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MAGLEV DEMONSTRATION, DESIGN and DEVELOPMENT PLAN

FINAL REPORT

AUGUST 1994

Rail Systems Center
Carnegie Mellon Research Institute
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213

FTA TECHNICAL ASSISTANCE PROGRAM

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16. Abstract

Congestion in the air and highway system in the United States continues to worsen. By the year 2005, the cost of congestion will rise to over $60 billion annually. High speed ground transportation, which can act as an alternative and complements air and highway travel, may help to relieve these congested modes.

This study examines the feasibility of a regional high speed magnetic levitation (MAGLEV) system connecting the Greater Pittsburgh airport with strategic stops between the Midwest and the East Coast. A suburban commuter system, which operates on the same lines as the regional system, is also investigated. The first link of the regional and suburban MAGLEV system consists of a demonstration line connecting the Greater Pittsburgh International Airport with downtown Pittsburgh. This study considers the economic value of such a system from the aspects of transportation, manufacturing and economic development.

The study concludes that an investment of $41 billion over the next 30 years would be required to build a regional MAGLEV system, cover its operating cost and produce enough additional transportation revenue to pay back part of this investment in the private sector financial markets. A substantial portion of this investment must come from the public sector. The additional economic activity generated by this investment would be over $78 billion. Over 675,000 person-years of work would be created by such a venture.

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Private Sector:

AEG Transportation Systems, Inc.
Michael Baker Jr., Inc.
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Union Switch and Signal, Inc.
U.S.- Japan Project Development Group
USX Corporation
Wheeling Pittsburgh Steel Corporation

Labor:

Pittsburgh Building and Construction Trades
United Steelworkers of America

Public Sector:

Commonwealth of Pennsylvania
County of Allegheny
Federal Railroad Administration
Federal Transit Administration through the Port Authority of Allegheny County
Urban Mass Transportation Administration
Urban Redevelopment Authority of Pittsburgh

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MAGLEV

THE CRISIS

America is facing a transportation crisis. Both air and highway congestion are increasing rapidly, with attendant air and noise pollution. By the year 2005 congestion is projected to cost Americans between $50 and $70 billion a year. While work is under way to enlarge and expand highway systems, at an estimated cost of $39 to $44 billion a year now and $70 billion by 2005, traffic is growing faster than roads can be improved and built. Air traffic in the U.S. is also congested, with little hope of relief in the near future, despite projected future expenditures of $44 to $63 billion.

THE INITIATIVE

In response to the growing transportation crisis, Carnegie Mellon University established a High Speed Ground Transportation Center (HSGTC) in January, 1987, with a grant from the Commonwealth of Pennsylvania. While creating a database on HSGT technologies and projects around the world, the Center became aware of the rapid development in MAGLEV technologies and concluded that MAGLEV Systems, linking airports with population centers, provide the best hope for solving congestion problems.

THE PITTSBURGH CONNECTION

Pittsburgh, strategically located between the Midwest and the East Coast, is ideally located to serve as a hub of a regional MAGLEV System linking the Midwest and East Coast. Such a system, based on existing MAGLEV technology, could also be engineered, manufactured and operated by firms in the Mid-Atlantic region.

THE MAGLEV WORKING GROUP

In 1989, the Center formed the MAGLEV Working Group, a private-public-labor partnership, which adopted the following objectives:

- Create a MAGLEV industrial base in the Mid-Atlantic region to provide magnetic levitation systems to world markets.
- Build and operate a regional high-speed MAGLEV system, linking the Midwest and the East Coast.
- Integrate the regional system with economic development to provide for future growth, improved mobility and reduced infrastructure costs.

A preliminary feasibility study issued by the Group in 1990 concluded that:

- A substantial market for MAGLEV systems would develop in North America, 83 percent of it in the East.
- A Demonstration System linking the Golden Triangle with Pittsburgh International Airport would cost $490 to $595 million and could serve as the first segment of the Mid-Atlantic Regional System.
- The best current high-speed MAGLEV technology has been developed in Germany.
- The development of a MAGLEV transportation system will require substantial public investment, and there appears to be considerable interest at all levels of government.

MAGLEV, INC.

MAGLEV, Inc., a private corporation, was formed from the MAGLEV Working Group concurrent with the publication of the Group's report in February, 1990. The corporation's first major task was to complete a more extensive feasibility study with the following objectives:

- Plan the Mid-Atlantic Regional System to the same level of detail as the Demonstration System.
- Develop a financing plan for the Demonstration System.
- Develop a manufacturing and assembly plan.
- Complete preliminary engineering of the Demonstration System.
- Assess the Demonstration System's environmental impact.

MAGLEV, Inc.

