Dual Use of Electric Utility Rights Of Way By Integration of an Urban Maglev Container Corridor And Gas Insulated Transmission Lines

Final Report

METRANS Project 07-323306

June 2009

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Abstract

Presently, goods movement by truck and rail through cities produces both crippling traffic congestion and significant health risks due to diesel particulate emissions. Container movement using electrically driven, magnetically levitated carriages (Maglev technology) has been shown to be a realistic approach to goods movement in congested urban areas such as the Los Angeles basin.[1] While this high-throughput, clean technology has a smaller physical footprint than road or rail; it still must compete with these modes of transportation for limited rights of way through the Los Angeles basin for national distribution of port cargo. While freeway expansion (addition of truck lanes, etc.) is one solution for expanding goods movement corridors, this option is usually not acceptable to communities adjacent to freeways for reasons, including the potential infringement upon the commercial tax base. A more attractive solution is to allow existing electric utility rights of way to support electrically driven alternative goods movement technology, such as that provided by a Maglev technology. This report describes and performs cost estimates for a means of integrating both Maglev goods movement and power distribution in a shared right or way...

The objectives of this investigation were (1) to determine the economic feasibility of allowing electric utility rights of way to serve as a goods movement corridor;; a dual use scenario involving the integration of shielded, Gas Insulated Transmission Lines (GITLs) within a specific Maglev based container transport system, the ECCO system. And (2) to select an existing utility rights-of-way alignment for further study of such an integrated system from the Ports of LA/LB to Inland Empire warehouse facilities and beyond. The cost estimates per mile of such a dual use system were determined to be between \$112M and \$134M per mile. These costs are a lower estimate in that requisite container load/offload, and electric power subsystems were not included in the calculation. Also, a more in depth analysis of dual use of public rights of way is recommended.

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Disclosure

This project was funded in entirety under this contract to California Department of Transportation.

Acknowledgments

The authors acknowledge the helpful assistance of Jerry Wood, Director of Transportation and Engineering of the Gateway Cities Council of Governments, and Southern California Edison (SCE) for many helpful discussions.

1 Introduction

Project Objective: Presently, goods movement by truck and rail through cities produces both crippling traffic congestion and significant health risks due to diesel particulate emissions. Likewise, unsightly elevated transmission line grids slice through urban neighborhoods, presenting associated safety concerns and possible health risks from long-term electromagnetic field exposure. "The objectives of this investigation were (1) to determine the feasibility of integrating shielded transmission lines within an electrically driven goods movement corridor over a utility rights of way; and (2) to select an existing utility right of way (alignment) for further study of such an integrated system for goods movement from the Ports of Los Angeles (LA)/Long Beach (LB) to Inland Empire warehouse facilities.

This project was divided into five (5) task analysis areas:

1) Collect and analyze structural and cost data from a variety of existing Maglev passenger systems and estimated per mile cost for an LA ECCO system

2) Estimate ECCO system rights of way costs in LA basin

3) Collect and analyze structural and cost per mile information on gas insulated transmission lines (GITL)

4) Project the cost for integrating ECCO system with GITL on a utility rights of way; include delineation of associated benefits

5) Formulate an alignment of an existing utility rights of way for an ECCO system from the Port to the Inland Empire

The following sections of the report address each of these areas. This report is divided into sections corresponding to these five (5) areas.

While a number of Maglev systems have been proposed over the last several years, two recent proposals involving distance and technology issues are most relevant to cost analysis of an LA ECCO system. **Section 2** provides the fundamental cost parameters from the aforementioned relevant proposed projects. Rights of way costs for placement of such a system are considered in **Section 3**. This somewhat controversial element of this report concludes that the estimate for urban freeway or above-ground light rail development cannot account for the changing status of eminent domain and associated costs. **Section 4** addresses the costs of gas insulated transmission lines (GITL). The execution of this investigation coincided with the rapid acceptance by European utilities of crossed polymer insulated transmission lines (XLPE). Thus, both means of electrical transmission are considered in this report. The cost of integrating either form of transmission line into a Maglev guideway structure provides relatively small variance in the total system costs. However, the consideration of XLPE lines as used by European utilities also introduces the possibility of using DC rather than AC transmission for integrating power transmission in Maglev guideways. **Section 5** considers cost of integrating both AC GITL and DC XLPE utility vaults into Maglev guideways. **Section 6** is a proposed route for such an integrated system.

2 Collect and Analyze Structural and Cost Data from a Variety of Recent Maglev Passenger Systems and Estimate Per-Mile Cost for an LA ECCO System

The National Maglev Initiative (NMI) identified a number of national sites, including LA, for a potential Maglev demonstration system. While not part of the final down-selection, the LA system continued to be studied by the Southern California Association of Governments (SCAG). The study focused on the area extending from the LA International Airport, West LA, Downtown LA at the Union Station, to the San Gabriel Valley, Ontario International Airport, Riverside, San Bernardino and an inland port at March Air Force Base. The original project length was approximately 92 miles and included parts of Los Angeles, Riverside and San Bernardino Counties. This study's cost data is a reliable source for estimations of the cost of a goods movement system infrastructure from the Ports of LA/LB to Inland Empire warehouse facilities. If a Maglev system were to operate solely as a passenger system, heavy public subsidies would be required, so “off-hour” freight traffic rates were integrated into system operation to remove the requirement for these subsidies. The subject report concerns, however; primarily a passenger system based on a high-speed Maglev passenger technology while the ECCO system is a slower, “freight only” system using a different Maglev technology. Thus, an additional data source with “ECCO-centric” system costs on the Southern California infrastructure has been included. That system design proposal was funded by the Port of Los Angeles (PoLA) and incorporated an ECCO system to dray containers from the Port of LA to the proposed Southern California International Gateway (SCIG)[1]. The project length was approximately five (5) miles. Consideration of both Southern California projects provided the following structural and cost data for the proposed ECCO system.

2.1 SCAG Guideway Structural Costs

Lockheed-Martin Integrated Systems Group of Santa Maria and IBI of Irvine performed the SCAG design project. Construction data was generated for three 54-mile routes, which utilized existing rights of way along the I-10 freeway, the SR-60 freeway, and the Metrolink/Union Pacific (UP) railroad path through Southern California, respectively. A shortened route to Ontario Airport was selected as a more realistic test application. Appendix A has a detailed cost breakdown for each route from the report. The costs of passenger stations and auxiliary rights of way were included in the funding estimates for the SCAG passenger/freight system’s cost per mile. Since ECCO freight terminals have not yet been defined for the Ports to Inland Empire freight system under consideration, a cost per mile projection should not include terminals. The passenger station costs and costs associated with those stations, e.g., parking, were also removed from the SCAG estimates. The costs for the two routes involving freeway rights of way were than averaged to arrive at the itemized cost per mile in Table 1.

2.2 PoLA Guideway Structural Costs

General Atomics of San Diego was the lead contractor on the Port of LA study. The CSULB College of Engineering was directly involved in this study as the system architect. A detailed cost breakdown from the report is included in Appendix B. The itemized costs per mile for the 4.7 mile route utilizing Port of LA and Caltrans rights of way are in Table 1

2.3 Comparison of Structural and Cost Data from SCAG and PoLA Proposals

Table 1 shows cost breakdowns for the two recent Southern California Maglev freight systems. Both systems use elevated infrastructures having the same seismic and construction requirements, but incorporate different levitation technologies. ECCO is an American technology invented by Lawrence Livermore National Laboratory, licensed and prototyped by General Atomics (GA) of San Diego, CA[2]. It uses a form of *electrodynamic* levitation different than the *electromagnetic* Maglev technology associated with passenger systems such as the Transrapid system considered in the SCAG proposal. The ECCO is designed to require less expensive guideways and vehicles[1]. The comparison of Table 1 and the less expensive cost per mile of the PoLA system bear this out.

	SCAG–LAX to Ontario	PoLA–Terminals to SCIG
Guideway	30.96	17.94
Infrastructure	44.20	42.24
Powering and Control	26.73	25.22
Vehicles	17.71	12.76
Maintenance Facility	3.30	3.34
Total	122.90	101.50

Table 1: Per mile costs in millions of dollars for recently proposed Maglev systems in LA basin

3 Gather ECCO System Right of Way Costs in LA Basin

Both the SCAG and the PoLA proposals utilize existing Caltrans or public road rights of way to limit the expense of land or easement rights, which includes relocation assistance, demolition costs, acquisition services, and the cost of purchase. The reason for this is most likely due to the growing realization that the costs associated with large-scale purchases of urban and industrial land for transportation corridors has become prohibitive. The last major at-grade, transportation corridor project in Southern California was the Century Freeway, completed nearly fifteen years ago. At that time, the rights of way cost for 17.3 miles was $680M in 1993 dollars, approximately equivalent to $975M (GNP comparison) in 2008 dollars[3,4]. The width of that freeway, including High Occupancy Vehicle Lanes (HOVL) and the light rail line is between 150 to 250 feet. Assuming a 50 ft alignment for the ECCO entails right of way costs for the ECCO of about $14M per mile. In addition to this cost, an estimate of recent land value of approximately $100/ ft^2 (exceeding GNP growth) implies a land acquisition cost in the neighborhood of $26.4M per mile for an elevated, double-guideway freight corridor. More likely, in light of recent eminent domain litigation, cost estimation for the rights of way could be indeterminate, and the time to acquire private rights of way, likewise indeterminate.

3.1 Use of Existing Caltrans or Public Road Rights of Way

Freeway rights of way and freeway medians seem to be the preferred candidates for routing Maglev freight systems. The Gateway Cities Council of Governments (GCCOG) represents twenty-two (22) cities between the ports and downtown Los Angeles rail yards. For reasons explained in Appendix C, recent guidelines adopted by GCCOG indicate that of the many candidate freeways in this critical region, only the I-710 will be considered for the incorporation of added truck lanes and an allowance for an “alternative technology”[5]. This decision potentially eliminates widened freeway rights of way from consideration as possible routes for Maglev freight systems and dedicated truck lanes, leaving a limited set of options to consider. The most feasible of these is the building of new, at-grade, freight corridors requiring costly rights of way; and in fact, such “trucks only” freeways with allowance for elevated Maglev freight movement are being considered.

3.2 Use of Power Line Rights of Way for Freight Transportation

Conventional road and rail rights of way have limited capacity and competition for use of these corridors by conventional transport is intense. Alternative technology such as Maglev freight movement, because of its unique elevated architecture, is not bound to such at-grade corridors, and can use other alternate routes. One such set of routes that already "crisscross" the Los Angeles basin are the rights of way for the electric power grid. These routes have not been considered for freight transport for a number of reasons. First, they are dedicated to overhead power lines, and there is little room for safe roadways directly underneath them. Implanting lines underground to open these rights of way for freight corridors is expensive and problematic. Second since overhead wires more easily conform to an un-sculptured terrain than road and rail, the placement of road or rail on electric power line paths would require the expense of reshaping these rights of way to accommodate the terrain requirements of conventional road and rail. Third the widths of these paths (typically about 100 feet)[6] are narrower than widths required for shared truck or rail routes.

