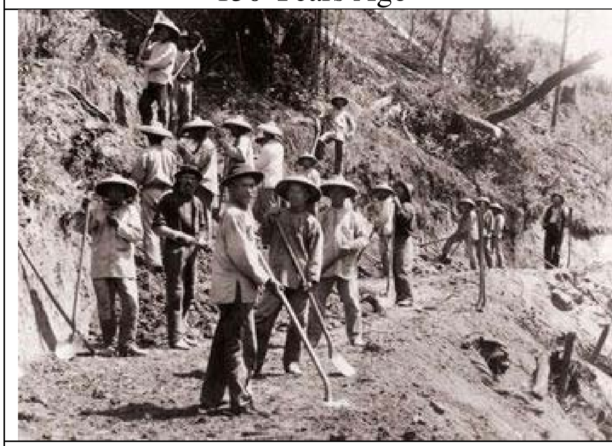
The Wright Brothers	Henry Ford and the Model T
	
• 1^{st} Powered Flight @ Kitty Hawk, N.C. (Dec, 1903 • Coast to Coast Travel in 1911 (The VIn Fizz) • Widely used in WWI (1914-1918)	• Production 1908-1927 • Most Influential Car of the 20^{th} Century • Cost $290 ($3,200 in Today's Dollars) • 10% of Cars in World were Model T's
Eisenhower's Interstate Highway System	The Moon Landing
	
• Eisenhower signed Interstate Highway Legislation in 1956 • 46,000 mile Network • 1/3 of US Road Travel is on Interstates	• 7 years from virtually zero to the landing (1962-1969) • Completely new technologies opened up space for commerce and exploration

In the early 1800's, we traveled by horse and wagon and sailing ships. Then America revolutionized transport with the innovations shown above, and greatly improved our standard of living. Without these innovations, we still would be using horses and wagons and sailing ships. America's transport innovations overcame tremendous engineering challenges and were carried out in only a few years. Can America still innovate in transport? The current experience is discouraging, as we see next.

3. American Transport Today – The Discouraging Reality

In the 40 years since the Moon Landing, American innovation in transport has been dismal. Our existing transport systems are in trouble. The US auto industry is in decline, highway congestion is growing, Trillions of dollars are needed to repair crumbling transport infrastructure, mass transit systems need bigger subsidies, and airlines are going bankrupt, as fares keep climbing.

What is the government's plan to improve American transport? Right now, it is to install subsidized Steel Wheel High Speed Rail (HSR) passenger trains from Europe and Asia in a few isolated locations around America. This is not like the Transcontinental Railroad that America built 150 years ago, when the good jobs went to Americans.

150 Years Ago	Today
	
Chinese Workers Laid the Tracks for American Trains	American Workers Will Lay the Tracks for High Speed Trains Bought From Europe & Asia

Outsourcing jobs and increasing the trade deficit by buying High Speed Rail is a big mistake. HSR will:

- Require massive government subsidies – cannot be privately financed
- Have high fares and serve only a tiny fraction of US transport needs
- Not take trucks off the road and reduce highway congestion
- Not be a National Network – only serve a few isolated locations
- Not significantly increase energy efficiency & reduce oil imports
- Benefit only a small portion of the US population, while all taxpayers will have to subsidize its construction and continued operation.

4. American Transport Today – Missed Opportunities

Each new transport revolution led by America over the last 200 years from the Erie Canal to the Moon Landing has generated a more productive economy, and a higher living standard.

What is the next step for America? It is not High Speed Rail, which can only yield a marginal improvement. The next step is Maglev, the first new mode of transport since the airplane. Maglev vehicles have no wheels or engines. Instead, they are magnetically levitated and propelled along a guideway with no mechanical contact or friction, their speed limited only by air drag. Maglev vehicles are electrically powered with very high energy efficiency. They do not emit pollutants and greenhouse gases.

Superconducting Maglev was invented in America in 1966 by James Powell and Gordon Danby. Sadly, so far, vested transport interests have prevented the US from developing Maglev. Japan, however, took Powell and Danby's inventions and has built their successful 1st generation Passenger Maglev System.

<table>
<tr><th>2nd Generation US Maglev-2000</th><th>Operating 1st Generation Japanese Maglev</th></tr>
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Japan's demonstration Maglev System has achieved speeds of 361 mph and carried well over 50,000 passengers, with accumulated running distances of hundreds of thousands of miles. Japan plans to build a 300 mile Maglev line between Tokyo and Osaka, to carry more than 100,000 passengers daily, with a trip time of 1 hour.

Powell and Danby have developed the new 2nd generation Maglev-2000 System that is much cheaper and more capable than the Japanese system. Besides passengers it can carry high revenue highway trucks, personal autos, and freight containers at lower cost and faster than present US transport systems. Full scale Maglev-2000 components have been successfully tested. Once certified by government testing, Maglev-2000 routes can be privately financed without government subsidies. The Maglev-2000 system is described later. Next is how it would enable the West Coast Maglev Network.

5. American Transport's Next Triumph – The West Coast Maglev Network

The West Coast Maglev Network	Network Connects 51 Million Persons

- California (36.5 Million)
- Oregon (3.8 Million)
- Washington (6.5 Million)
- Nevada (2.6 Million)
- Vancouver, BC (1.3 Million)
- 85% within 15 miles of a station

Main Maglev Routes Along I-5 and I-15

- Side Routes to San Francisco, San Jose, Fresno, etc.
- 1,380 Route Miles San Diego to Canada
- 2,000 Total Route Miles in Network

West Coast Network Connects to the East Thru Montana (I-90), Idaho (I-84), Utah (I-80) and Arizona (I-10)

Table 1

Trip Times & Costs on the West Coast Maglev Network					
Illustrative Trip	Trip Miles	Trip Time	One Way Trip Cost		
			Passenger	Auto w/ Passengers	Highway Truck *
San Diego to Seattle	1260	4 Hr 30 Min	$36.50	$403	$128
San Francisco to Los Angeles	480	1 Hr 45 Min	$13.90	$154	$49
Portland to San Francisco	640	2 Hr 30 Min	$18.60	$205	$65
Los Angeles to Las Vegas	275	1 Hr	$8.00	$88	$28

*$ Per Ton of Load, 30 Tons Load per Truck

<u>Basis</u>

280 mph Avg Speed
Daily Avg Traffic

- 30,000 Passengers
- 20,000 Autos w/Passengers
- 5000 Highway Trucks

10 Cents/KWh
Unit Capital Cost

- 25 M$/2-Way Mile for Guideway
- 5 M$/Maglev Vehicle

Trip costs include amortization and maintenance of the Maglev guideway and vehicles, propulsion energy cost, vehicle operating cost, and system labor cost. They do not include profit, if privately financed.