Shareholders:

AEG Transportation Systems, Inc.
Michael Baker Jr., Inc.
Carnegie Mellon University
Duquesne Light
Pittsburgh Building Trade
United Steel Workers of America
USAir Inc.
USX, Inc.
Wheeling-Pittsburgh Steel Corporation

Participating Board Members:

Commonwealth of Pennsylvania
County of Allegheny
Reed Smith Shaw & McClay
Tri-State Conference on Manufacturing
Urban Redevelopment Authority of Pittsburgh

Other Participants
(non-Board)

Price Waterhouse (accounting services)

FEASIBILITY REPORT

MAGLEV, Inc., has completed a study of a magnetically levitated and propelled transportation system for the Mid-Atlantic Region. This report summarizes the conclusions of that study and identifies the next steps MAGLEV, Inc., plans to take to design, finance, and construct the MAGLEV Demonstration System described here, as well as more detailed planning of the Regional System.

Under contract with MAGLEV, Inc., Michael Baker Jr., Inc., prepared alignments of the Demonstration System, estimates of capital costs, ridership projections, preliminary engineering of the Demonstration System, and the environmental overview; Carnegie Mellon University laid out the regional alignments, simulated the system's performance, completed an economic analysis for the Regional System and developed the manufacturing plan; AEG Transportation Systems, Inc. provided program management and consulting services; and Booz, Allen & Hamilton, Inc., made recommendations on financing the system.

The Design

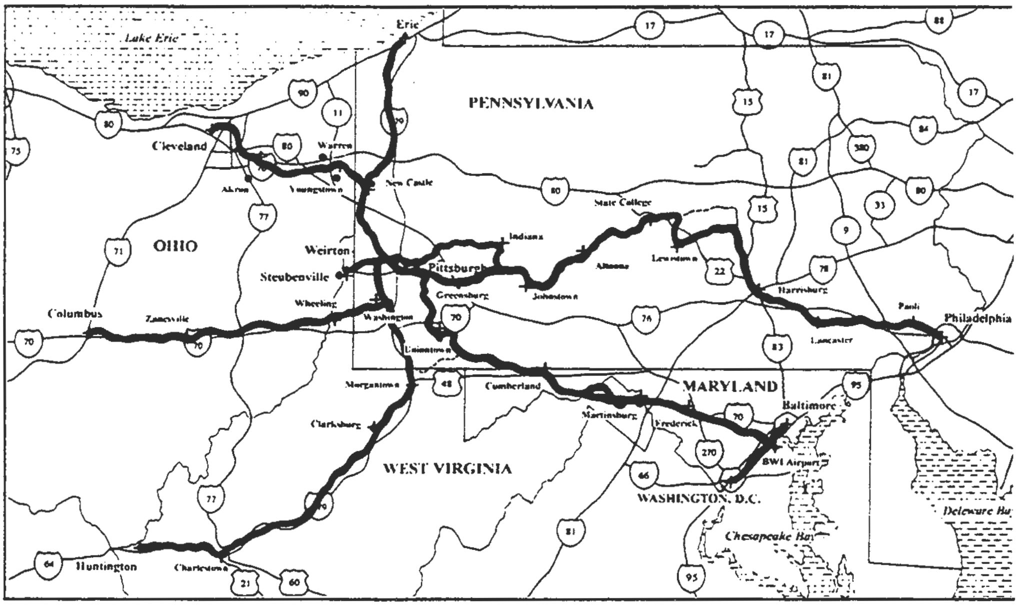
In order to map the Mid-Atlantic Regional System, it was first necessary to determine whether the MAGLEV system could use existing highway and railroad rights-of-way. Despite the apparent advantages of doing so, the study concluded that following existing rights-of-way with a MAGLEV system would require either extensive changes to the rights-of-way or purchase of substantial lands to enable the system to operate near its potential. The high speeds of MAGLEV require more gradual curves than slower moving cars and trains. (The maximum operational speed of 311 mph requires a horizontal radius of more than 21,000 feet when the guideway is banked at 12 degrees.) In addition, highways have many obstacles for MAGLEV systems, such as bridges, cloverleafs, signs and lights. Analyses showed that a 250-mph MAGLEV alignment would be within an existing right-of-way for 55 percent of its length or, conversely, that a MAGLEV vehicle constrained to traveling on an existing right-of-way would be half as fast. A review of the Interstate 79-Interstate 70 corridor between Pittsburgh and Columbus showed 86 underpasses, 96 overpasses and a tunnel - about one obstacle per mile - which a MAGLEV traveling at 250 mph would not be able to negotiate without major changes to the roads. In addition, to maintain high speeds, the MAGLEV system would have to cross over the highway frequently, requiring long spans which would increase costs. For these reasons, alignments were developed using new rights-of-way (Magways) except where conditions dictated that existing rights-of-way had to be used, such as in metropolitan areas where new land acquisition costs would be high and speeds must be kept low.