The *dual-use* solution proposed here assumes that the transmission rights of way owner would allow the Elevated ECCO to be built in those rights of way in exchange for the ECCO operator financing the placement of overhead lines into cable vaults built into the ECCO infrastructure. Direct stakeholders and the public might accept, and even welcome the dual-use solution's potential to reduce pollution, traffic congestion, and eliminate unsightly overhead transmission lines.

4 Collect and Analyze Structural and Cost per Mile Information on Gas Insulated Transmission Lines

Conventional multi-strand cable power lines have both resistive and reactive transmission losses. Transmitting higher power through conventional transmission lines increases the costs of energy transmission. A new form of power transmission line, the Gas Insulated Transmission Line (GITL), has been shown to have the ability to significantly reduce losses and allow for higher power transmission while occupying the same "footprint."[7] A detailed description of high power electrical transport and gas insulated electrical transmission lines may be found in Appendix D.

4.1 Structural and Electrical Characteristics of GITLs

GITLs are solid coaxial tubes using an insulating gas to isolate the center conductor from the outer shielding. As such, they are not intended for "overhead" use, but for installation in underground tunnels or above ground (shown in Figure (1)). The architecture of a GITL is ideal for encapsulation in a cable vaults, such as are found in proposed ECCO guideways. Manufactured, pre-engineered lengths of the GITLs are transported to the job site, welded together, and pressurized with the insulating gas.[7]

420 kV GIL system at Elstree, London, Great Britain, commissioned in 2004

Figure 1: Example of above ground GITL installation

In order to put more power carrying capacity in existing rights of way and minimize losses, electrical distributors have a variety of choices, as shown in the following graph. Basic requirements for power transmission are high power capacity combined with long distance application. The length of high voltage alternating current (HVAC) cables are constrained by their high capacitance and low thermal permissible power. GITLs do not have these disadvantage because their capacitance is significantly lower and their corresponding permissible power is much higher. Therefore, from a technical point of view GITLs offer the best HVAC transmission line capability for long distance applications. Figure (2) compares the AC transmission capability of overhead lines, cross-linked polyethylene insulated power cables (XLPE), and GIL, respectively

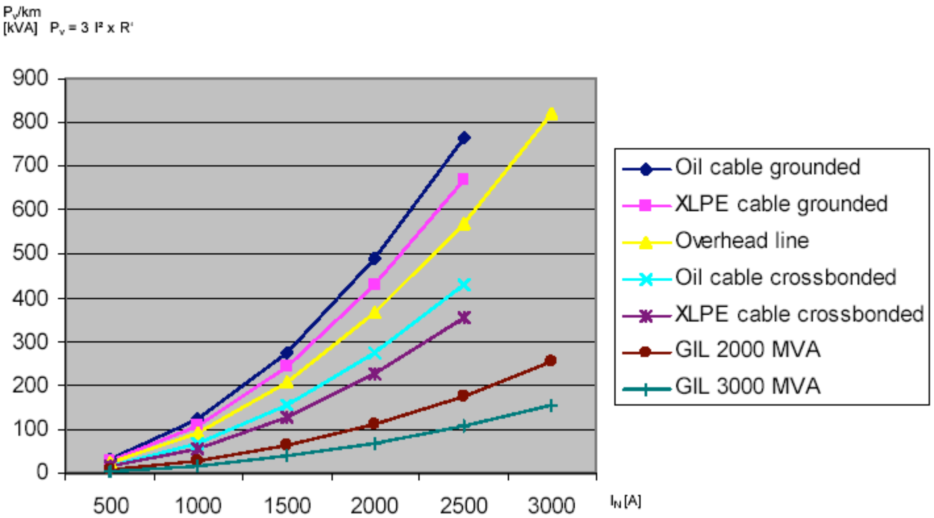


Figure 2: Transmission losses of different 420 kV systems

A summary of other GITL electrical characteristics, for cable vault retrofits in existing overhead cable transmission rights of way, are as follows:

- Highest ampacity -- up to 4000 A at 500k
- Low capacities -- no compensation for long transmission lengths
- High personal and operational safety -– no burn through of the enclosure
- Low radiation -- no external electric field and very low electromagnetic radiation
- Well known three phase AC technique -– easily applicable in existing power distribution
- Very robust and simple design -– benefit for the above ground vault environments
- Long lifetime -– more than fifty (50) years

4.2 Cost Characteristics of GITLs

GITL cannot economically compete with overhead lines but can be applied as a means of power transmission where overhead location of lines cannot or must not be applied, such as in densely populated areas or in environmentally sensitive regions. Additionally, due to their many electrical transmission advantages (listed previously), GITLs may be applied where the application of overhead cables are not possible or where they reach their technical limits, e.g., high power or long distance requirements. Power distribution providers state their overhead line costs for 450 kV lines or greater to be about \$0.69M per mile[8]. The costs of GITLs are approximately 10 times higher at \$6.47M per mile[8] due to (one-time) engineering and installation labor.

5 Project the Cost for Integrating ECCO System with GITLs on a Utility Rights of Way; Including Delineation of Benefits

Since the infrastructure, supporting the guideway is typically a pre-stressed concrete, “box beam” geometry, placement of insulated power transmission lines within, or mounted outside the structure should be straightforward. Enclosing the lines in such a structure allows them to be “transmission only” and not require strength members added to their cross-section in order for them to be strung between towers. Enclosing them in a fixed structure also allows for rigid transmission lines such as gas-insulated lines Figure (3).

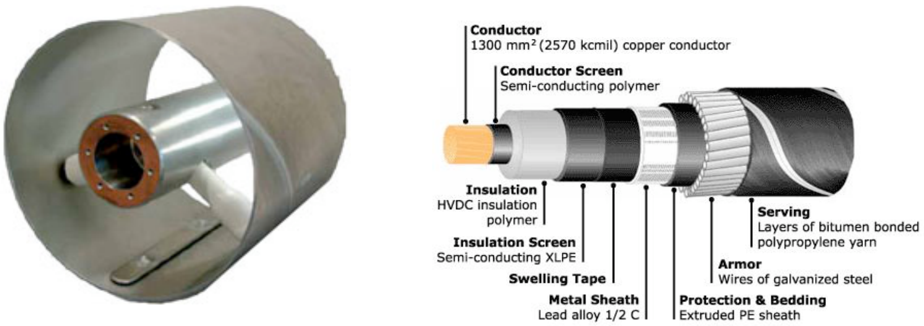
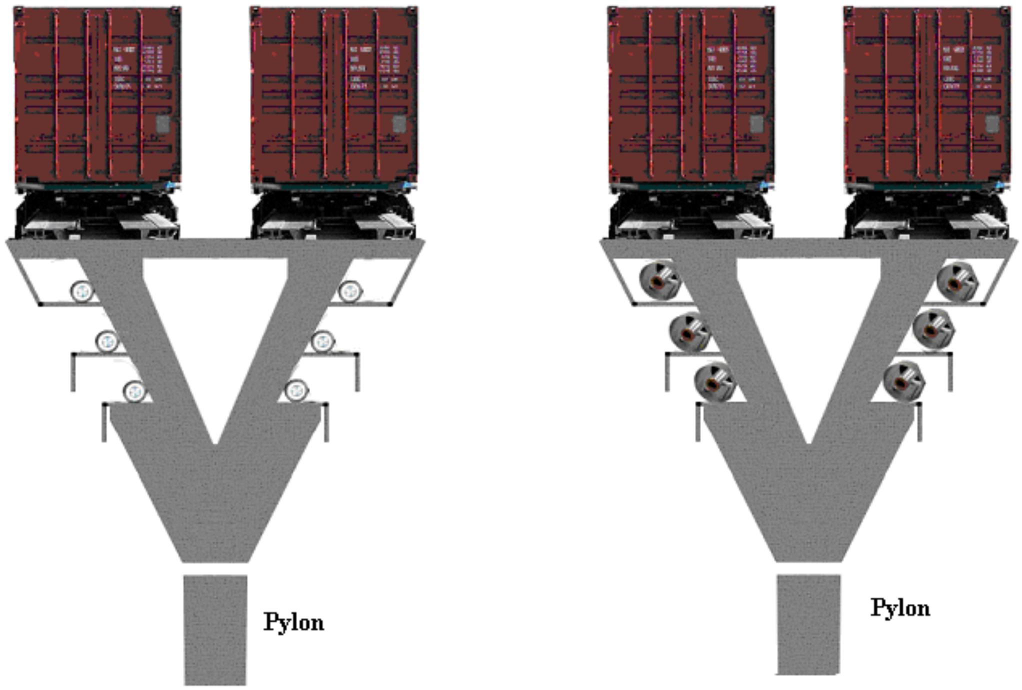


Figure 3: Cross Sections of Gas Insulated Lines and Conventional Cross Polymer Cable

5.1 Suggested Geometries of Co-Located Electrical Transmission/ECCO Guideways

Figure (4) shows two possible configurations for an ECCO system cross-sectional geometry that accommodates AC power transmission in electrical vaults built into the ECCO guideway support infrastructure. Both gas insulated and conventional cables are considered. The particular form of conventional cable involved is a state-of-the-art XLPE submarine cable, (also shown in Figure (3), that can be fabricated in 25-mile lengths. Figure (5) shows two possible configurations, the vault and the open “cable-tray”, for an ECCO system cross-sectional geometry that accommodates DC power transmission. Two such cables can be supported in a single ECCO guideway, each of which may transmit up to 1.4 GW of electrical power operating at 450kV.