The travel times for Maglev are comparable to those for air, and much faster than by highway and conventional rail, and substantially faster than high speed rail. Table 2 compares trip times on the West Cost Maglev Network with existing transport modes. For shorter trips, Maglev is faster than air travel because of the pre-boarding times at the airport.

Table 2
Comparison of Maglev Trip Times With Those of Other Transport Modes

Illustrative Trip	West Coast Maglev Passenger, Auto , or Truck	Air [(1)] Passenger	Rail Passengers [(2)]		Highway, [(3)] Auto & Truck
			Conventional Rail	High Speed Rail	
San Diego to Seattle	4 Hrs 30 min	4 Hrs	21 Hrs	9 Hrs 40 min	25 Hrs 15 min
San Francisco to Los Angeles	1 Hr 45 min	2 Hr 30 min	6 Hrs	3 Hrs 45 min	9 Hrs 40 min
Portland to San Francisco	2 Hrs 30 min	2 Hr 45 min	10 Hrs 45 min	4 Hrs 50 min	12 Hrs 45 min
Los Angeles to Las Vegas	1 Hr	2 Hr	4 Hrs 40 min	2 Hrs 10 min	5 Hrs 30 min

(1) Includes 1 Hr Pre-Boarding Time at Airport for Check-In
(2) Average Speed of 60 mph by Conventional Trains (Amtrak)
Average speed of 130 mph by High Speed Rail (French TGV)
(3) Average Highway Speed of 50 mph (Including Congestion Delays & Rest Stops

The average speed on Amtrak is taken as 60 mph. The peak average speed on the Amtrak system is 75 mph on the Acela Express from New York City to Washington, DC. The average speed for the Boston to Chicago run (Lake Shore Limited) is only 44 mph. The assumed 60 mph as an average speed for conventional rail probably overstates the actual speed. The highest average speed for High Speed Rail in Europe is the French TGV, at 130 mph. An average highway speed of 50 mph on Interstate I-5 appears reasonable, including delays due to congestion and rest stops, though there are long segments where average speed can be much less than 50 mph. The air passenger speed is taken from airplane schedules, plus 1 hour for pre-flight activities at the airport. The trip miles and times for Maglev service to San Francisco includes the 41 mile distance from Sacramento, which is on I-80, to San Francisco.

6. Traffic and Travel Costs on the I-5 Corridor

The Interstate I-5 Corridor is already highly congested, and congestion will grow further in the years ahead, as projected by the US DOT. Average vehicle flow refers to the flow averaged over the 1,380 mile-long I-5 Interstate Highway from San Diego to the Canadian Border, while maximum flow refers to the maximum at some point along the corridor.

Table 3
Vehicle Flows and Congestion Along Interstate I-5

	2007		2035	
Parameter	Average Flow	Maximum Flow	Average Flow	Maximum Flow
Vehicles/Day	71,000	300,000	150,000	~600.000
Trucks/Day	10,000	35,000	22,000	~70,000
% Congestion	• 65% of Urban segments (550 miles) heavily congested • 31% of rural segments (800 miles) heavily congested		• 95% of urban segments and • 85% of rural segments heavily congested.	

Highway trip times in 2035 will be even longer than those given in Table 2. Virtually all 1,380 miles of the I-5 corridor will be heavily congested.

Table 4 compares the cost of Maglev travel with the other transport modes for the I-5 Corridor, based on the unit costs for Maglev and today's costs for the other transport modes, which will significantly increase as oil becomes more expensive.

Table 4
Comparison of Maglev Travel Costs with Costs for other Modes

	Unit Cost	Maglev [1]	Highway [2]	Air [3]	High Speed Rail [4]
Passengers	Cents/passenger mile	2.4	---	15	50
Autos	Cents/mile	3.2	40	---	---
Trucks	Cents/ton mile	10.2	30	---	---
Seattle to San Diego Trip (1,260 miles one way) Dollars					
Passengers		$36.50	Travel w/Auto	$190	$630
Auto w/Passengers		$403	$500	---	---
Trucks		$128	$480	---	---

(1) Costs include amortization and maintenance of guideway & vehicles
(2) Avg cost of operating a car (depreciation, fuel, tires, etc)
(3) Avg cost per passenger mile (US Statistical Abstract)
(4) Cost/passenger mile for High Speed Rail in Europe

7. Why Are Maglev Travel Costs So Low?

The costs of passenger travel on the West Coast Maglev Network is very low, compared to the cost for High Speed Rail, 2.9 cents per passenger mile for Maglev, versus 50 cents per passenger rail. Partly this is because the Maglev-2000 guideway cost is less than that for High Speed Rail, but principally because Maglev can transport high revenue highway trucks and High Speed Rail cannot. In the travel costs shown in Tables 1 and 4, 30,000 passengers daily are carried by 300 Maglev vehicles, while 2,500 Maglev vehicles are used to carry trucks (2 trucks per Maglev vehicle) and 2,000 vehicles are used to carry autos. The guideway amortization and maintenance cost per vehicle is apportioned by dividing the total guideway A&M cost by the number of Maglev vehicles that operate on it. As a result, passenger Maglev vehicles pay only 6% of guideway A&M cost, while High Speed Rail passenger trains pay 100% of the track A&M costs. Essentially, Maglev passengers only pay for vehicle A&M costs, plus propulsion energy and labor costs, which are very low.

Why would trucks want to travel on Maglev? Basically, because their costs per ton-mile of load on Maglev are only about 10 cents per ton-mile, compared to about 30 cents per ton-mile of highway. Why are the costs lower by Maglev?

1. A trucking company needs much fewer trucks to deliver loads. One truck on 300 mph Maglev = 5 trucks @ 60 mph by highway.
2. Maintenance costs are much lower for the trucks
3. Avoids high fuel costs (~7 Cents/ton-mile by highway)
4. Much lower driver costs
5. Avoids need for long-distance driver to rest
6. No congestion delays or weather problems
7. No need to pull over for contacts with dispatchers
8. No fees for highway maintenance and damage
9. No taxes for pollution and greenhouse gas emissions

Very importantly, the public will have a much more favorable attitude toward trucks – reduced pollution, less accidents, less congestion, less damage to highways, etc.

8. Why Trucks Are Vital to the US Economy and High Speed Rail is Not

Trucks are vital to the US economy. 500 Billion dollars is spent per year for truck freight compared to only $36 Billion for rail freight. Of the $500 Billion spent on trucking, over $300 Billion goes for intercity trucks. Only 65 Billion dollars goes for intercity air passenger travel, and a tiny amount, 3 Billion dollars annually, for intercity passenger rail. The Tables below illustrate how vital trucking is to the US, even with a high cost per ton mile.