The following guidelines were used to develop the alignments for the Mid-Atlantic Regional System:

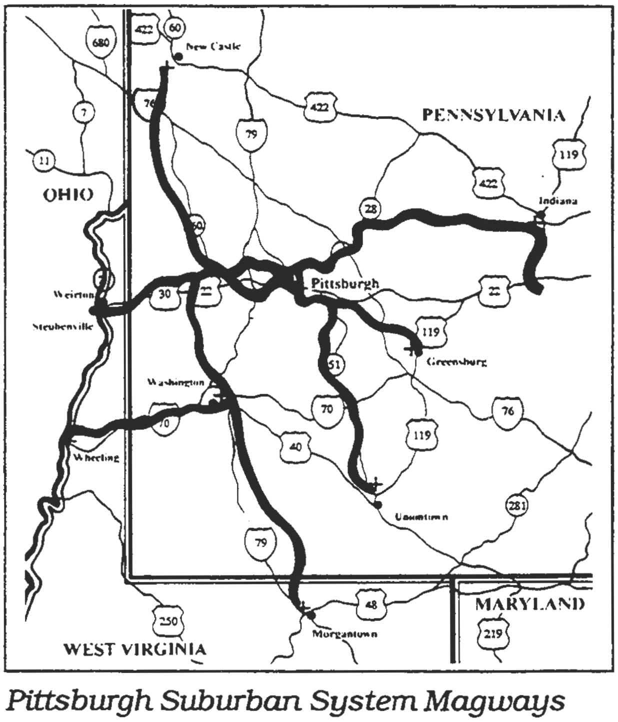
- When outside metropolitan areas, develop new right-of-way and keep speed above 250 mph.
- When approaching a metropolitan area containing a station (Magport), use existing right-of-way as needed.
- Minimize earthwork, tunnels and bridges by avoiding sharp changes in terrain.
- Avoid federal, state and local parks and game lands.
- Avoid communities, businesses, residential areas, schools, hospitals, churches and cemeteries.
- Cross major roads and rivers perpendicular to their path.

The Mid-Atlantic Regional System consists of three groups of lines covering over 1,300 miles in four states and the District of Columbia.

- North Lines: Pittsburgh International Airport to Cleveland and Erie.
- East Lines: Pittsburgh to Philadelphia, Baltimore, and Washington D.C.
- Southwest Lines: Pittsburgh International Airport to Columbus, Charleston, Morgantown, Huntington and Steubenville/Weirton.



Mid-Atlantic Regional System Magways



Pittsburgh Suburban System Magways

A Suburban System for the Pittsburgh area could use the regional network with the construction of 19 off-line Magports. This suburban system would increase penetration of the regional system, provide high-speed transportation to the airport throughout the area, and serve as an efficient commuter system within the Pittsburgh area.

In the study, a simulator was used to imitate the operation of the regional MAGLEV system. The simulator used the characteristics of the corridors that had been mapped (including grades, curves, speed restrictions, and stations) and of the German MAGLEV system to estimate run times and energy consumption of the regional system. These estimates were then used to estimate the system's operating costs and its market for passengers.

Performance Simulation of Mid-Atlantic Regional System

		1	2	3	4	5	6	7	8	9	10	11	
		Pittsburgh Airport, PA	Pittsburgh Downtown, PA	Cleveland Airport, OH	Erie, PA	Harrisburg, PA	Philadelphia Downtown, PA	Philadelphia Airport, PA	Cumberland, MD	Baltimore-Washington Airport, MD	Charleston, WV	Columbus, OH	
1	Pittsburgh Airport, PA		18 00:08	134 00:36	120 00:32	251 01:20	349 01:51	356 01:58	134 00:47	260 01:21	205 00:51	183 00:50	Miles HH:MM
2	Pittsburgh Downtown, PA	18 00:08		152 00:46	138 00:42	233 01:10	331 01:41	338 01:48	116 00:37	242 01:11	223 01:01	201 01:00	Miles HH:MM
3	Cleveland Airport, OH	134 00:36	152 00:46		N/A	385 01:58	483 02:29	490 02:36	268 01:25	394 01:59	339 01:29	317 01:28	Miles HH:MM
4	Erie, PA	120 00:32	138 00:42	N/A		371 01:54	469 02:25	476 02:32	254 01:21	380 01:55	325 01:25	303 01:24	Miles HH:MM
5	Harrisburg, PA	251 01:20	233 01:10	385 01:58	371 01:54		98 00:30	105 00:37	N/A	N/A	456 02:13	434 02:12	Miles HH:MM
6	Philadelphia Downtown, PA	349 01:51	331 01:41	483 02:29	469 02:25	98 00:30		7 00:05	N/A	N/A	554 02:44	532 02:43	Miles HH:MM
7	Philadelphia Airport, PA	356 01:58	338 01:48	490 02:36	476 02:32	105 00:37	7 00:05		N/A	N/A	561 02:51	539 02:50	Miles HH:MM
8	Cumberland, MD	134 00:47	116 00:37	268 01:25	254 01:21	N/A	N/A	N/A		126 00:33	339 01:40	317 01:39	Miles HH:MM
9	Baltimore-Washington Airport, MD	260 01:21	242 01:11	394 01:59	380 01:55	N/A	N/A	N/A	126 00:33		465 02:14	443 02:13	Miles HH:MM
10	Charleston, WV	205 00:51	223 01:01	339 01:29	325 01:25	456 02:13	554 02:44	561 02:51	339 01:40	465 02:14		388 01:43	Miles HH:MM
11	Columbus, OH	183 00:50	201 01:00	317 01:28	303 01:24	434 02:12	532 02:43	539 02:50	317 01:39	443 02:13	388 01:43		Miles HH:MM