AC XLPE Lines — AC Gas Insulated Line

Figure 4: Possible ECCO Power Corridor Configurations for AC Transmission

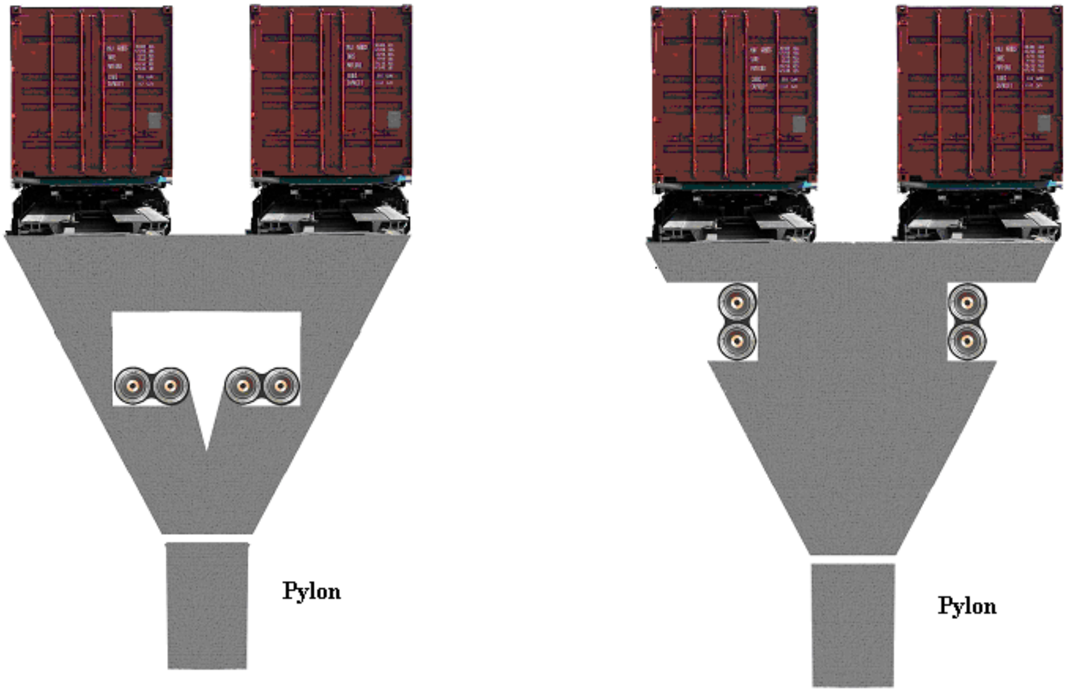


Figure 5: Possible ECCO Power Corridor Configurations for DC Transmission

5.2 Projected Costs of Integrating ECCO with GITLs on a Utility Right of Way

The costs of the supporting infrastructure for both the reference LA basin Maglev and Inland Port systems are $42M to $44M per mile. The addition of cable vaults or ducts may add a relatively small cost, perhaps 2% to 5% of this estimate to the total. Most of this cost would involve adding access within the infrastructure, to transmission lines for maintenance and repair. Integrating the three phase GITLs would add a cost to the ECCO infrastructure of $8.6M to $8.7M per mile, which represents an approximate 7.5% increase to the costs of building the ECCO itself. Table 2 summarizes the per-mile cost of an ECCO/GITL system.

As previously mentioned, the ECCO system per mile cost estimate does not include load/offload facilities, which could be a major cost factor for the project. Similarly, the addition of high power transmission capabilities within the elevated freight transport system does not include possible required electrical substations, or the added land used by those sub-stations.

Guideway	17.94
Infrastructure with Cable Vault	43.93
Powering and Control	25.22
Vehicles	12.76
Gas Insulated Transmission Line	8.70
Maintenance Facility	3.34
Total	111.89

Table 2: Cost breakdown in millions of dollars per mile for GITL power transmission integrated into ECCO-like guideway

5.3 Potential Benefits to Co-Location of ECCO Guideways and Electrical Transmission

As an example of how the integration of an elevated, small footprint, advanced technology freight system can influence urban planning, consider the possible relationship of a hypothetical ECCO system to an urban electric power grid. Consider, in addition, the difficulty of building new electrical generating plants near the cities, which require the power produced. Such plants are built and operated most effectively in isolated areas away from urban regions, but this option traditionally has not been exercised because of the expense of requisite power distribution lines to deliver power to the city from outlying plants. Also, newly developed solar, wind, and geothermal sources of electric power tend to be located at significant distances away from locations where power is required. The postulated ECCO system's ability to share the same rights-of-way as power distribution lines is pertinent here. A fundamental premise of this report is that the ECCO runs on an elevated alignment through the city, reducing pollution and traffic congestion while moving freight to a remote area for container processing and storage. By a fortuitous combination of architecture and function, the architecture required for elevated freight movement to remote intermodal facilities conforms to the same land use requirements as those of remote power plants and renewable energy sources. Because of this, power generators located near to remote inland terminus used for freight off-loading allows the ECCO to perform as the backbone of the power grid (and vice versa).

There are other benefits to use of gas insulated transmission lines (GITLs), or cross-linked polyethylene transmission lines (XLPEs) in a rights of way sharing approach. In addition to enabling the aforementioned effective transfer of power, it is possible that the ubiquitous transmission line towers which dot the landscape may be eliminated. Also, an increased ease of access facilitates maintenance of these power lines. Many urban communities would prefer to consolidate overhead lines into power line vaults; but the cost of these enclosures is significant; they must be elevated for safety reasons, which adds to the cost of construction. However, the integration of GITLs into alternative technology infrastructure such as present on an ECCO system, not only reduces the cost of consolidating overhead electrical power transmission but also allows a more effective use of existing and future transmission line rights-of-way.

6 Formulate an Alignment of an Existing Utility Right of Way for an ECCO System from the Port to the Inland Empire

The I-710 EIR[9] provides for an alternative technology such as the ECCO; however, as previously discussed, the proposed corridor only extends from the Port of LA/LB to downtown Los Angeles. This necessitates a provision for continuation of container flow beyond this nexus in the numbers projected by economic growth estimates. If freeway stretches beyond the downtown area cannot be expanded to include more lanes, and if rail improvements to reduce traffic congestion cannot be made without impeding local commerce, then there presently exists no way to provide the requisite container flow from the Los Angeles area to the inland empire. The combined truck and alternative technology corridor presently under consideration as a link between the terminus of the I-710 and the I-15 would route freight traffic from downtown Los Angeles to the I-15 along a path adjacent to the Union Pacific rights of way as shown in Figure (6), a path which would heavily impact the already congested area south of the Ontario airport. A preferable choice to alleviate this difficulty would be to follow electrical power transmission rights of way as shown in Figures (7) and (8) , a route which avoids the aforementioned urban congestion.