Table 5		
US Freight Value Shipped By Mode		
(Billions of $ per year)		
Category	2006	2035
Truck	$9,765	$23,767
Rail	$430	$702
Water	$102	$151
Air, Air &Truck	$1,048	$5,925
Intermodal	$2,096	$8,966
Pipelines	$1, 494	$2,357
Total	$14,935	$41,869
Source: ASHTO 2009 Bottom Line Report		

Table 6		
Average Freight Revenue Per Ton Mile		
Mode	2001	2006
Air Carrier	80.4¢/TM	82.2¢/TM
Truck	26.6¢/TM	NA
Class 1 Rail	2.24¢/TM	2.84¢/TM
Barge	0.72¢/TM	NA
Oil Pipeline	1.47¢/TM	NA
Producer Price Index 1982 = 100	141	180
Source: USDOT, Bureau of Transport Statistics		

Trucks cost 10 times more per ton mile carried than rail freight. Yet they carry much more freight value than rail. Why? Because their delivery time is much shorter, and they are much easier and convenient to use. Including their role in the air and truck and intermodal categories, they now carry more than 80% of the US transport freight value and will continue to do so in 2035.

Using Maglev, intercity truck costs will be much less, greatly increasing US productivity and living standards.

High Speed Rail cannot transport trucks – only passengers. It will not take trucks off the highway and will not decrease the tremendous amount of money the US spends on truck transport. HSR will not even attract a significant percentage of the travelers that now go by air or highway. At 50 cents per passenger mile, the European value, HSR will be more expensive than air travel or driving. The average American drives 10,000 miles per person per year and flies 2,000 miles. The average Californian would take about 1.5 trips per year on the proposed California HSR system, for an average travel distance of only about 400 miles. People in Europe and Japan take similar small travel distances on their HSR systems, about 400 to 500 miles per year, and they have the advantage of a connected network of HSR trains, not isolated routes as planned for the US. HSR would be only a minor contributor to US transport needs.

9. The West Coast Maglev Network -- Economic, Energy and Environmental Benefits

Table 7 summarizes estimates of the economic, energy, and environmental benefits of the West Coast Maglev Network. The basis for the estimates is given in Table 7. Unit costs for Maglev and present transport systems are given in Table 4. A number of important conclusions can be drawn from the estimates.

First, the West Coast Maglev Network would directly save 21 Billion dollars annually in passenger, auto, and truck transport costs, compared to the costs if they traveled by highway and air using the present modes of transport. The amortized costs of the Maglev guideway and vehicles are included in the unit costs charged to the user (Table 7A), along with the operating costs of the Maglev systems, i.e., energy, maintenance and personnel. There are no hidden costs or subsidies for the Maglev system, so the annual 21 Billion dollars in savings are real. In contrast, the costs for transport by present modes undoubtedly include hidden subsidies that when accounted for, further increase the savings in transport that Maglev will enable. Such hidden subsidies include the economic costs of deaths and injuries on the highways, health damage from pollutants and micropollutants.

When these external costs are added in to the present cost of transport by highway, the savings resulting from using Maglev would be substantially greater than 21 Billion dollars annually. Moreover, the projected savings given in Table 7 are based on traffic flow assumptions that are a relatively small fraction of the traffic flow projected for the I-5, I-15 corridors in 2035 AD. The Maglev traffic flows in that time frame could easily be twice those projected in Table 7 with a corresponding increase in the savings that the West Coast Maglev Network would offer. Finally, the cost of gasoline and diesel fuel, measured in constant dollars, will be much higher in 2035 than today, as World oil production peaks and rapidly industrializing countries like China and India compete very strongly for an ever shrinking supply of oil.

When all the above factors are included, the cost savings in 2035 AD that the West Coast Maglev Network would offer could easily be 100 Billion dollars or more, measured in constant dollars.

Second, the West Coast Maglev Network would save 47 Billion KWh of energy annually. Even more important it would save 86 Billion KWh of oil energy used for highway and air transport, equivalent to 4 days worth of oil imports. Doubling Maglev traffic flow as the West Coast Network would save 8 days of oil imports.

The cost savings discussed above would be very significant. Today, highway fuel at $3.30 per gallon costs 10 cents per KWh of fuel energy, about the same as 10 cents per KWh of electrical energy. When highway fuel climbs to 10 dollars per gallon, it will be equivalent to 30 cents per KWh. At 10 dollars per gallon in 2035, the fuel costs for highway travel alone at the traffic flow levels in Table 7 would be 26 Billion dollars annually. The actual traffic flow requirements in 2035 would be much greater than the values in Table 7B, resulting in a fuel bill for highway travel that would be on the order of 100 Billion Dollars annually.

Third, the West Coast Maglev Network will significantly reduce the emissions of greenhouse gas emissions from transport. Table 7C compares the carbon dioxide emissions from Maglev with those from Highway transport. The CO_2 emissions for Maglev are taken as zero since the vehicles are electrically powered. In practice, if the West Coast Network were in operation today, there would be some associated CO_2 from electric power plants that burn fossil fuels. For example, of the present US power plants, approximately 50% burn coal. If Maglev was operating today, some of the electric power it would use would come from coal and natural gas fueled power plants.

However, power plant CO_2 emissions will decrease substantially in the next decade, as nuclear and renewable energy sources – wind, solar, etc – are built and replace fossil fueled power plants. In addition, CO_2 emissions from coal and natural gas fueled power plants will be captured and sequestered underground, rather than released to the atmosphere.

By the time that Maglev becomes widely implemented in the US, CO_2 capturing systems and new, non-fossil-fueled power plants will dominate electrical production, so that very little CO_2 will be emitted to the atmosphere from power plants. The assumption of essentially zero CO_2 emissions for Maglev transport thus appears reasonable.

However, there does not appear to be any practical way to capture CO_2 emissions from oil fueled autos, trucks, and airplanes. Today, US CO_2 emissions from oil fueled transport is over 2 Billion tons per year, 1/3 of total US CO_2 emissions. World transport emissions are on the order of 6 Billion tons, 1/4th of total World CO_2 emissions.

If the World fails to transition away from oil fueled transport to electric transport, CO_2 transport emissions will drastically increase for 2 reasons:

1. The increasing World population and rising living standards will inevitably result in large increases in World CO_2 transport emissions.