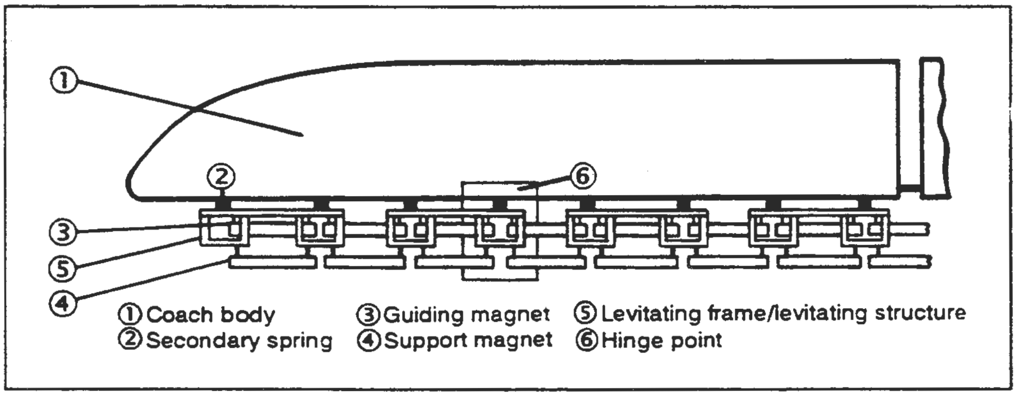
The MAGLEV technology developed and tested in Germany by a consortium of companies, is the most developed and tested in the world. Development of this technology began in the late 1960's. In 1979, the system carried 50,000 passengers at the Transport Exposition in Hamburg.

Between 1979 and 1984, the first 13 miles of a 19-mile test track was built in northern Germany. This test track was completed in 1987. In 1992, the German government certified this technology for public use. In June of 1993, the MAGLEV attained the speed of 280 mph carrying passengers.

This technology is a member of the electromagnetic (in contrast to the electrodynamic) family of MAGLEV systems. Electromagnetic suspension (EMS) systems utilize electromagnets located on the vehicle that are attracted to ferromagnetic materials on the guideway for their levitation and guidance, and are thus known as attraction MAGLEV systems. A feedback control loop monitors the air gap between the vehicle and guideway and adjusts the power fed to the electromagnets so as to maintain the proper gap.

This technology employs a long-stator linear synchronous motor to attain its top operational speed of 311 mph. The vehicle supplies, by batteries and generator, its own auxiliary power for lights, heating, cooling, and so forth. The vehicle shell utilizes aluminum and fiberglass to attain its high stiffness and low aerodynamic drag.

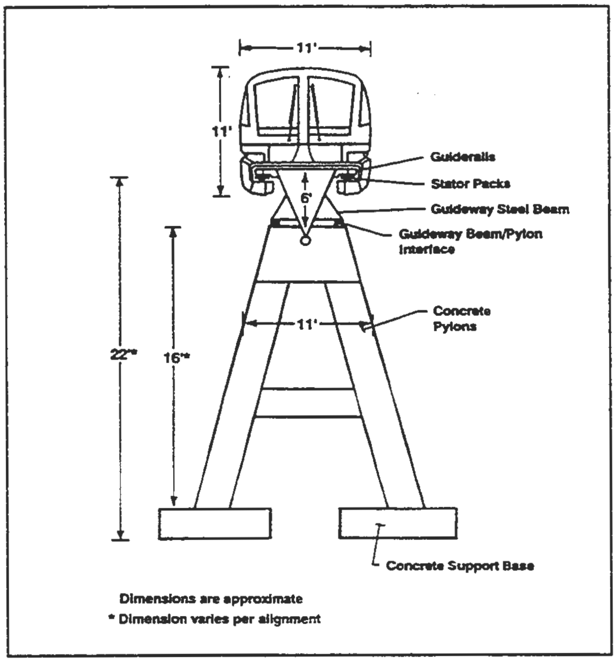
Guideway Support System



Exceptional ride quality is achieved via two separate systems. The stiff primary suspension system is provided by the support magnets located on both sides of the vehicle, while the soft secondary suspension is supplied by pneumatic springs mounted between the levitation bogie and the vehicle.

The guideway is an elevated structure with prefabricated, T-shaped, steel beams set on concrete pillars of various heights. This elevated double guideway requires approximately 5,000 tons of steel per mile, primarily rolled plate steel. Attached to these beams are several functional components, including a linear motor, guidance rails and low-friction skids. The linear motor, which is part of the guideway and provides the propulsion for the vehicles, requires approximately 275 tons of magnetic steel per mile of guideway. The shape of the guideway is adjusted to the alignment and gradient for high-speed operation, making few girders completely identical in shape. The strict tolerances, far exceeding the values usual in steel construction, require an automated production concept. Therefore, to achieve the accuracy and minimize the cost of guideway construction, a computer-integrated manufacturing process is used, whereby the measurements taken at the construction site are input directly to the beam fabrication equipment.