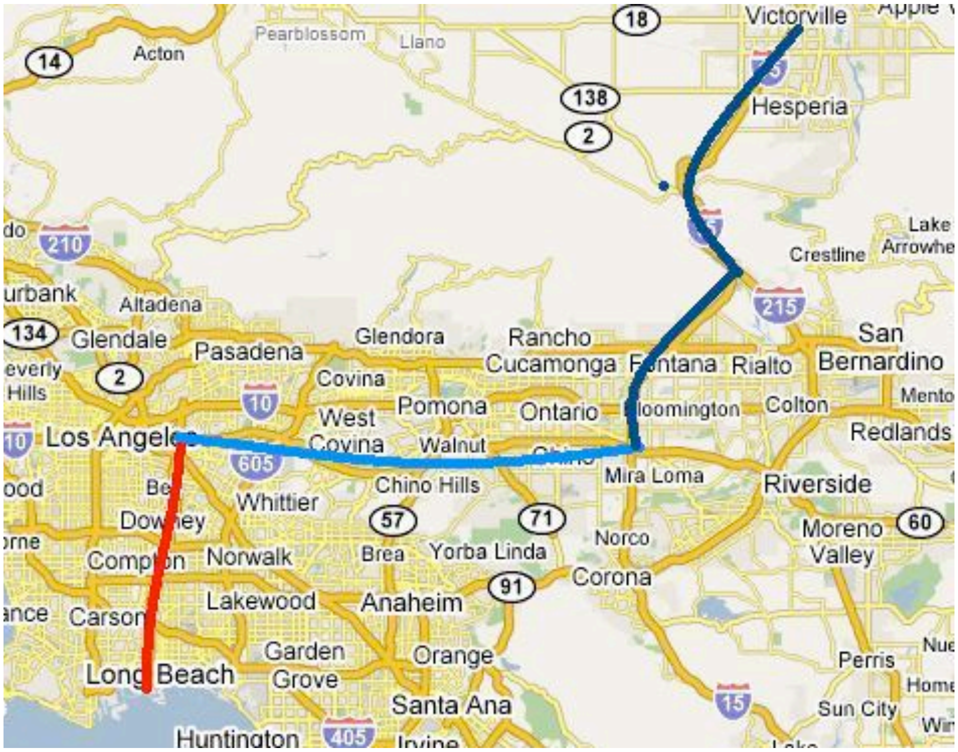


Figure 6: I-710 to the I-15

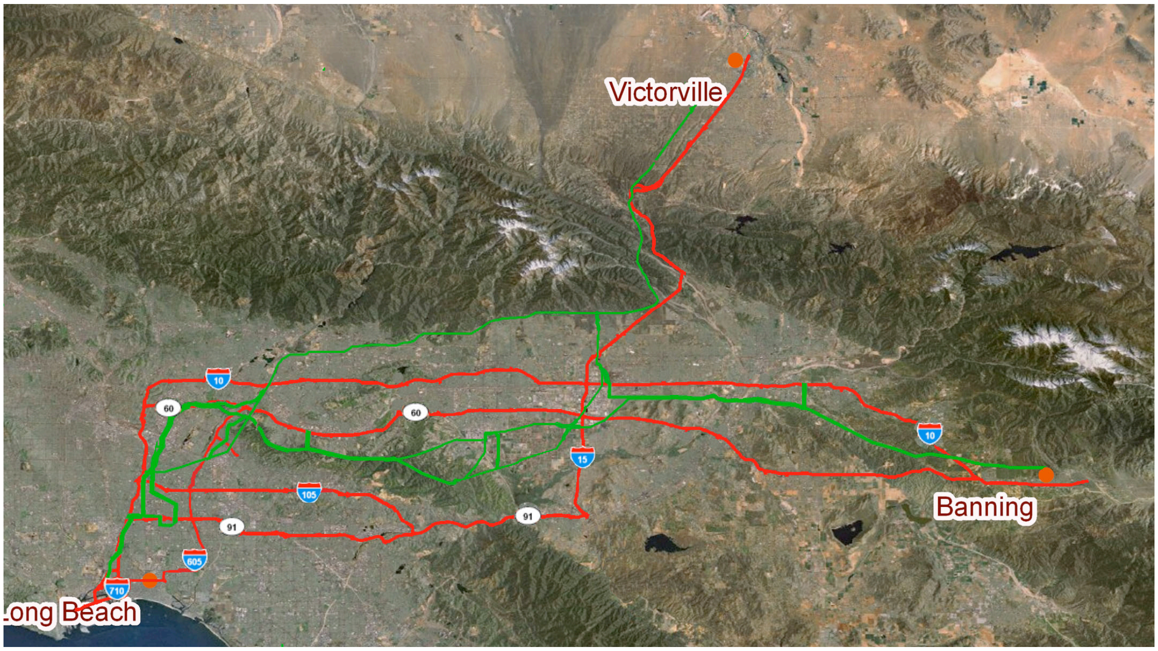


Figure 7: Possible Freight Corridors Along 230 kV Transmission Lines

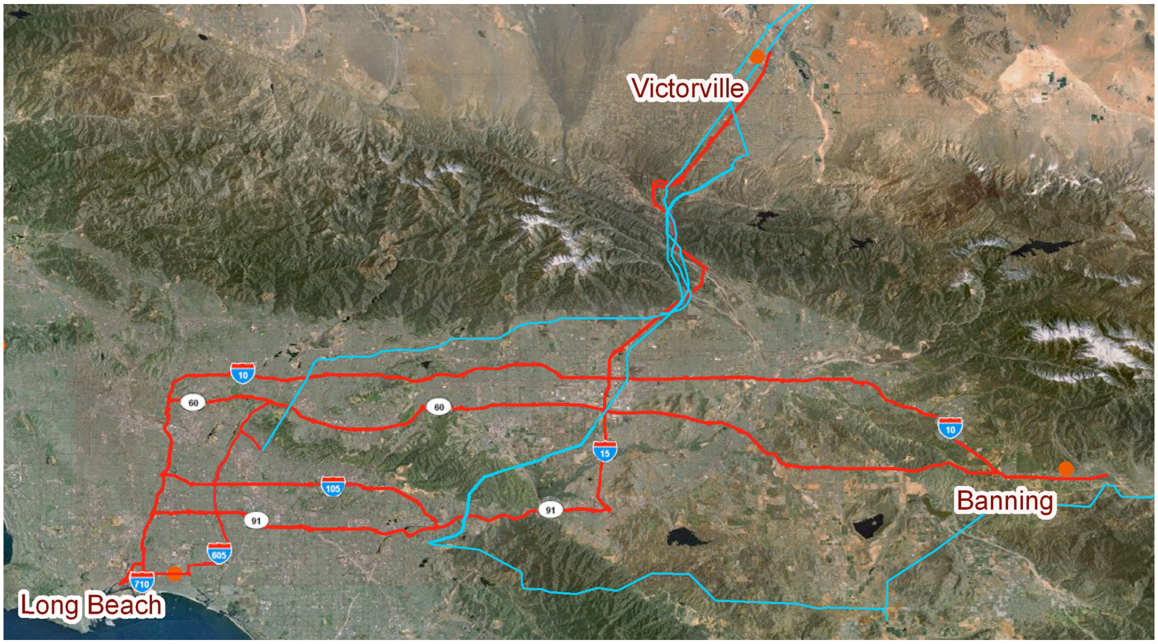


Figure 8: Possible Freight Corridors Along 500 kV Transmission Lines

6.1 Satellite Imaging of Route Profile

Figure (9) shows a possible northern route, which follows a 500 kV line right-of-way. Using *Google Maps*, the route was analyzed for potential geography issues such as rivers or arroyos. The location of each transmission tower was established so that the overall path relative to the LA basin could be visualized. Figure (10) shows how a sample region in the vicinity of two (2) transmission towers might appear if the present rights of way were to be transformed from sole use as overhead electrical transmission to dual-use ECCO freight/utility corridor.

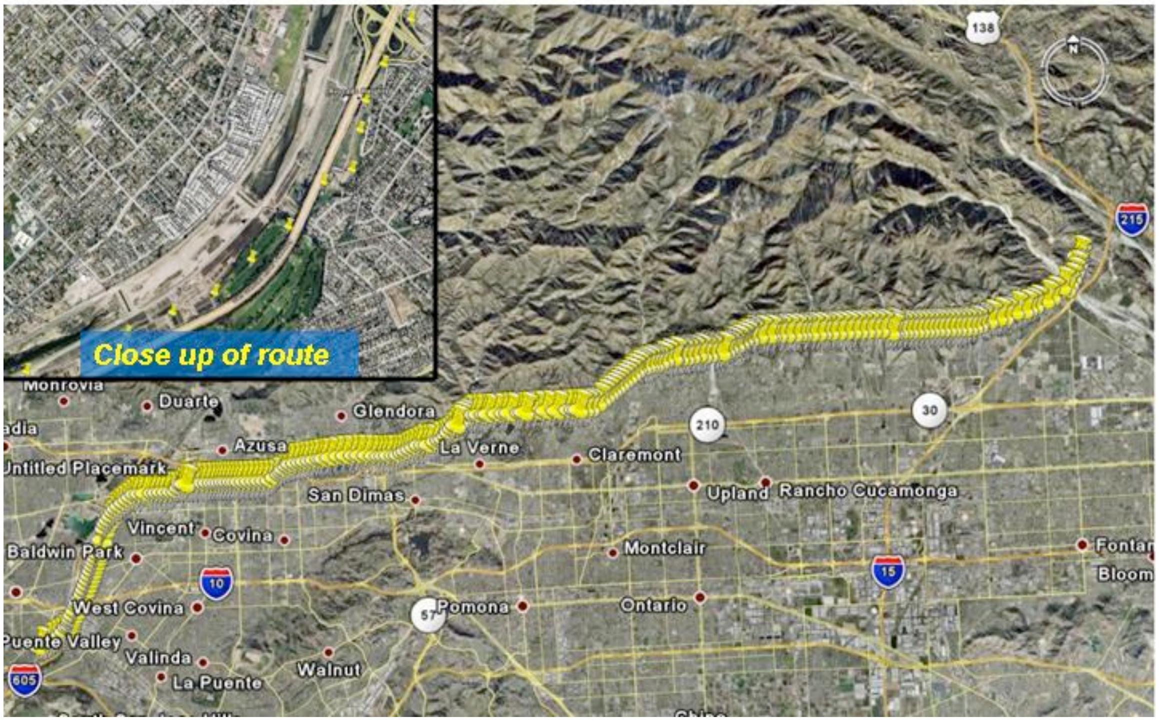


Figure 9: Possible 500 kV Line Dual-use Route (Yellow Pins Locate Towers)

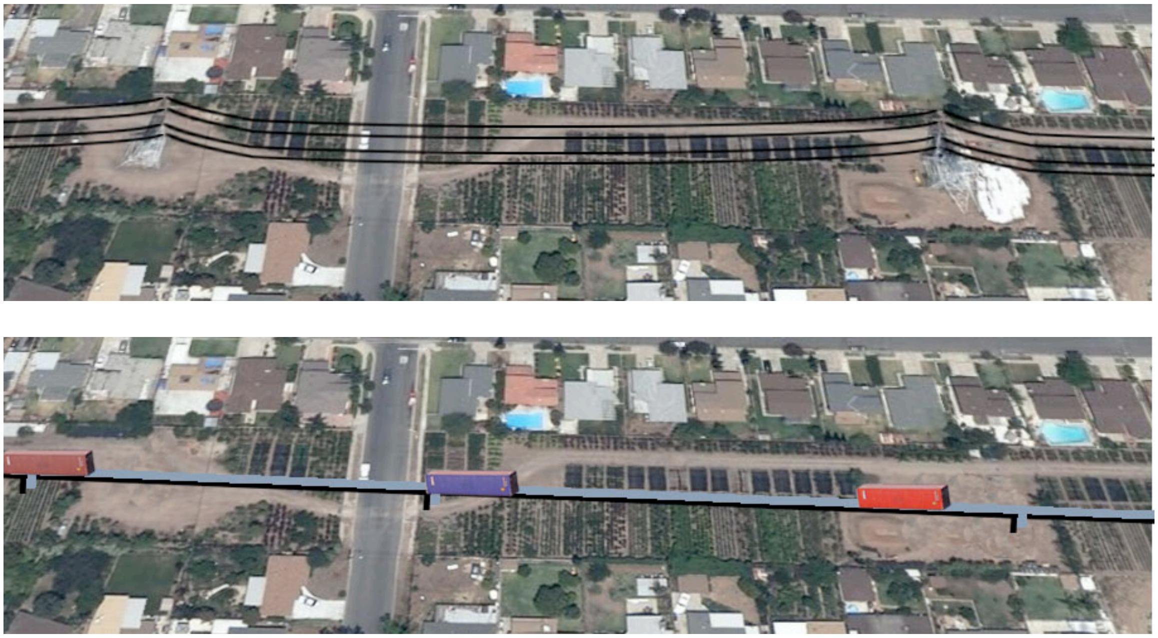


Figure 10: Locale of Two (2) Transmission Towers along the 500 kV Route and the Envisioned Evolution of the Route from Electric Transmission to Dual-Use ECCO Freight/Utility Corridor

6.2 Local Distribution with Electric Trucks and Inland Ports

Local container deliveries could be accommodated by the addition of satellite terminals along an established corridor, which would actually be extensions of Port terminals. For example, an ITS satellite terminal containing a container gate and an APL gate could function as a dual-use ECCO "station." In a similar fashion to that employed by home port operations, the consignee chooses a satellite terminal from which to pick up a container for local delivery. Clean (most likely electric) trucks will pick up containers from satellite terminals for the much shorter local delivery routes rather than making round trips to and from the port itself, an option, which in itself further reduces congestion. In this scenario, the short range of electric trucks is not a detriment to their use, and they can be recharged while they wait for a delivery assignment by the satellite terminal's electric utility. Intercontinental trains can also be loaded at the terminus of the dual-use freight corridor, obviating the necessity for sorting containers at the Port.

7 Conclusions and Recommendations

This investigation produced a cost per mile estimate for a Maglev based container cargo conveyor with integrated transmission lines. The capacity to integrate gas insulated transmission lines allows the system to use existing power transmission rights of way through the Los Angeles basin. A preliminary ECCO/GITL route, presently used by 500kV power lines is also presented. The cost for the basic system using the ECCO electrodynamic levitation approach and gas insulated transmission lines is $112M per mile. Using a conventional form of Maglev technology could increase costs to $134M per mile. These per mile cost estimates do not include the costs of freight terminals at the ends or along the proposed route. Also, these costs do not account for possible enhancements to electrical distribution stations along the potential route. This report concludes that use of power line rights of way by Maglev or other electrically driven freight transport with integrated power transmission capability is feasible. The total cost per mile of such a system could be considerably higher if numerous, auxiliary transportation and electric power supporting subsystems are included in the calculation. The definition, requirements, and costs of such subsystems would be of value in further evaluations of such systems

The referenced SCAG and PoLA systems, and the presently proposed ECCO/GITL system all rely on public rights of way such as freeways and transmission line corridors; thus, the dual use of public rights of way seems to be a major issue in the development of new transportation systems. This investigation points out the need for a clear understanding of the many aspects, beyond technology, of multiple-use of public rights of way.