2. As conventional World oil production sharply declines because the oil resources are running out, there will be an inevitable shift towards producing oil from coal and oil sands. The processing essentially doubles the CO_2 emissions per gallon of fuel-burned in autos, trucks, airplanes, and ships, because of the energy inefficiencies in making synthetic oil

In the coming decades, the above 2 effects could easily lead to World CO_2 emissions from transport alone climbing to more than all of the present CO_2 emissions from all fossil fuel consumption sources. World leaders are calling for an 80% reductions in present CO_2 emissions. There would be no hope of significant reductions in CO2 emissions by 2050 if oil fueled transport continue to dominate. Instead, World CO_2 emissions in 2050 from just transport alone would substantially exceed present World CO_2 emissions from all sources.

The projected reduction of 26 million tons of CO_2 using the West Coast Maglev Network would in practice be much greater, since by 2035 there will only be a relatively minor amount of oil fueled travel.

One of the very interesting benefits of the West Coast Maglev Network is that instead of costing money to curb CO_2 emissions to the atmosphere, Maglev curbs CO_2 emissions while at the same time saving money in transport costs.

The EPA has concluded that the "social cost" of CO2 was between $40 and $68 per ton in 2007, and would rise to $179 per ton in 2040, if we don't cut emissions soon. (NY Times editorial, "The Price of Disappointment", Dec.25th, 2009).

At $100 per ton social cost, the West Coast Maglev Network would save 2.7 Billion dollars per year in carbon dioxide costs, in addition to the saving of 21 Billion dollars in direct transport costs summarized in Table 7A (as discussed above). When the various hidden costs for the existing transport modes – highway, rail, and air are included, and the Maglev Network takes a greater fraction of the I-5/I-15 Traffic flow than assumed, the actual savings resulting from the West Coast Maglev Network will approach 100 Billion dollars annually.

Table 7
<u>Direct Economic, Energy and Environmental Benefits of the West Coast Maglev Network</u>

Basis: 2000 Route Miles on West Coast Maglev Network
30,000 Passengers/Day Traffic Flow Average on Network
20,000 Autos Transported/Day Flow Averages on Network
5,000 Trucks Transported/Day Flow Average on Network
20 Tons of Cargo Average per Truck
100 Passengers on a Maglev Passenger Vehicle
10 Autos Plus Passengers on a Maglev Auto/Passenger Carrier Vehicles
2 Trucks on a Maglev Truck Carrier Vehicle
280 mph, 0.20 Drag Coefficient
3 x 3 Meter Equivalent Cross Section for Passenger/Auto Maglev Vehicles
3 x 4 Meter Equivalent Cross Section for Truck Carrier Vehicles
500 Kw(e) I^2R Guideway Loop Power Losses
10 Cents/KWh(e) Electric Energy Cost
20 mpg Auto & 5 mpg Truck by Highway

Table 7A: Transport Costs By Mode

	Passengers		Passengers w/Autos		Trucks	
Parameter	Maglev	Hi-wy/Air	Maglev	Highway	Maglev	Highway
Units	Cost per Passenger Mile		Cost per Passenger Mile		Cost per Ton Mile	
Unit Cost	2.9 Cents	.30 Cents	32 Cents	40 Cents	10 Cents	30 Cents
Total Annual Cost	0.64 B$	6.6 B$	4.7 B$	5.8 B$	7 B$	21 B$
Total Annual Cost for All Modes: 12.3 B$ By Maglev; 33.4 B$ by Highway						
Annual Cost Savings Using Maglev: 21.1 B$ Per Year						

Table 7B: Energy Consumption By Mode

Units	KWh per Passenger Mile		KWh per Auto Mile		KWh per Truck Mile	
Unit Consumption	0.10 (e)	1.67 (th)	1.0 (e)	1.67 (th)	6.2 (e)	9 (th)
Total Annual KWh	2.2 Billion	36 Billion	14 Billion	24 Billion	2.3 Billion	30 Billion
Total Annual Consumption for All Modes: 39 Billion KWh By Maglev, 88 Billion KWh By Highway						
Annual Energy Savings Using Maglev: 49 Billion KWh Per Year						

Table 7C: Carbon Dioxide Emission By Mode

Units	Lbs CO_2 Per Passenger Mile		Lbs CO_2 Per Auto Mile		Lbs CO_2 Per Truck Mile	
Unit Emission	0	1	0	1	0	5
Total Annual Emissions	0	11 Million Tons	0	7.4 Million Tons	0	79 Million Tons
Total Annual Emissions for All Modes: 0 by Maglev, 27 Million Tons by Highway						
Annual CO2 Emissions Savings Using Maglev: 27 Million Tons						

10. The West Coast Maglev Network: Societal and Security Benefits

The West Coast Maglev Network will generate a wide range of societal benefits, including:

1. Many thousands of new, high paying manufacturing job related to the implementation of Maglev systems, both domestically and in other countries. The export of Billions of dollars per year of Maglev equipment will significantly reduce the 700 Billion dollar per year US trade deficit, strengthening the dollar and helping to keep interest rates low.

2. Significantly reduce deaths and injuries on US highways. Currently, 40,000 people are killed each year on US highways and hundreds of thousands of people seriously injured. This tragic toll not only costs the US economy over 100 Billion dollars annually, but impacts peoples' personal lives in dreadful ways. The US spends very little per capita to reduce this tragic toll. Maglev can substantially reduce highway deaths and injuries while at the same time, it substantially reduces the cost of transport. High Speed Rail will do very little to reduce highway deaths and injuries, because it will carry only a very small fraction of the passenger miles traveling by highway, and because it will not take trucks off the highway.

3. Damage to the health of Americans from pollutants and microparticulates emitted from cars and trucks is a very serious problem. In heavy traffic areas, the American Lung Association estimates that on average, the lifespan of local inhabitants is reduced by 2 years. Many of the inhabitants, particularly children develop asthma as a consequence of the emissions. Maglev does not damage the health of local inhabitants and passengers, no matter how heavy the traffic in a given area.

4. Compared to existing modes of travel by highway, air, or rail Maglev travel will be very comfortable, very reliable – no delays due to weather or congestion – very fast with short trip times, without engine or rail noise or vibration, and substantially lower in cost. Travelers will not experience the stresses that often turn trips on existing transport systems into nightmares and they will be able to productively use the time they save by going on Maglev.

5. Finally, taking the lead in the development and implementation of Maglev will inspire a new generation of US scientists and engineers, and help to create a stimulating environment for the innovation and development of other new technologies by the US.

With regard to the security benefits for the US from Maglev, there are a number of important ones, including:

1. Significant decrease in the dependence on oil imports. The US currently imports 7 Billion barrels of oil per year, much of it from unstable and even hostile countries. If conflicts break out, or political conditions substantially reduce oil imports to the US, our present modes of transport would not be able to sustain the economy at its present levels, reducing not only living standards, but also military capability. Moreover, in the long term, the US will not be able to maintain its present oil imports, as world oil production declines and rapidly industrializing countries like India and China compete for the ever shrinking, evermore expensive oil pool.