There are three separate methods for braking the vehicle. The primary braking system involves reversing the current fed to the linear motor, thus producing a reverse thrust. The second braking method makes use of the drag generated by inducing eddy currents in the guide rails via the guidance magnets. This method is only effective above speeds of approximately 30 mph. During emergencies, the MAGLEV is slowed to near 30 mph through the use of eddy currents and aerodynamic drag, at which time power to the suspension magnets is removed and the vehicle settles onto the low-friction skids, which brings the train to a comfortable stop.



View of vehicle and guideway

Transfer from one guideway to another is accomplished using a bending steel beam switch. The bending of the steel beam is attained through the use of electromechanically or hydraulically actuated drives.

The signal and communication system employed by the technology provides for exchange of information among three levels: the vehicle; the communication, power, and control equipment along the guideway; and the traffic control center. The traffic control center monitors operational status, evaluates timetables, and determines any required modifications to current operations.

Several components of the system, including foundations and piers, safety signals and controls, guideway switches, and the vehicles, will be adapted and improved for use in the American market.

The MAGLEV system sets new standards for safe transportation. Because the vehicle wraps around the guideway, derailment cannot occur. The control strategy and guideway propulsion system will prevent two vehicles from moving within the same section at different speeds, and prevent two vehicles from approaching each other from opposite directions.

Because there is no motor with movable parts and no contact between vehicle and guideway, noise emission, maintenance, and energy consumption are low.

Financing

The study explored the extent to which development of the proposed MAGLEV system will be able to rely on financing from the private sector, and what role will remain for public financing. To do this, the study estimated both the expected costs and revenues of the system, in constant dollars, then evaluated the alternative private and public sources of financing that could contribute to its development.

Capital costs include planning and design of the system, fabrication and construction of the guideway, special construction (right-of-way acquisition and civil works), equipment and facilities, Magports, maintenance and operations facilities, vehicles, and construction management. The estimated total cost of the regional system is $41 billion (Of this, the largest component is the guideway, estimated to cost $17 billion). The Pittsburgh Suburban System would add $378 million.

Operating and maintenance costs include wages, energy, maintenance, and administration. The study used two different models to estimate these costs, resulting in estimated annual costs of $393 million and $462 million, or $293,000 and $344,000 per mile, respectively, for the regional system. The Pittsburgh Suburban System would add $65 million.

Revenues will come from several sources, including passenger fares, freight hauling, Magport development, Magport retailing, parking fees, automobile rentals, and manufacturing royalties. Because so many of these are presently difficult to estimate, the study attempted to estimate only passenger fares, which will be the single largest source of revenue. To estimate revenues required estimating market demand. The study used a model originally designed by the firms of Parsons Brinckerhoff Quade & Douglas and Gannett Fleming Transportation Engineers for the Pennsylvania High Speed Intercity Rail Passenger Commission. Comsis Corporation modified and expanded this model to simulate the Midwest-Atlantic Regional System.

The model found that over half of the projected MAGLEV trips would be by commuters, with the remaining 39% to 45% of the trips accounted for by (in order of importance) business travelers, tourists, various others, and school travelers. The forecast predicted that the regional system would carry approximately 19 million passengers per year if built by 2010. The suburban system would add an additional 15 million riders. The fares that optimized revenues were $0.37 per mile for the regional system and $0.28 per mile for the suburban system. At such fares a round trip between Pittsburgh and the airport would cost $14; Harrisburg, $218; Philadelphia, $268; Baltimore, $185; Washington,D.C., $208; Columbus, $140; Erie, $92; and Cleveland, $106.

At the optimal fares, total estimated annual passenger revenues for the regional system would be $1.3 billion, or $966,000 per mile. The suburban system would add $75 million in annual revenues.

Using these estimates of costs and revenues, the Mid-Atlantic Regional System can adequately meet its operating expenses from fares, and repay between ten and twenty percent of its capital expenses. Certain line segments (such as those to the east) have much greater potential to be self-supporting than others.

MAGLEV, Inc., retained the firm of Booz, Allen & Hamilton, Inc., to develop a financing plan for the Regional System. The consultant concluded that private financing of infrastructure, which is difficult for any form of transportation, will be especially difficult for MAGLEV systems because of uncertainties regarding costs, demand, and the technology. Private financing of equipment, because of possible tax advantages conferred by ownership, will be a more likely possibility. Most of the cost of building MAGLEV systems will have to come in the form of public investment.

The benefits of MAGLEV systems are many and diverse, and the study did not attempt to quantify most of them. They include reduced travel times and air pollution, and increased safety and efficiency. The study did estimate the direct and indirect economic benefits of the project, using the University of Pittsburgh's REMI (Regional Economic Models, Inc.) model. The model estimated that each billion dollars of capital invested in the MAGLEV system will create over 16,500 person-years of work. The regional system would create over 676,500 person-years of work, and the suburban system 6,240 more (22,760 new full-time jobs over a 30-year construction period). Manufacturing would account for 34% of the work, with 10% in construction, and the remainder in other industries.

Since the bulk of capital will necessarily come from the public sector, the consultant particularly examined the applicability of present federal programs for financing the MAGLEV system. The two primary potential sources of federal financing are the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Federal Transit Act of 1984. In addition, federal tax exemption for financing of MAGLEV systems would make private financing more attractive.