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Appendix A: SCAG Maglev Deployment Program

SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS
MAGLEV DEPLOYMENT PROGRAM

PART 2 - MILESTONE 7

SUMMARY OF PRELIMINARY
ENGINEERING FOR IOS

August 2006

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Santa Maria, CA 93458

IBI Group
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Irvine, CA 92612

MAGLEV
TURNING THE VISION INTO REALITY

V. Refined Cost Estimates

Cost estimates have been developed for the three alignment options of the I-10, UPRR and SR-60. The costs provided are in year 2006 dollars and are based on recent industry experience relating to material and labor rates and available information from TRI-USA relating to maglev system component costs. Specific details of the unit costs and assumptions are provided in the Refined Cost Estimate report. The report provides information on the key components of the system which include:

- Structures/Foundations/Tunnels
- Earthwork
- Stations
- Parking Facilities
- Operation and Maintenance Facilities
- Guideway/ Propulsion/Power Supply/Operation Control (OCS)
- Sound Walls (Noise Protection)
- Safety Fencing/Landscape
- Maglev Vehicles
- ROW/Roadway Improvements/Utility Relocation/Traffic Control
- Contingencies, Project Implementation, and Environmental Mitigation

In summary, the cost for each alignment is summarized as the following:

- I-10 Alignment - $7.811 billion
- Union Pacific Railroad Alignment - $8.066 billion
- SR-60 Alignment - $8.177 billion

The following tables provide a more detailed summary of the cost for each of the three alignment options.

Table 1: I-10 Alignment

Item	Quantity	Unit	Unit Cost	Cost	Subtotal	Estimated Design/Constr. Contingencies	Estimated Program Implementation	Environmental Impact Mitigation	Contingencies, Management, & Mitigation Costs	Estimated Item/System Total Cost
Conversion from feet to meters	0.3048									
Conversion from miles to kilometers	1.6093									
Conversion from cubic yards (cu-yd) to cubic meters (cu-m)	0.7646									
Conversion from square feet (sq-ft) to square meters (sq-m)	0.0929									
Length of Alignment (miles)	54.44									
						10.0%	30.0%	3.0%	43.0%	
Guideway =====>					$ 1,085,492,300	$ 108,549,230	$ 325,647,690	$ 32,564,769	$ 466,761,689	$ 1,552,254,000
Type 1 Guideway	534,100	LF	$ 1,943	$ 1,037,756,300						
Type 3 Guideway	40,800	LF	$ 1,170	$ 47,736,000						
						25.0%	30.0%	3.0%	58.0%	
Structures/Foundations/Tunnels =====>					$ 1,364,124,200	$ 341,031,050	$ 409,237,260	$ 40,923,726	$ 791,192,036	$ 2,155,316,200
Substructure for Guideway Type 1 and 3	287,450	LF	$ 4,516	$ 1,298,124,200						
Elevated Walkways	20,000	LF	$ 800	$ 16,000,000						
Sound Walls	10,000	LF	$ 1,000	$ 10,000,000						
Tunnel substructure	-	LF	$ 15,000	$ -						
Retaining Walls	1	LS	$ 10,000,000	$ 10,000,000						
Ground Densification	1	each	$ 30,000,000	$ 30,000,000						
						25.0%	30.0%	3.0%	58.0%	
Stations/Maintenance Total Cost =====>					$ 803,917,376	$ 200,979,344	$ 241,175,213	$ 24,117,521	$ 466,272,078	$ 1,270,189,500
Stations					$ 594,383,376					
Ontario Airport Station (Center Side Platform Mezzanine)	1	LS	$ 80,377,000	$ 80,377,000						
Ontario Airport Station Parking Structure	5927	Spaces	$ 19,173	$ 113,638,371						
West Covina Station (Center Platform)	1	LS	$ 44,184,000	$ 44,184,000						
West Covina Station Parking Structure	6368	Spaces	$ 19,173	$ 122,093,664						
Union Station (Center Side Platform Mezzanine)	1	LS	$ 80,377,000	$ 80,377,000						
Union Station Parking Structure	3500	Spaces	$ 19,173	$ 67,105,500						
West LA (Center Platform)	1	LS	$ 42,184,000	$ 42,184,000						
West LA Parking Structure	2317	Spaces	$ 19,173	$ 44,423,841						
Maintenance & Operations Facilities					$ 209,534,000					
Central Maintenance Facility & OCC (Building and Non-Maglev Equipment)	1	LS	$ 91,452,000	$ 91,452,000						
Decentral Maintenance Facility (Building and Non-Maglev Equipment)	1	LS	$ 27,332,000	$ 27,332,000						
Maglev Vehicle Equipment	1	LS	$ 70,000,000	$ 70,000,000						
Maglev Maintenance and Inspection Vehicles	1	LS	$ 10,000,000	$ 10,000,000						
Maglev Train Wash Facility	1	LS	$ 7,000,000	$ 7,000,000						
Parking Facility	250	LS	$ 15,000	$ 3,750,000						
						25.0%	30.0%	3.0%	58.0%	
Communications/Signal/Power =====>					$ 849,264,000	$ 212,316,000	$ 254,779,200	$ 25,477,920	$ 492,573,120	$ 1,341,837,100
Power Substations/Distribution	54.44	Mile	$ 10,400,000	$ 566,176,000						
Operations/Control/Communications	54.44	Mile	$ 5,200,000	$ 283,088,000						
						10.0%	5.0%	0.0%	15.0%	
Vehicles Total Cost =====>					$ 800,800,000	$ 80,080,000	$ 40,040,000	$ -	$ 120,120,000	$ 920,920,000
(8) Car Consists	10	each	$ 80,080,000	$ 800,800,000						
						0.0%	0.0%	0.0%	0.0%	
Right of Way =====>					$ 324,049,875	$ -	$ -	$ -	$ -	$ 324,049,900
Right of Way	1	LS	$ 324,049,875	$ 324,049,875						
						25.0%	30.0%	3.0%	58.0%	
Roadway Improvements/Utility Relocation/Traffic Control=====>					$ 156,240,400	$ 39,060,100	$ 46,872,120	$ 4,687,212	$ 90,619,432	$ 246,859,800
Roadway Improvements										
Roadway Improvements w/Drainage	1	LS	$ 45,000,000	$ 45,000,000						
Utility Relocation	1	LS	$ 50,000,000	$ 50,000,000						
Traffic Control During Construction (2.5% of structure+guideway)	1	LS	$ 61,240,400	$ 61,240,400						
					System Subtotal	**Estimated Design/Constr. Contingencies**	**Estimated Program Implementation**	**Environmental Impact Mitigation**	**Contingencies, Management, & Mitigation Costs**	**Estimated Item/System Total Cost**
Subtotal =====>					$ 5,383,888,151	$ 982,015,724	$ 1,317,751,483	$ 127,771,148	$ 2,427,538,355	$ 7,811,426,500
Cost per Mile (Double Track System) =====>					$ 98,895,815	$ 18,038,496	$ 24,205,575	$ 2,347,009	$ 44,591,079	$ 143,486,894