2. Maglev, by reducing oil imports and by exporting US made Maglev equipment will substantially reduce the US trade deficit. Over the long term, the US cannot continue to operate with a 700 Billion dollar per year trade deficit. As other countries accumulate US debt, they inevitably will have greater power over US foreign policy and actions, which may work against the best interests of the US.

3. Maglev, with its ability to move people and goods very quickly and efficiently around the US, will strengthen the capability of the US government to respond rapidly to emergencies both domestically, and abroad by getting the people and goods to the affected areas in the US, and to parts where they can be quickly shipped out to affected areas in other countries. The emergencies may be caused by natural disasters, terrorist attacks, and armed conflicts abroad.

11. <u>Layout of the West Coast Maglev Network – Population and Metropolitan & Micropolitan Areas Served</u>

Table 8 gives the metropolitan and Micropolitan areas served by the West Coast Maglev Network, grouped by the 4 States connected to the Network – California, Nevada, Oregon, Washington, plus the areas in British Columbia served by the route from Seattle to Vancouver in Canada.

In addition to the metro/micro areas through which the I-5 and I-15 (from Anaheim to Las Vegas) highways directly pass through, other metropolitan areas are connected to the Maglev route along I-5 highway by side Maglev routes. These metro/micro areas are identified with a * in Table 8. For example San Francisco,, San Jose, Oakland, and the Bay area, in general, are connected to the I-5 Maglev route by a side Maglev route along I-80 from Sacramento.

The 2007 population numbers for the various metro/micro areas are taken from the US Statistical Abstracts. Virtually all of the population in those areas live within 15 miles of a Maglev station or the West Coast Maglev Network.

California has the largest number of people served by the Maglev Network, 32.7 million (Table 8A). The total population of California is 36.6 million, so that the Maglev Network directly serves 89% of California's citizens.

The Network does not connect Santa Barbara, San Luis Obispo, and other metro/micro areas along the California coast from Oxnard/Ventura North to Santa Cruz/Watsonville, nor does it connect with the Palm Springs area. With additional Maglev routes along the coast and to Palm Springs, almost 100% of California's population would be directly served by the West Coast Maglev Network.

Table 8B gives the population numbers served by the Maglev Network for Nevada, Oregon, Washington State, and the Vancouver region.

78% of Nevada's 2.56 million population is served by the Network, 76% of Oregon's 3.75 million population, and 68% of Washington State's 6.47 million population. In all, 42 million Americans in California, Nevada, Oregon and Washington are directly served by the Network, equal to 85% of the population living in the 4 states. Add in the 1.3 million Canadians living in the Vancouver region, and the total population served by the Network is 43.3 million people.

Table 9 summarizes the mileage along the highway various corridors that make up the West Coast Maglev Network. The total mileage is slightly more than 2000 miles. Most of the Maglev mileage is in California, amounting to about 1340 miles out of the 2000 miles total.

Table 8A: Metropolitan and Micropolitan Areas in California Served by West Coast Maglev Network

California I-5 Corridor Served By Maglev Network
Plus Side Routes from I-5 (Side Routes Marked by *)

Metro/Micro Area	2007 Population (millions)
San Diego - Carlsbad - San Marcos	2.98
Santa Ana - Anaheim-Irvine	3.00
Los Angeles - Long Beach - Glendale	9.88
Oxnard - Thousand Oaks -Ventura	0.80
Bakersfield*	0.79
Hanford – Corcoran*	0.15
Visalia – Parkersville*	0.42
Fresno*	0.90
Merced*	0.25
Santa Cruz – Watsonville*	1.80
San Jose – Sunnyvale – Santa Clara*	0.08
Tracy - Paterson	0.51
Modesto*	2.04
Sacramento – Arden – Arcad - Roseville*	2.48
San Francisco – Oakland – Fremont*	1.72
Red Bluff	0.06
Redding	0.18
Yreka	0.10
Total	28.44
California I-15 Corridor	
Riverside – San Bernadino - Ontario	4.08
Victorville – Apple Valley - Hesperta	0.20
Total	4.28
Total California Population Served by West Coast Maglev Network	32.70
Total California Population	36.6
% Served by WC Maglev Network	89%

Table 8 B: Metropolitan and Micropolitan Areas in Nevada, Oregon, Washington, and British Columbia served by West Coast Maglev Network

Nevada I-15 Corridor Served by West Coast Maglev Network

Metro/Micro Area	2007 Population (millions)
Las Vegas	1.84
Boulder City	0.15
Total	1.99
Total Nevada Population	2.56
% Served by WC Maglev Network	78%
Oregon I-5 Corridor Served By West Coast Maglev Network	
Medford	0.20
Eugene	0.34
Corvallis	0.08
Albany	0.11
Salem	0.39
Portland	1.75
Total	2.87
Total Oregon Population	3.75
% Served by WC Maglev Network	76%
Washington State I-5 Corridor to Canadian Border Served by Maglev Network	
Vancouver	0.43
Longview	0.10
Olympia	0.24
Tacoma	0.77
Seattle – Bellevue - Everett	2.54
Mount Vernon	0.12
Bellingham	0.19
Total	4.34
Total Washington State Population	6.47
% Served by WC Maglev Network	68%
British Columbia I-5 Corridor Served By West Coast Maglev Network	
Vancouver	0.54
Burnaby	0.19
Richmond	0.16
Surrey	0.35
Langley	0.02
White Dock	0.04
N. Vancouver	0.04
Total	1.52

Summary
Population (millions)

State	Served by Maglev Network	Total Populations of States
California	32.7	36.6
Nevada	1.99	2.56
Oregon	2.87	3.75
Washington	4.39	6.47
Total	42.0	49.4
% of Total Population in the 4 states Served by the Maglev Network = 85%		
Total Population Served by Maglev Network Including Vancouver, BC = 43.3 million		

Table 9: Maglev Route Miles for West Coast Maglev Network

Route	Mileage
California I-5 Corridor	796
California I-15 Corridor	225
California – Side Routes to I-5	320
Nevada I-15	50
Oregon I-5 Corridor	308
Washington State I-5 Corridor	277
Border- Vancouver, BC Corridor	30
Total Maglev Route Mileage	2006 Miles

12. Construction Methods and Schedule for the West Coast Maglev Network

The West Coast Maglev Network will be a major project. Together with the other Maglev projects in the US that will lead to the goal of a National Maglev Network for the entire United States, it will be comparable to President Eisenhower's program for the construction of the Interstate Highway System.