ISTEA contains three sections specifically aimed at promoting the development of MAGLEV technology. Two of these (the Technology Demonstration Program at $50 million, and the Research and Development Program at $25 million) are research programs, and the third, the National Magnetic Levitation Prototype Development Program, would authorize $725 million to fund construction of a demonstration project. In addition, ISTEA allocates funds annually (largely from the Highway Trust Fund) for surface transportation programs developed by each metropolitan planning organization, such as the Southwestern Pennsylvania Regional Planning Commission (SPRPC) here in Pittsburgh. While portions of these funds are restricted to specified uses, a portion is unrestricted, and may be allocated to maintain or upgrade roads, build highways, or be used for transit. Over 22 years, this unrestricted amount is expected to amount to $4.5 billion, some of which could, through the planning process sponsored by SPRPC, be allocated for construction of the MAGLEV system.

The Federal Transit Act, under Section 3, funds "new start fixed guideway projects" for the

Most Likely Funding Sources for Different Elements of the MAGLEV Demonstration and Regional Systems

	National Magnetic Levitation Prototype Dev. Program	High Speed Ground Transp. Dev. Program	TITLE 23 Surface Transportation Program	FTA Section 3 Program	PA Tax Increment Financing	Tax-Exempt Bonds	Airport Passenger Facility	Private Sector Financing	State
Equipment	◆		◆	◆		◆		◆	◆
Downtown Terminus	◆		◆	◆	◆	◆		◆	◆
Right-of-Way	◆		◆	◆		◆			◆
Right-of-Way/ Guideway on Airport Property	◆		◆	◆		◆	◆		◆
Airport Terminus	◆		◆	◆	◆	◆	◆	◆	◆
R & D	◆	◆	◆					◆	

exclusive use of buses or rail vehicles. The Port Authority of Allegheny County used funds authorized by this section to build its exclusive busways. The project evaluation and rating process includes an assessment of the cost-effectiveness of the capital investment, and an evaluation of the local fiscal commitment to the project. Two-thirds of recent projects in other cities have had local financing in excess of the 25% required in the act.

Under any scenario, state and private sources will be needed to supplement or match federal grants.

The MAGLEV Industry

The German test track provides proof that the MAGLEV technology can perform. It also has demonstrated the automated engineering, fabrication and installation of the guideway. The demonstration project in Pittsburgh will translate that concept into a system that can be mass produced. To accomplish this will require engineering the system for local manufacturing and conformance to American standards of quality and safety.

Still, manufacture of the system will entail payment of licensing fees and royalties to the companies that own the many patents that protect the technology. MAGLEV, Inc., must negotiate those fees and royalties with the companies, taking into account the adaptation and improvement of the technologies for American production and use. American suppliers will pay those fees and royalties to MAGLEV, Inc., which in turn will pay the German companies.

MAGLEV, Inc., has identified six major systems, each of which will correspond with a principal contractor or supplier. These are MAGLEV systems engineering, civil engineering, guideway fabrication, stator pack supply, electrical supply, and vehicle supply. For each of these, MAGLEV, Inc., will establish component and manufacturing process specifications, prepare a demand schedule, send these to selected vendors for comments, hold supplier conferences, invite bids, and select suppliers on the basis of quality and price.

The proposed MAGLEV system can be designed and manufactured in the Mid-Atlantic Region. Established firms from the region can do the civil engineering and construction; provide most of the steel for the guideway and supports; and provide the electrical systems, signalling, control and communications, and vehicles. Plants for the fabrication of the guideway beams can be established in the region. Shipping the steel in and shipping the finished beams out is physically and financially possible. The study identified 30 major companies in Pennsylvania, Ohio, Maryland and West Virginia that could supply at least one of the six major systems called for in the manufacturing plan.

DEMONSTRATION

The first phase of the proposed regional MAGLEV system is a demonstration line between downtown Pittsburgh and the Pittsburgh International Airport. The demonstration line has the following objectives:

- Verify the safety and reliability of MAGLEV technology.
- Verify the capital and operating costs.
- Verify performance characteristics.
- Verify environmental impacts.
- Define, set up and test manufacturing and construction methods.
- Increase the visibility of MAGLEV to promote its public acceptance.
- Establish the primary link in the Regional System.

Alignments

The study of the alternative alignments for the Demonstration System between Pittsburgh and the airport was more detailed than for the Regional System. It included the following objectives:

- Collect available data.
- Perform preliminary transportation planning, including ridership forecasts.
- Prepare preliminary horizontal and vertical alignments.
- Develop estimates of capital and operating costs.
- Evaluate corridors for potential environmental impacts.
- Compare costs and benefits of alternative alignments to form the basis for the future selection of a preferred alignment.

Where the study identified alignments for the Regional System at a scale of 1"=2000', alternative alignments for the demonstration study were explored at the more detailed scale of 1"=200'. The study examined three of the six alignments from the Preliminary Feasibility Study and added a fourth alternative, each starting from the airport and terminating in Pittsburgh:

- Alternative A - Ohio River West Shore

  Follows the Airport Expressway, Parkway West and old Montour Railroad to the Ohio River in Coraopolis, along the Ohio River, crossing under the West End and Fort Pitt Bridges, over Carson Street to Station Square.