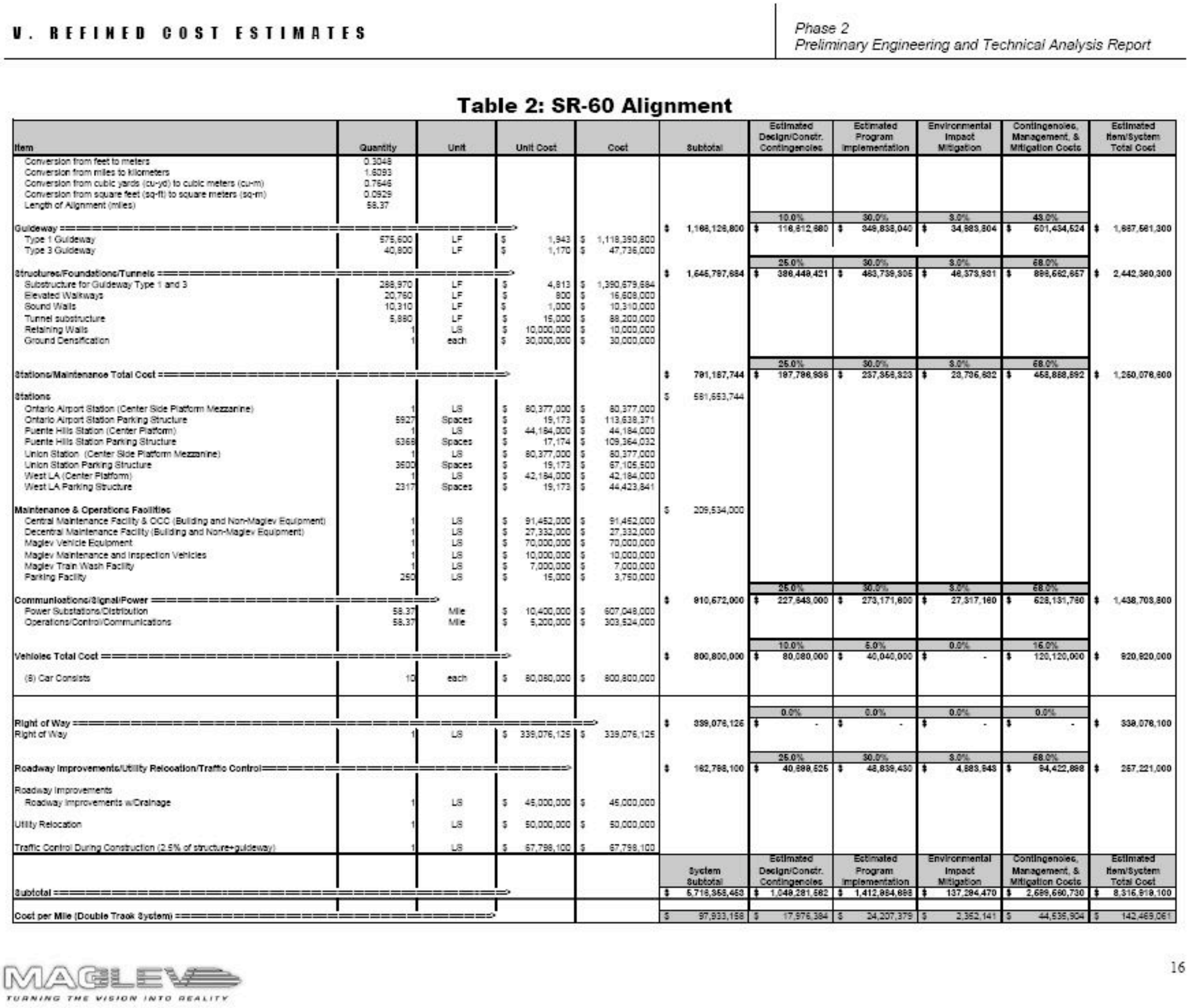


Table 2: SR-60 Alignment

Item	Quantity	Unit	Unit Cost	Cost	Subtotal	Estimated Design/Constr. Contingencies	Estimated Program Implementation	Environmental Impact Mitigation	Contingencies, Management, & Mitigation Costs	Estimated Item/System Total Cost
Conversion from feet to meters	0.3048									
Conversion from miles to kilometers	1.6093									
Conversion from cubic yards (cu-yd) to cubic meters (cu-m)	0.7646									
Conversion from square feet (sq-ft) to square meters (sq-m)	0.0929									
Length of Alignment (miles)	58.37									
						10.0%	30.0%	3.0%	43.0%	
Guideway ==========>					$ 1,166,126,800	$ 116,612,680	$ 349,838,040	$ 34,983,804	$ 501,434,524	$ 1,667,561,300
Type 1 Guideway	575,600	LF	$ 1,943	$ 1,118,390,800						
Type 3 Guideway	40,800	LF	$ 1,170	$ 47,736,000						
						25.0%	30.0%	3.0%	68.0%	
Structures/Foundations/Tunnels ==========>					$ 1,545,797,684	$ 386,449,421	$ 463,739,305	$ 46,373,931	$ 896,562,657	$ 2,442,360,300
Substructure for Guideway Type 1 and 3	288,970	LF	$ 4,813	$ 1,390,679,684						
Elevated Walkways	20,760	LF	$ 800	$ 16,608,000						
Sound Walls	10,310	LF	$ 1,000	$ 10,310,000						
Tunnel substructure	5,880	LF	$ 15,000	$ 88,200,000						
Retaining Walls	1	LS	$ 10,000,000	$ 10,000,000						
Ground Densification	1	each	$ 30,000,000	$ 30,000,000						
						25.0%	30.0%	3.0%	68.0%	
Stations/Maintenance Total Cost ==========>					$ 791,187,744	$ 197,796,936	$ 237,356,323	$ 23,735,632	$ 458,888,892	$ 1,250,076,600
Stations					$ 581,653,744					
Ontario Airport Station (Center Side Platform Mezzanine)	1	LS	$ 80,377,000	$ 80,377,000						
Ontario Airport Station Parking Structure	5927	Spaces	$ 19,173	$ 113,638,371						
Puente Hills Station (Center Platform)	1	LS	$ 44,184,000	$ 44,184,000						
Puente Hills Station Parking Structure	6368	Spaces	$ 17,174	$ 109,364,032						
Union Station (Center Side Platform Mezzanine)	1	LS	$ 80,377,000	$ 80,377,000						
Union Station Parking Structure	3600	Spaces	$ 19,173	$ 67,105,500						
West LA (Center Platform)	1	LS	$ 42,184,000	$ 42,184,000						
West LA Parking Structure	2317	Spaces	$ 19,173	$ 44,423,841						
Maintenance & Operations Facilities					$ 209,534,000					
Central Maintenance Facility & OCC (Building and Non-Maglev Equipment)	1	LS	$ 91,452,000	$ 91,452,000						
Decentral Maintenance Facility (Building and Non-Maglev Equipment)	1	LS	$ 27,332,000	$ 27,332,000						
Maglev Vehicle Equipment	1	LS	$ 70,000,000	$ 70,000,000						
Maglev Maintenance and Inspection Vehicles	1	LS	$ 10,000,000	$ 10,000,000						
Maglev Train Wash Facility	1	LS	$ 7,000,000	$ 7,000,000						
Parking Facility	250	LS	$ 15,000	$ 3,750,000						
						25.0%	30.0%	3.0%	58.0%	
Communications/Signal/Power ==========>					$ 910,572,000	$ 227,643,000	$ 273,171,600	$ 27,317,160	$ 528,131,760	$ 1,438,703,800
Power Substations/Distribution	58.37	Mile	$ 10,400,000	$ 607,048,000						
Operations/Control/Communications	58.37	Mile	$ 5,200,000	$ 303,524,000						
						10.0%	5.0%	0.0%	15.0%	
Vehicles Total Cost ==========>					$ 800,800,000	$ 80,080,000	$ 40,040,000	$ -	$ 120,120,000	$ 920,920,000
(8) Car Consists	10	each	$ 80,080,000	$ 800,800,000						
						0.0%	0.0%	0.0%	0.0%	
Right of Way ==========>					$ 339,076,125	$ -	$ -	$ -	$ -	$ 339,076,100
Right of Way	1	LS	$ 339,076,125	$ 339,076,125						
						25.0%	30.0%	3.0%	58.0%	
Roadway Improvements/Utility Relocation/Traffic Control ==========>					$ 162,798,100	$ 40,699,525	$ 48,839,430	$ 4,883,943	$ 94,422,898	$ 257,221,000
Roadway Improvements										
Roadway Improvements w/Drainage	1	LS	$ 45,000,000	$ 45,000,000						
Utility Relocation	1	LS	$ 50,000,000	$ 50,000,000						
Traffic Control During Construction (2.5% of structure+guideway)	1	LS	$ 67,798,100	$ 67,798,100						
					System Subtotal	Estimated Design/Constr. Contingencies	Estimated Program Implementation	Environmental Impact Mitigation	Contingencies, Management, & Mitigation Costs	Estimated Item/System Total Cost
Subtotal ==========>					$ 5,716,358,453	$ 1,049,281,562	$ 1,412,984,698	$ 137,294,470	$ 2,599,560,730	$ 8,315,919,100
Cost per Mile (Double Track System) ==========>					$ 97,933,158	$ 17,976,384	$ 24,207,379	$ 2,352,141	$ 44,535,904	$ 142,469,061

TURNING THE VISION INTO REALITY

Table 3: UPRR Alignment

Item	Quantity	Unit	Unit Cost	Cost	Subtotal	Estimated Design/Constr. Contingencies	Estimated Program Implementation	Environmental Impact Mitigation	Contingencies, Management, & Mitigation Costs	Estimated Item/System Total Cost
Conversion from feet to meters	0.3048									
Conversion from miles to kilometers	1.6093									
Conversion from cubic yards (cu-yd) to cubic meters (cu-m)	0.7646									
Conversion from square feet (sq-ft) to square meters (sq-m)	0.0929									
Length of Alignment (miles)	56.33									
						10.0%	30.0%	3.0%	43.0%	
Guideway ==========>					$ 1,133,878,580	$ 113,387,858	$ 340,163,574	$ 34,016,357	$ 487,567,789	$ 1,621,446,400
Type 1 Guideway	566,560	LF	$ 1,943	$ 1,100,826,080						
Type 3 Guideway	28,250	LF	$ 1,170	$ 33,052,500						
						25.0%	30.0%	3.0%	58.0%	
Structures/Foundations/Tunnels ==========>					$ 1,454,987,650	$ 363,746,913	$ 436,496,295	$ 43,649,630	$ 843,892,837	$ 2,298,880,500
Substructure for Guideway Type 1 and 3	297,410	LF	$ 4,665	$ 1,387,417,650						
Elevated Walkways	20,900	LF	$ 800	$ 16,720,000						
Sound Walls	10,400	LF	$ 1,000	$ 10,400,000						
Tunnel substructure	-	LF	$ 15,000	$ -						
Retaining Walls	1	LS	$ 10,450,000	$ 10,450,000						
Ground Densification	1	each	$ 30,000,000	$ 30,000,000						
						25.0%	30.0%	3.0%	58.0%	
Stations/Maintenance Total Cost ==========>					$ 801,917,376	$ 200,479,344	$ 240,575,213	$ 24,057,521	$ 465,112,078	$ 1,267,029,500
Stations					$ 592,383,376					
Ontario Airport Station (Center Side Platform Mezzanine)	1	LS	$ 80,377,000	$ 80,377,000						
Ontario Airport Station Parking Structure	5927	Spaces	$ 19,173	$ 113,638,371						
Industry Station (Center Platform)	1	LS	$ 42,184,000	$ 42,184,000						
Industry Station Parking Structure	6368	Spaces	$ 19,173	$ 122,093,664						
Union Station (Center Side Platform Mezzanine)	1	LS	$ 80,377,000	$ 80,377,000						
Union Station Parking Structure	3500	Spaces	$ 19,173	$ 67,105,500						
West LA (Center Platform)	1	LS	$ 42,184,000	$ 42,184,000						
West LA Parking Structure	2317	Spaces	$ 19,173	$ 44,423,841						
Maintenance & Operations Facilities					$ 209,534,000					
Central Maintenance Facility & OCC (Building and Non-Maglev Equipment)	1	LS	$ 91,452,000	$ 91,452,000						
Decentral Maintenance Facility (Building and Non-Maglev Equipment)	1	LS	$ 27,332,000	$ 27,332,000						
Maglev Vehicle Equipment	1	LS	$ 70,000,000	$ 70,000,000						
Maglev Maintenance and Inspection Vehicles	1	LS	$ 10,000,000	$ 10,000,000						
Maglev Train Wash Facility	1	LS	$ 7,000,000	$ 7,000,000						
Parking Facility	250	LS	$ 15,000	$ 3,750,000						
						25.0%	30.0%	3.0%	58.0%	
Communications/Signal/Power ==========>					$ 878,696,591	$ 219,674,148	$ 263,608,977	$ 26,360,898	$ 509,644,023	$ 1,388,340,600
Power Substations/Distribution	56.33	Mile	$ 10,400,000	$ 585,797,727						
Operations/Control/Communications	56.33	Mile	$ 5,200,000	$ 292,898,864						
						10.0%	5.0%	0.0%	15.0%	
Vehicles Total Cost ==========>					$ 800,800,000	$ 80,080,000	$ 40,040,000	$ -	$ 120,120,000	$ 920,920,000
(8) Car Consists	10	each	$ 80,080,000	$ 800,800,000						
						0.0%	0.0%	0.0%	0.0%	
Right of Way ==========>					$ 314,461,250	$ -	$ -	$ -	$ -	$ 314,461,300
Right of Way	1	LS	$ 314,461,250	$ 314,461,250						
						25.0%	30.0%	3.0%	58.0%	
Roadway Improvements/Utility Relocation/Traffic Control ==========>					$ 161,721,700	$ 40,430,425	$ 48,516,510	$ 4,851,651	$ 93,798,586	$ 255,520,300
Roadway Improvements										
Roadway Improvements w/Drainage	1	LS	$ 47,000,000	$ 47,000,000						
Utility Relocation	1	LS	$ 50,000,000	$ 50,000,000						
Traffic Control During Construction (2.5% of structure+guideway)	1	LS	$ 64,721,700	$ 64,721,700						
					System Subtotal	Estimated Design/Constr. Contingencies	Estimated Program Implementation	Environmental Impact Mitigation	Contingencies, Management, & Mitigation Costs	Estimated Item/System Total Cost
Subtotal ==========>					$ 5,546,463,147	$ 1,017,798,687	$ 1,369,400,569	$ 132,936,057	$ 2,520,135,313	$ 8,066,598,600
Cost per Mile (Double Track System) ==========>					$ 98,469,513	$ 18,069,559	$ 24,311,747	$ 2,360,089	$ 44,741,395	$ 143,210,910

Appendix B: Port of LA Maglev Study

GA-C25498

CONCEPTUAL DESIGN STUDY FOR THE ELECTRIC CARGO CONVEYOR (ECCO) SYSTEM

Final Report

Prepared for
The Port of Los Angeles
San Pedro, CA

In support of
Agreement No. E-6304
GA Project 20132

Submitted by
GENERAL ATOMICS

Mackin

hi

UNION SWITCH & SIGNAL

Lawrence Livermore
National Laboratory

CSULB CCDoTT

15 June 2006

4. BUDGETARY COST ESTIMATE

A rigorous approach using a detailed work breakdown structure (WBS) was used to generate this budgetary cost estimate. Please note that this budgetary cost estimate is for planning purposes only and does not constitute an offer. Team members were responsible for providing a grassroots estimate for the equipment and labor required in their area of responsibility. The estimate includes all nonrecurring capital costs associated with the engineering, construction, and commissioning of the project.