We assume a start of construction date for the West Coast Maglev Network of January 1st 2015, and a final completion date of December 31st, 2018. The 5 year period between now, Jan 2010, and Jan 2015 is sufficient to fully test the 2nd generation Maglev-2000 system, and certify it for commercial transport of passengers, highway trucks, personal autos, and fright, given an aggressive demonstration program with government funding of the Maglev Test and Certification Facility.

Once demonstrated and certified, the West Coast Maglev Network can be constructed using private financing. It is assumed that because of the very favorable return on investment once Sections of the Network begin operating, that investors will want to build it as quickly as possible, to minimize finance charges on the bonds issued.

To ensure that private investment is ready to go ahead one the 2nd generation Maglev-2000 System has been demonstrated and certified as a public carrier, it will be necessary to test construction methods as well as operating vehicles and to carry out the route planning and obtain the needed permits. These activities can proceed in parallel with the vehicles testing and certification, during the 5 year period leading up to the start of construction.

To achieve low construction cost it is very desirable to minimize field construction work and maximize the use of mass production methods for the guideway components – which account for approximately 90% of total system cost – and to design them so they can be rapidly erected at the guideway construction site at low cost with a small number of workers.

The proposed Maglev-2000 guideway construction methods are outline in Figures 2 and 3. The West Coast Maglev Network is divided into 9 construction segments (Table 10). Each Construction segment has one or more beam and pier manufacturing plants located at some point in the segment. The plants manufacture conventional reinforced concrete box beams and piers similar to those used in highways and bridges. The beams are used for the elevated monorail guideway for the Maglev-2000 vehicles, while the piers are erected on pre-poured concrete footings to support the elevated guideway beams.

The piers are made in segmented form so that they can be easily adjusted for the proper height at the point of erection. This enables the Maglev-2000 monorail guideway to remain flat and level as it proceeds along terrain that has hills and valleys.

At the beam and pier plant, thin panels that contain the aluminum loops used to levitate and propel the Maglev-2000 vehicles are attached to the sides of the guideway beams, together with sensors and electronic equipment. These components are manufactured in plants elsewhere, and shipped to the beam & pier plant for attachment to the guideway beams.

The finished guideway beams and piers are then trucked to where the guideway is being constructed (Figure 3). The guideway beams will be erected at both ends of the ever lengthening completed guideway. Prepoured concrete footings will have been put in place several miles ahead of the advancing end of the guideway, and piers will have already been erected on the footings 1 to 2 miles ahead of the advancing end.

At 16 beams manufactured per day, each 100 feet long at the beam & pier plant, each end of the lengthening 2 way guideway will advance 400 feet per day, equivalent to 14 miles per year, with the total length advancing 28 miles per year, counting both ends. 4 beams will be added per day to each side of the 2-way guideway. A mobile crane will unload the beam from the truck that transports it from the beam & pier plant, and place it on top of the previously erected pier, with the center of the beam positioned at the top of the pier. With an 8 hour shift, a new beam would be emplaced every 2 hours; with 2 shifts, a new beam could be emplaced every 4 hours. After a beam was in place, workers would make the necessary electrical connections to the previous beam through simple junctions.

The pace of 4 beams erected a day is quite conservative and the rate of construction can probably proceed much faster if desired. Likewise, sending 8 beams a day by truck to each end of a lengthening guideway section is very conservative, and will not significantly impact highway traffic. Beams can be readily shipped long distances at low cost. For example, Maglev-2000 had a 72 foot long guideway beam manufactured in New Jersey, and shipped by truck to the Maglev-2000 facility in Titusville, Florida, a distance of 1, 140 miles. The transport cost was only 4,000 dollars. For the West Coast Maglev Network, the average shipping distance for the guideway beams and piers will only be about 150 miles. With 2 shift operation, a truck could deliver 2 beams a day on average, requiring only 8 trucks for each segment under construction. Likewise, the production of 16 beams a day from a beam & pier plant is conservative. The production rate could be several times greater, if desired.

Table 11 shows how the construction segments map into the Maglev route lining the major metropolitan areas in the West Coast Maglev Network, and when the various routes would begin operation, based on a construction start date of January 1st, 2015 and a production rate of 15 beams per day from each beam & pier plant.

The first route to be completed in April 2017, 28 months after start of construction, would be the Portland to Eugene, Oregon route. It would be quickly followed by the San Diego to Los Angeles route, completed by May, 2017. The last route to be completed would be the Los Angeles to Sacramento route in June 2018, 42 months after start of construction. These completion dates are nominal and could easily be accelerated by increasing the beam & pier production rates from the appropriate beam & pier plants.

The important conclusion to be drawn is that the West Coast Maglev Network can be in full operation within 4 years after the start of construction and even sooner if the construction rate is accelerated. Major sections can operate even earlier than the full Network, such as San Diego to Los Angeles, Anaheim to Las Vegas, Eugene to Portland, and Seattle to Vancouver, since their routes are relatively short.

Table 10. Length & Construction Time for Segments of West Coast Maglev Network

<u>Basis</u>

- Construction Segments in 2000 mile West Coast Maglev Network
- 1 or More Beam & Pier Manufacturing Plants in Each Segment
- Beams & Piers Trucked from Manufacturing Plant to Be Erected at the Ends of the Already Completed Portion of Maglev Guideway.
- Manufactured Panels, sensors, etc. Attached to Beam Before It Is Trucked
- Segment Construction Time Shown As Function of Beams Manufactured per Day
- 100 Foot Length Beams

Segment #	Segment Location	Segment Length (miles)	# of Beam/Pier Factories Operating In Segment	Time To Construct Segment (years) As Function of # of Beams Mfg/Day		
				10	15	20
1	1-5, San Diego to Los Angeles	125	1	3.6	2.4	1.8
2	I-15, Anaheim to Las Vegas	275	2	4.0	2.7	2.0
3	*I-5 Los Angeles to Sacramento	540	3	5.2	3.5	2.6
4	**I-80, Sacramento to San Francisco	160	1	4.6	3.1	2.3
5	Sacramento to Oregon Border	270	2	3.9	2.6	1.95
6	Oregon Border to Eugene, OR	190	1	5.5	3.7	2.75
7	Eugene, OR to Portland/Washington Border	120	1	3.5	2.3	1.75
8	Portland/Washington Border to Seattle	175	1	5.0	3.3	2.5
9	Seattle to Vancouver, BC	140	1	4.0	2.7	2.0
	Total	2000	13			
*Segment # 3 includes 380 miles along I-5, plus 160 miles of side routes to Oxnard, Bakersfield, Hanford-Visalia, Fresno, Merced, & Modesto						
**Segment #4 Connects I-5 guideway to Oakland, San Francisco, San Jose and rest of Bay Area						