- Alternative D - North Side

  Follows Alternative A to just west of the railroad yard in McKees Rocks, crosses the Ohio River 3/4 of a mile northwest of the McKees Rocks Bridge, then parallels the north side of the Ohio River and terminates at a station just south of Allegheny Center.

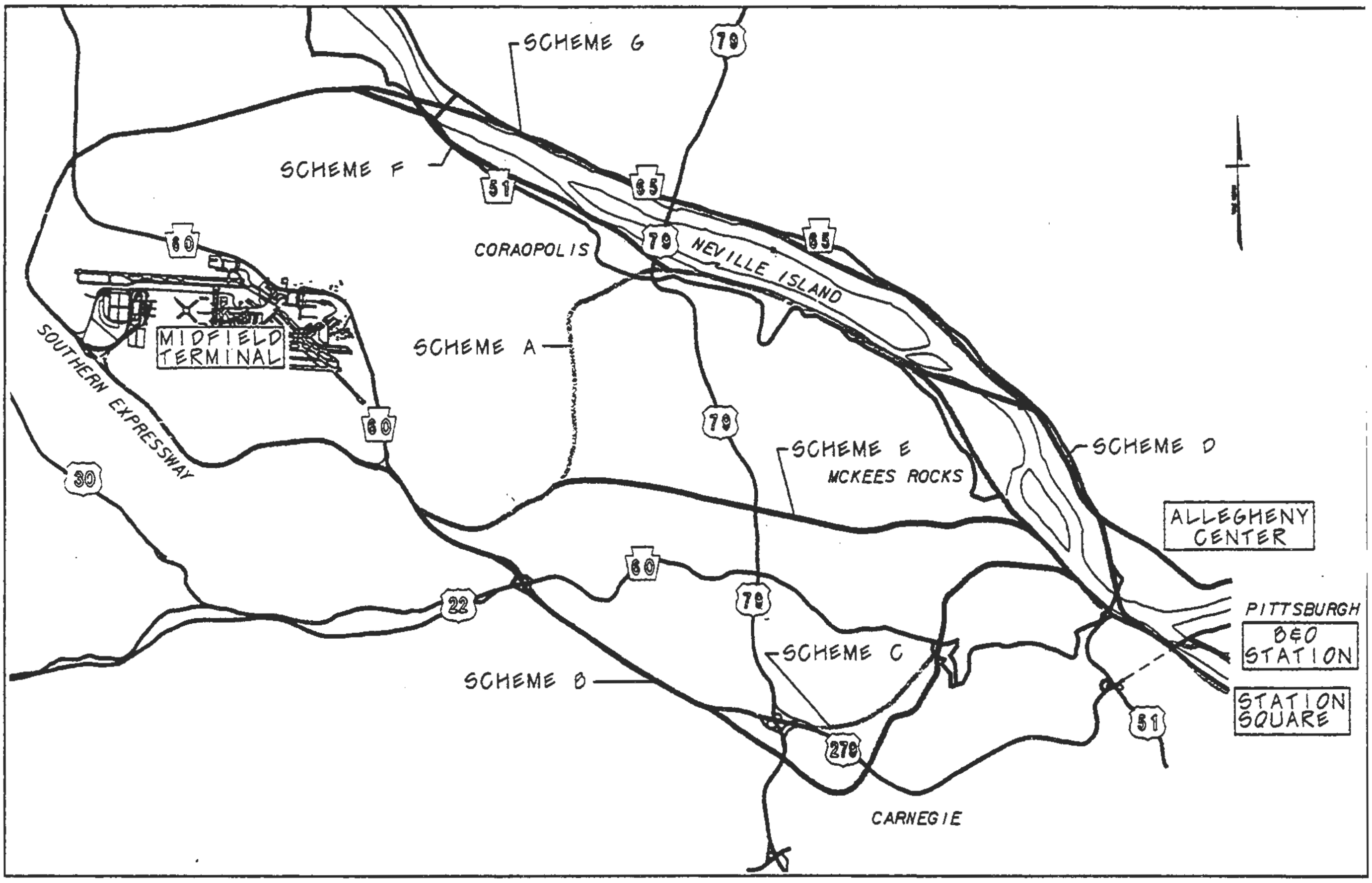
- Alternative E - Chartiers Creek

  Follows Alternative A to south of Hookstown Grade Road where it continues east, crisscrosses over Chartiers Creek to the Ohio River, passes over Stadium Drive and then follows Alternative A to Station Square.

❒ Alternative G - Ohio River East Bank

Turns west out of the airport, follows the north side of Route 60, follows Flaugherty Run Road and crosses over Route 51 and the Ohio River, crosses under the Sewickley Bridge, under Interstate 79 and past the Emsworth Locks and Dam and crosses the Ohio River near Franklin Street and follows Alternative A to Station Square.

Alternatives B,C and F from the Preliminary Feasibility Study were not investigated further due to a lack of feasible right-of-way.