Site Specific/Detail Engineering costs are those application engineering tasks associated with identifying specific requirements and interfaces of the system, and those engineering tasks associated with completing the engineering drawings and specifications for the Port of Los Angeles ECCO system.

Construction costs include all purchased parts, fabricated hardware, components, assembly, and labor to construct, assemble, and install the complete Port of Los Angeles ECCO system (excluding cargo handling).

Commissioning costs include those tasks needed to put the Port of Los Angeles ECCO system into service. These tasks include safety planning, failure modes and effects analysis (FMEA), test planning, component acceptance testing, system acceptance testing, training, the cost of energy, and project integration.

All cost estimates in this plan reflect unescalated 2006 dollars and include all business factors such as warranties, competitive profit margins, and so forth.

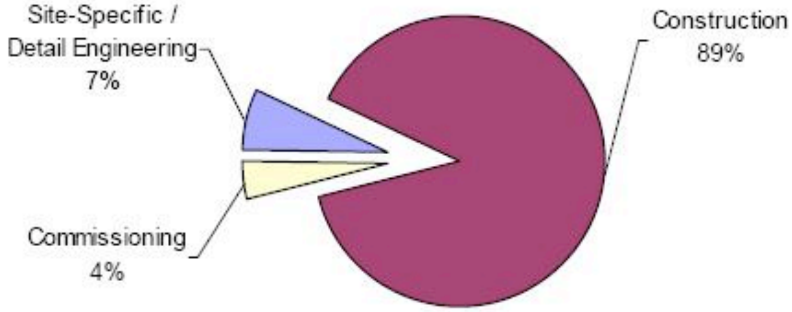
4.1 BUDGETARY COST ESTIMATE – PORT OF LOS ANGELES ECCO SYSTEM

Baseline ground rules and assumptions issued in preparing this estimate are provided below.

1 This budgetary estimate is for planning purposes only and does not constitute an offer
2 Constant, unescalated 2006 dollars, including all business factors such as warranties, competitive profit margins, and so forth
3 Right-of-way and environment impacts costs are not included
4 Channel and freeway crossings are included
5 The Port of Los Angeles ECCO system design concept is a close derivative of current passenger Maglev concept
6 Site-specific/detail engineering is a 1.5-year activity
7 Construction is a 3-year activity
8 Commissioning occurs 3 months after completion of construction
9 Throughput – 2500 40-ft containers per direction/per year

10 Operation will be 24 hours a day/7 days a week
11 Length of project is 4.7 miles
12 Cargo handling equipment not included
13 Driverless operation
14 Single container Maglev chassis (no consist)

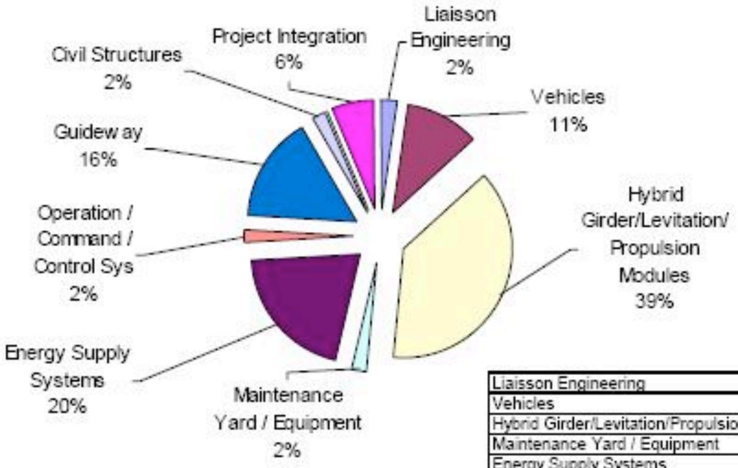
The total cost is depicted in Fig. 4-1.



Site-Specific / Detail Engineering	$ 40,359,000
Construction	$ 510,149,000
Total Engineering & Construction	$ 550,508,000
Commissioning	$ 24,070,000
Total	$ 574,578,000

Fig. 4-1. Cost summary

Because construction is the biggest driver, a further breakdown is provided in Fig. 4-2.



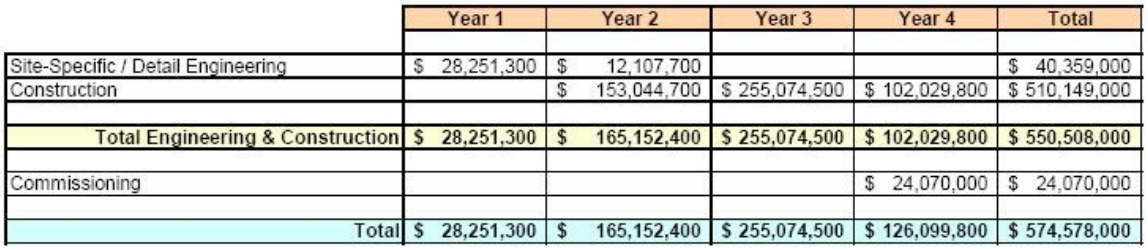
Liaisson Engineering	$ 12,500,000
Vehicles	$ 55,505,000
Hybrid Girder/Levitation/Propulsion Modules	$ 194,074,000
Maintenance Yard / Equipment	$ 11,234,000
Energy Supply Systems	$ 103,326,000
Operation / Command / Control Sys	$ 10,721,000
Guideway	$ 79,875,000
Civil Structures	$ 10,375,000
Right-of-Way / Corridor	$ -
Project Integration	$ 32,539,000
Total	$ 510,149,000

Fig. 4-2. Construction cost breakdown

4.2 FUNDING PROFILE

Table 4-1 presents the estimated funding profile.

TABLE 4-1
FUNDING PROFILE



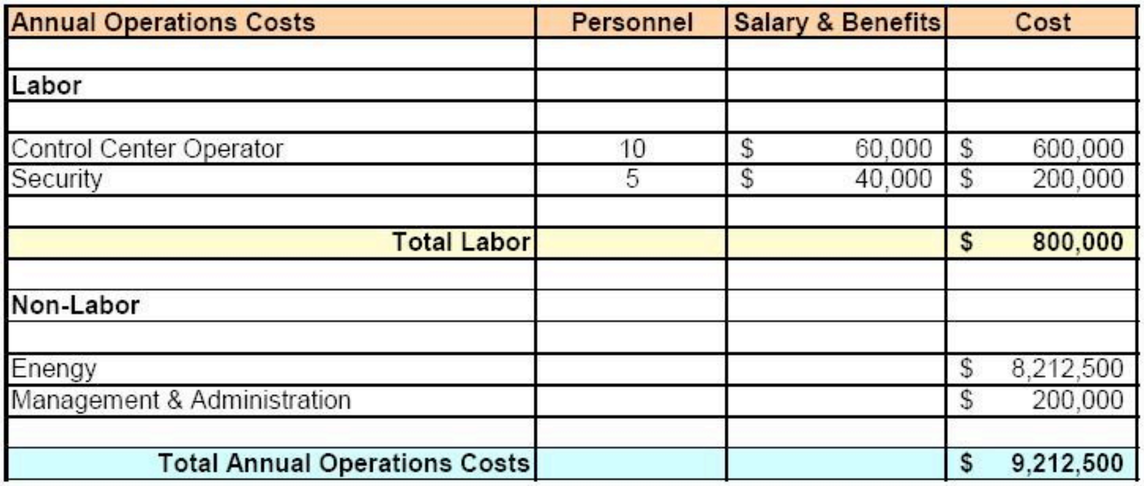
	Year 1	Year 2	Year 3	Year 4	Total
Site-Specific / Detail Engineering	$ 28,251,300	$ 12,107,700			$ 40,359,000
Construction		$ 153,044,700	$ 255,074,500	$ 102,029,800	$ 510,149,000
Total Engineering & Construction	**$ 28,251,300**	**$ 165,152,400**	**$ 255,074,500**	**$ 102,029,800**	**$ 550,508,000**
Commissioning				$ 24,070,000	$ 24,070,000
Total	**$ 28,251,300**	**$ 165,152,400**	**$ 255,074,500**	**$ 126,099,800**	**$ 574,578,000**

4.3 OPERATING AND MAINTENANCE COSTS

To estimate the operating cost, we assumed that the system will be operated by a minimum staff of three people for 24 hours a day, seven days a week. Based on these assumptions, annual operating expenses are provided in Table 4-2.

Train operation requires one supervisor and one controls engineer located in the control room, and one security team member to provide for roving security watch of the system. Operations 24 hours a day and a 40-hour workweek result in a total operations staff of about 15 people. Additional staff is required for maintenance and emergency vehicle operation.

TABLE 4-2
ECCO-SYSTEM ANNUAL OPERATIONS COST ESTIMATE



Annual Operations Costs	Personnel	Salary & Benefits	Cost
Labor			
Control Center Operator	10	$ 60,000	$ 600,000
Security	5	$ 40,000	$ 200,000
Total Labor			**$ 800,000**
Non-Labor			
Enengy			$ 8,212,500
Management & Administration			$ 200,000
Total Annual Operations Costs			**$ 9,212,500**

With regard to maintenance, it is expected that staff of 19 people will work the day shift, performing routine maintenance and inspection of the system. Based on this assumption, annual maintenance costs are provided in Table 4-3.