Table 11. Schedule for Connection Between Major Metropolitan Areas on the West Coast Maglev Network

Basis:

- 1/2015 Start of Construction of West Coast Maglev Network
- 12/2018 Complete Network in Operation
- 15 Beams Manufactured Per Day at Plant

Operating Section	Segments in Section	# of Beam Mfg Plants	Completion Time (Yrs)	Completion Date
San Diego to Los Angeles	1	1	2.4	5/2017
Anaheim to Las Vegas	2	2	2.7	8/2017
Los Angeles to Sacramento	3	3	3.5	6/2018
Sacramento to San Francisco, Oakland and San Jose	4	1	3.1	2/2018
Sacramento to Eugene	5 & 6	3	3.7	9/2018
Eugene to Portland	7	1	2.3	4/2017
Portland to Seattle	8	1	3.3	4/2018
Seattle to Vancouver	9	1	2.7	9/2017

Figure 2
Procedures for Construction of West Coast Maglev Network

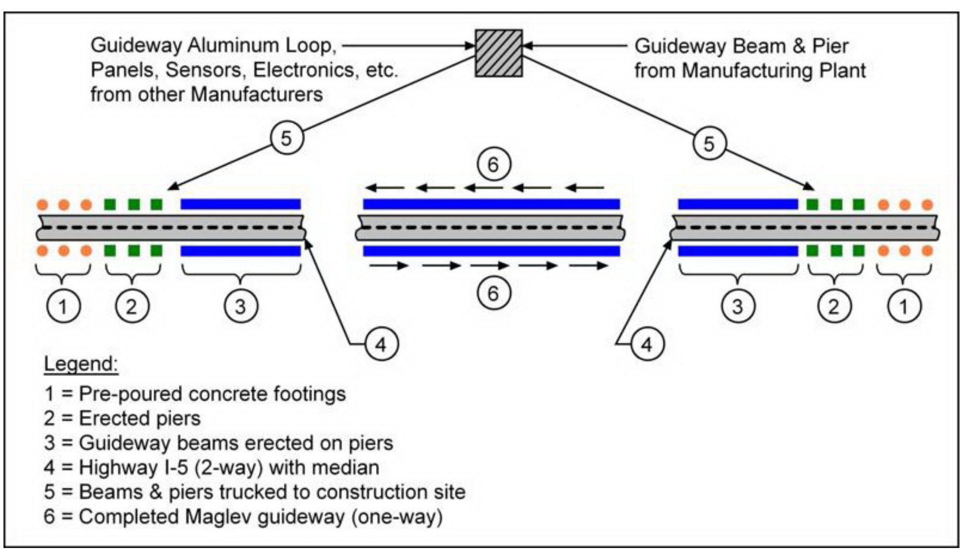
Beam & Pier Manufacturing Plant Procedures

- Beam & Pier Plant Manufactures Reinforced Concrete Monorail Beams and Segmented Piers
  - 100 Foot Nominal Beam Length
  - Piers are Segmented – Segments of Appropriate Lengths are Assembled into Finished Piers of Proper Height. Pier Height Varies with Terrain along Guideway – Guideway Beam Remains Flat – No Ups or Downs
- Beam & Pier Plant Attaches Aluminum Loop Panels to Guideway Beams, plus Sensors, Electronic Equipment, etc. that have been shipped from other Manufacturers
- B&P Plant Ships Out Beams and Piers with Attached Equipment by Truck to Guideway Construction Site.

Guideway Construction Site Procedures
Construction Team Performs Following Functions

- Prepares Pre-Poured Concrete Footings in Advance of Erection of Piers and Beams – Typically, Several Miles Ahead of the Next Beam Erection Point
- Erects Delivered Piers on Pre-poured Concrete Footing, Typically 1 to 2 miles Ahead of the Next Beam Erection Point
- Erects Beam on Pier Using Conventional Mobile Crane & Makes Connections Between Successive Beams
- At Nominal Production Rate of 16 Beams Per Day, 8 Beams Would Be Trucked to each end of an extending Guideway Segment, with 4 Beams erected per day on each side of the 2-way Guideway – 2 Hours per Beam on a 8 Hour Work Schedule per Day and 4 Hours per Beam on a 16 Hour Work Period/Day. The End of the Guideway Segment Would Extend 400 Feet/Day, equivalent to 28 miles per year.

Figure 3
Schematic of Construction Sequence of Maglev Guideway Segment (Not to Scale)



13. Other Maglev Applications -- Electric Energy Storage

Wind and Solar are very attractive sources of clean, renewable electric energy, and are beginning to be widely implemented in the US and around the World. Their output varies widely, however, depending on whether the wind is blowing, the sun is shining, clouds are present, etc. Frequently, their output does not match the demands of the electric grid system – either the electric output is not needed by the grid, or the grid needs power, but the wind or solar farm cannot generate it.

On average, wind turbines only generate full power about 20 to 30% of the time, because of the variability in wind speed. Solar power systems only generate a fraction of their maximum power in the morning and late afternoon, because of the less favorable position of the sun, at a time when the grid demand typically peaks.

A practical way to store large amounts of electric energy at high efficiency and low cost, to be delivered during peak demand periods, would be of tremendous value to the implementation of clean, renewable electric energy generation. It would substantially increase the amount of electric energy a given wind or solar farm could deliver for the grid, and substantially reduce the cost of the delivered power.

The only approach to date for storing large amounts of electric power at an acceptable cost is pumped hydro, where water is pumped from lower level up to a lake, either natural or formed by a dam, when surplus power is available, and then returned to the lower level through a turbine that generates electric power for the grid when demand is high.

Pumped hydro has many drawbacks, including:

- High environmental impact from the storage of large amounts of water
- Low efficiency – typically, only 60% of the input electric energy to the pumped hydro facility is returned to that electric grid, because of inefficiencies in the pumps and turbines, and pressure losses in the piping system
- High cost for storage – on the order of 10 cents/KWh or more
- Limited number of locations for siting

Other proposed approaches for storage of large amounts of electric energy – batteries, flywheels, compressed air, superconducting coils, etc. – appear to be too expensive and limited in capacity to be practical.

In contrast, Maglev appears to offer a very low cost, very efficient approach for the storage of large amounts of electric energy. In the MAPS (MAglev Power System), electric energy is stored by moving heavy concrete blocks, of approximately 100 tons in weight, from a lower to higher elevation in Maglev Vehicles that travel on a guideway. To store electric energy the Maglev propulsion system operates in the motor mode, using input electric power to move the blocks uphill. When output electric power is desired, the concrete blocks are moved downhill, with the Maglev propulsion system operating in the generator mode, converting the stored gravitational potential energy to electric power as the blocks travel downwards.