TABLE 4-3
ECCO-SYSTEM ANNUAL MAINTENANCE COST ESTIMATE

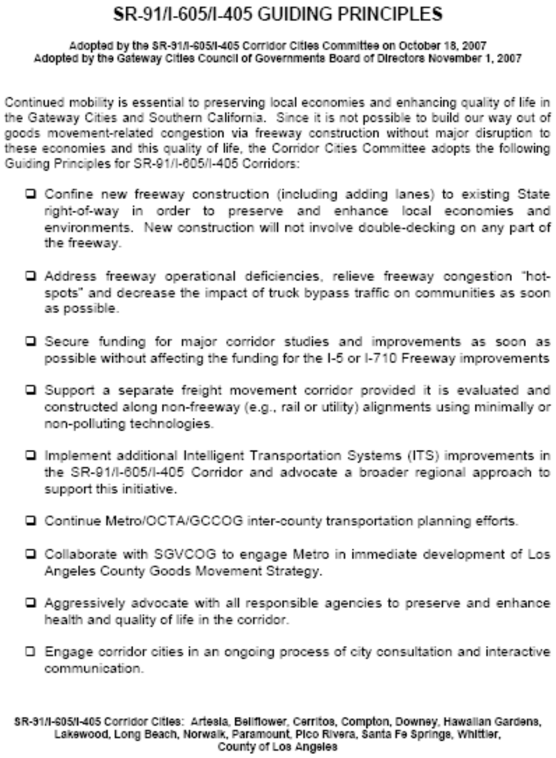
Annual Maintenance Costs	Personnel	Salary & Benefits	Cost
Labor			
Vehicles	6	$ 90,000	$ 540,000
Electrical Systems	8	$ 90,000	$ 720,000
Guideway Inspection and Maintenance	5	$ 90,000	$ 450,000
Total Labor			**$ 1,710,000**
Non-Labor			
Spare Parts			$ 1,800,000
Total Annual Operations Costs			**$ 3,510,000**

Based on the above estimates, the annual operating and maintenance cost is estimated to be $12.7M per year.

Appendix C: Gateway Cities Council of Governments Guiding Principles

Iteris Inc., formally Meyer, Mohaddes and Associates performed a study for the city of Long Beach to determine the required expansion of existing freeways to carry the container traffic forecast to occur by the year 2030. The Gateway Cities Council of Governments used this study for its long term policy planning. That report determined that to maintain the rate of good movements from the Ports and through the neighboring area, two (2) to eight (8) added lanes on a number of local freeways would have to vbe added. The number of added lanes in most cases will encroach on the lucrative tax base provided by businesses that are located adjacent to freeways.

Recognizing these tax base issues, the Gateway Cities have adapted specific guiding principles (Figure 1) that CALTRANS, the Metropolitan Transit Authority (MTA), and other long-term traffic planning agencies will be required to address in any proposals regarding freight movement in the Los Angeles basin. Note that Principles 1 and 4 directly address the freight corridor issues pertaining to alternative technologies.



SR-91/I-605/I-405 GUIDING PRINCIPLES

Adopted by the SR-91/I-605/I-405 Corridor Cities Committee on October 18, 2007
Adopted by the Gateway Cities Council of Governments Board of Directors November 1, 2007

Continued mobility is essential to preserving local economies and enhancing quality of life in the Gateway Cities and Southern California. Since it is not possible to build our way out of goods movement-related congestion via freeway construction without major disruption to these economies and this quality of life, the Corridor Cities Committee adopts the following Guiding Principles for SR-91/I-605/I-405 Corridors:

- ☐ Confine new freeway construction (including adding lanes) to existing State right-of-way in order to preserve and enhance local economies and environments. New construction will not involve double-decking on any part of the freeway.
- ☐ Address freeway operational deficiencies, relieve freeway congestion "hot-spots" and decrease the impact of truck bypass traffic on communities as soon as possible.
- ☐ Secure funding for major corridor studies and improvements as soon as possible without affecting the funding for the I-5 or I-710 Freeway improvements
- ☐ Support a separate freight movement corridor provided it is evaluated and constructed along non-freeway (e.g., rail or utility) alignments using minimally or non-polluting technologies.
- ☐ Implement additional Intelligent Transportation Systems (ITS) improvements in the SR-91/I-605/I-405 Corridor and advocate a broader regional approach to support this initiative.
- ☐ Continue Metro/OCTA/GCCOG inter-county transportation planning efforts.
- ☐ Collaborate with SGVCOG to engage Metro in immediate development of Los Angeles County Goods Movement Strategy.
- ☐ Aggressively advocate with all responsible agencies to preserve and enhance health and quality of life in the corridor.
- ☐ Engage corridor cities in an ongoing process of city consultation and interactive communication.

SR-91/I-605/I-405 Corridor Cities: Artesia, Bellflower, Cerritos, Compton, Downey, Hawaiian Gardens, Lakewood, Long Beach, Norwalk, Paramount, Pico Rivera, Santa Fe Springs, Whittier, County of Los Angeles

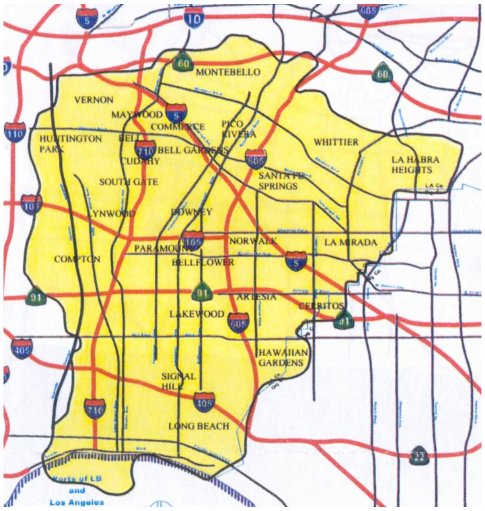


Figure 1 Gateway Cities Guiding Principles

Appendix C: Gateway Cities Council of Governments Guiding Principles

Gateway Cities Guiding Principles 1 & 4:86

Confine new freeway construction (including adding lanes) to existing State right-of-way in order to preserve and enhance local economies and environments. New construction will not involve double-decking on any part of the freeway.

Support a separate freight movement corridor provided it is evaluated and constructed along non-freeway (e.g., rail or utility) alignments using minimally or non-polluting technologies.

The neighboring San Gabriel Council of Governments (SGCOG) will also not likely to accept a diminished tax base due to the requirements of freeway expansion within their region. The net result of the stated policies is that a dedicated container freight corridor utilizing an alternative technology faces a prospective "disconnect" between the terminus of the I-710 and the area north of the Ontario International Airport, where freeway rights of way on the I-15 and I-210 have wide medians that may accommodate an alternative technology for freight movement.

Appendix D: Characteristics of High Voltage Transmission

Transformers that easily shift AC voltage levels were developed over a hundred years ago, which brought about the existing AC power grid. AC high power transmission, however, suffers from a number of physical limitations. The limiting efficiency in power transmission is the "resistance loss" in the conductors, which is proportional to the current squared, times the inherent resistance of the cable. Since the power carried by the line is the current times the voltage, stepping up the voltage reduces the current for the same power transmission. AC transmission systems can transmit higher power more efficiently through a high-voltage system by reducing resistive or heating loss.

Due to the inherent nature of AC, not all power loss is "resistive;" cables develop time varying electric and magnetic fields that produce a "reactive" component which results in "phase shifts" in the delivered current. In longer transmission lines, these phase shifts produce transmission system stability issues. Approximately, the power flowing over an AC line is proportional to the sine of the phase angle between the receiving and transmitting ends. Since this angle varies depending on system loading and generation, it is undesirable for the angle to approach 90 degrees. Very approximately, the allowable product of line length and maximum load is proportional to the square of the system voltage"

Wire diameter is limited for AC transmission lines due to the "skin effect" that causes the bulk of the power to propagate near the surface of the wire rather than at the core. Hence, there is a lower limit on the size of the wire, which must be used in AC transmission, requiring the cable to be made of multiple strands producing a less than optimum cross-section. In addition, at high AC voltages, significant amounts of energy are lost due to coupling of the AC energy to ground, water, metal structure, etc., making overhead AC transmission almost an economic requirement.

After a hundred years and trillions of dollars later, AC now completely dominates electric power transmission utilities. However, because of the many recently demonstrated advantages of DC power transmission over AC, DC will likely be the preferred means of initial power transmission from necessarily remote major electrical generation sites (geothermal or wind farms) to urban areas, allowing the established AC grid to distribute electric power to users.

With the advent of advanced semiconductor devices, it has become possible to realize shifts in DC voltage levels; similar to shifts in AC levels achieved by transformers. DC transmission occurs virtually without current, so resistive losses are nil. Thus, less expensive aluminum works as well as copper for wires used in DC transmission. Also, since there is no reactive component in DC transmission, there are no stability problems involved in long distance DC transmission, and no limit to the voltage due to phase shifts.

With no skin effect, more readily manufacturability, single strand solid conductors can be used as cables. In addition, there is no energy coupling to the surrounding environment, with the result that DC cables can be placed underground, underwater, or in above ground vaults or "cable trays" within a transportation guideway.

While elevated, small footprint, container transport systems like the ECCO can easily accommodate both HVAC and HVDC lines; the system will most likely carry bipolar HVDC. Due to the great distances between city centers and power generation (as described previously for sources such as geothermal or coal burning), DC power transmission is more effective and for long distances than AC and hence more economically feasible. Since terrestrial HVDC requires two lines in comparison to three lines for 3-phases HVAC circuits, more HVDC cables can be bundled into the same size guideway housing. Also DC does not electromagneticly couple power to surrounding environments and hence does not lose power by generating potentially dangerous currents in rebar and other metal structural components. Finally, since the cable rests in a vented vault or a cable "tray", it does not have to be actively cooled and does not have to be designed to support its own weight.

While the geometry of an electrically driven freight transport guideway and HVDC power transmission cables are quite compatible, there is and added benefit to integrating HVDC rather than HVAC into the guideway structure. Electrically driven systems using linear synchronous motors vary the speed of the container carriage by varying the frequency of the power to the motor; low frequency, low speed; high frequency, high speed. Present linear motor driven systems rectify the readily available 3-phase, 220 volt industrial power to produce DC and use inverters to convert the DC to variable frequency AC to drive the variable speed electric motor. By using the guideway as the means of support for an HVDC transmission system, the DC power used by linear electric motors is readily available and the necessary inverters can be placed in the guideway pylons. The need for AC to DC rectification as well as the likely separate HVAC transmission system can been eliminated.

1) High Voltage Direct Current (HVDC) Transmission Systems Technology Review Paper
http://www.worldbank.org/html/fpd/em/transmission/technology_abb.pdf