MAPS is the analogue of the pumped hydro system, except that concrete blocks are moved uphill and downhill, compared to moving water up and down hill. A 100 ton block will store 250 KWh of electric energy if moved 3000 feet uphill. MAPS systems can be located virtually anywhere, unlike pumped hydro, since the movement and presence of the concrete blocks will have very little environmental impact. MAPS can be located in hilly terrain, where the guideway would ascend from a valley floor upwards on an adjacent hill to a higher altitude site where the concrete blocks would be stored. In flat terrain, MAPS sites would operate with a vertical shaft to move the blocks between the surface and an underground tunnel for storage.

Compared to pumped hydro, MAPS is very attractive, with:

- Much greater efficiency – In MAPS, 95% of the input electric energy can be returned to the grid, versus 60% for pumped hydro
- Very low cost for storage – Using MAPS, electric energy can be stored for about 2 cents/KWh, versus about 10 cents/KWh for pumped hydro.
- Much less environmental impact than pumped hydro, and a much wider range of potential sites.
- Much wider range of power output from the MAPS storage site than pumped hydro & water pumps and turbines are constrained in operational range.

All 4 states in the West Coast Maglev Network – California, Nevada, Oregon, and Washington – have the potential to become major producers of wind and solar power, if a practical way to store large amounts if electrical energy is available. MAPS is that practical way, and uses the same Maglev-2000 technology that makes the West Coast Maglev Network possible.

14. Other Maglev-2000 Applications – Long Distance Transport of Water

Two of the 4 States on the West Coast Maglev Network, Nevada and California, are experiencing severe water shortages in parts of the States. A practical way to transport fresh water over long distances at low cost from sources that have large amounts of surplus water would be of great benefit.

Maglev, because of its excellent energy efficiency at speeds of 150 to 200 mph, can transport large quantities of water for hundreds of miles with very low propulsion energy requirements. The Maglev Water Train design envisions a consist of 50 to 100 Maglev vehicles connected together, with each vehicles transporting 200 tons of water (50,000 gallons). In each vehicle the water is contained in an inflatable bladder during the transport phase from source to user. After deliver of the water, the empty bladder is deflated, reducing the cross sectional area of the Maglev vehicles and the associated air drqag on it when it returns to the source for the next load of water.

For a distance of 300 miles between source and user, a 100 vehicle Water Train can make 6 round trips daily, delivering 30 million gallons of fresh water. Thirty three trains operating on the Maglev guideway would deliver a Billion gallons daily, at a cost of less than 1 dollar per 1000 gallons, far less than by pipeline, enough to meet the water needs of more than 10 million people.

Moreover, the Maglev Water Train can readily deliver water over long distances of rolling terrain, where it easily coasts up and down hills with out requiring special propulsion for the traverse. If a water pipeline has to climb over a 200 foot high hill, for example, the water pressure at the bottom of the hill must be 100 psi greater than the pressure at the top of the hill. To climb such hills, it would be necessary to pump the water to a higher pressure using a pump, and then on the downhill side, to reduce the pressure to an acceptable level by recovering through a turbine, with the energy generated by the turbine supplying a portion of the energy used by the pump on the uphill side. The various inefficiencies involved in the pump/turbine process make it impractical for pipeline delivery if the pipeline has to traverse terrain with frequent and significant hills.

In contrast, if an Maglev Water Train traveling at 225 mph climbs a 500 foot hill, its speed would drop to 180 mph at the top of the hill, and then increase back to 225 mph as it reached the bottom of the hill on the other side. The process would not have any energy losses – all of the kinetic energy of the Water Train as it started up the hill would be completely recovered one it reached the bottom of the hill on the other side.

15. Maglev Test and Certification Facilities

The operability, reliability, and safety of Maglev transport has been well established by the 1st generation Maglev Passenger Systems that have operated in Japan, China, and Germany. The Japanese Superconducting Maglev system, which is based on the 1960's inventions of Powell and Danby, has carried approximately 100, 000 passengers and accumulated running distances of hundred of thousands of miles at the Japan Railways Maglev demonstration guideway in Yamanashi Prefecture, North of Mount Fuji. Peak vehicles speeds of 361 mph have been achieved. Safe operation has been demonstrated on guideways located in open terrain, as well as in deep tunnels. JR vehicles have operated both as single units and in multi-vehicle consists of up to 5 vehicles.

Japan Railways plans to proceed with the construction of a 300 mile Maglev route between Tokyo and Osaka, 60% of which will be in deep tunnels. The 300 mile Tokyo-Osaka Route will have a trip time of 1 hour, and carry over 100,000 passengers per day.

The Japanese and German Maglev Systems have a very high capital cost, however, of over 60 million dollars per mile of 2 way guideway. At this cost level, a passenger only Maglev System is not economically attractive for implementation in the US.

Recognizing this, Powell and Danby have developed the 2nd generation Maglev-2000 System, which is much lower in cost than the 1st Generation Japanese and German Systems, and has much greater capabilities, including:

- Low cost high speed levitated guideway
- Ability to transport high revenue highway trucks, freight and personal autos, as well as passengers, on the same guideway
- Ability to electronically switch at high speed to off-line stations when scheduled to do so
- Capability for levitated travel on existing RR tracks that have been adapted for Maglev operations at very low cost (4 million dollars per 2-way mile).

These and other attractive feature enable a very fast payback time for a Maglev route, typically less than 5 years. The fast payback time will attract private investment, so that government funding for construction and operation of the West Coast Maglev network is not necessary – once the 2nd generation Maglev-2000 system is certified, private investors will build and operate the West Coast Network.

The testing and certification would be carried out at a facility, location to be determined, that was funded by the government. The testing and certification program would take 4 to 5 years, depending on when it began and funding level, enabling a 2015 start of construction for the West Coast Network.

The testing and certification program does not require any technology breakthroughs. Maglev is already a proven technology. The 2nd generation is a more efficient engineering design that evolves from the existing technology base, e.g. quadrupole superconducting Magnets instead of dipole magnets, lighter, less expensive monorail guideway beams instead of massive U-shaped trough structures, minimization of expensive field construction, ability to lift heavier loads through the use of more efficient placement of the superconducting magnets on the vehicles, ability to electronically switch vehicles to a different guideway when desired, instead of mechanically moving a long massive section of guideway, and so on.

The testing and certification facility would operate a long, 20 to 30 mile section of guideway for long-term continuous running tests of Maglev vehicles. This test guideway section could become a portion of the final West Coast Network. The facility would test and certify the different types of vehicles that would travel on the Network, i.e., passenger vehicles, truck carrying vehicles, auto carrying vehicles, and freight carrying vehicles.