MAGLEV Demonstration System Alternative Schemes

The study examined the probable impact of each of the alignments, including analyses of adjacent land uses; displacement of homes, businesses and other uses; traffic and parking considerations; energy; air quality; historic buildings and potentially significant archeological sites; aesthetics; water quality; vegetation; geotechnical considerations; safety and security of MAGLEV users; access by pedestrians and bicyclists; noise and vibration; parks, recreational areas and wildlife and waterfowl refuges; navigable waterways; wetlands; threatened and endangered species; and construction impacts.

Pittsburgh Demonstration System
Summary of Potential Environmental Impacts

Resources	Alternative A	D	E	G
Land Use (acres)				
Residential	1.4	2.0	75.4	20.4
Commercial	22.4	23.1	22.9	36.9
Industrial	114.3	110.7	91.9	102.1
Public/Institutional	0.5	0.7	3.6	-
Displacements				
Residential	2	2	42	15
Commercial	1	1	5	1
Industrial	0	1	0	1
Public/Institutional	0	1	0	1
Traffic				
Major Roadway Crossings	11	11	10	6
Minor Roadway Crossings	11	17	18	10
Annual Energy Consumption (Btus)	6.83×10^{10}	6.62×10^{10}	5.61×10^{10}	7.05×10^{10}
Air Quality	-	-	-	-
Noise (No. of Receptors w/in. 250 ft.)	157	175	200	259
Cultural Resources				
Historic Structures	6	2	6	8
Historic Districts		5		
Known Arch. Sites	4	2	8	2
High Probability Areas (acres)	1134.5	1059.9	623.9	2161.5
Water Quality (No. of Stream Crossings)	36	35	25	20
Floodplains (acres)	402.1	394.6	285.3	201.0
Geotechnical Concerns				
Coal Subsidence & Waste Areas (Linear Feet)	2,100	2,100	14,700	2,000
Landside Prone Areas (L.F.)	28,400	23,600	28,165	20,800
Deep Foundation Soils (L.F.)	62,030	59,320	34,700	70,870
Pedestrian & Bicyclists	1	0	1	0
Navigable Waterways (No. of Crossings)	0	1	0	2
Wetlands (acres)	998.6	996.0	1069.6	626.9
Threatened & Endangered Species	No Impact	No Impact	No Impact	No Impact

In addition, the study examined the structural requirements of each alignment, including curves, piers, bridges, tunnels, and stations. From these considerations, the study was able to estimate run-times, maximum speeds and capital and operating costs.

Alternative E is the shortest (16 miles) and G the longest (20.4 miles). E is the quickest (7.8 to 8.2 minutes), but G allows the greatest speeds (265 to 282 mph). Alternatives A, E, and G, terminating at Station Square, are situated where the CSX and Conrail rail lines can easily be followed out of the city toward future destinations to the east. Alternative D on the other hand, is on a Conrail right-of-way, and the horizontal alignment east of the station is much too sharp for MAGLEV to use, so that extending the line eastward would entail great expense for acquisition of additional property.

Financing

Alternative G would be the most costly alignment ($595 million), and E the least costly ($494 million) to build. G has the highest annual energy cost ($1.0 to $1.2 million), and A, the lowest ($.7 to $.8 million). Total operating costs range from $5.0 million to $5.5 million per year.

COMSIS Corporation, using its transportation model, estimated ridership revenues using three cases involving different fares and headways. On the basis of these estimates, the Demonstration System will produce at least $6 million in annual ridership revenues, enough to cover operating costs.

The largest part of capital costs, as with the entire regional system, will need to come in the form of public grants. These are justified by the special demonstration value of this system, as well as by other economic benefits the system will produce, including approximately 9,300 person-years of work resulting from the manufacture and construction of the demonstration project.

Capital Cost Estimates for the Pittsburgh Demonstration System

ITEM	CAPITAL COST (in millions)			
	A	D	E	G
Guideway Structure	143	138	121	145
Special Construction	48	59	62	111
Electrical, Control, Communications	111	108	96	114
Magports/Maintenance Facilities	17	17	17	17
Vehicles	32	32	32	32
Right-of-Way	9	14	17	24
Other Items	65	65	65	65
Design Engineering	74	74	74	74
Construction Management/Inspection	10	11	10	14
TOTAL	$509	$518	$494	$596

Annual Operating and Maintenance Cost Estimates

ITEM	O & M COST ESTIMATES (in thousands)			
	A	D	E	G
O & M Staff (Production)	3,902	3,902	3,902	3,902
Vehicles Costs	148	148	148	148
Subcontractor Costs	200	200	200	200
Energy	626	937	811	1,219
TOTAL	$4,831	$5,142	$5,016	$5,424

The federal government has specifically authorized $725 million in funds for construction of a MAGLEV demonstration system. The National Magnetic Levitation Prototype Demonstration Program (ISTEA Section 1036(B)(4)) will finance construction of a system that uses some highway rights-of-way; is at least 19 miles long and allows for full-speed operation; can be ready for operation within three years after award of the contract; can convert to commercial operation after testing; uses a technology that can be extended throughout the U.S.; has at least one switch; demonstrates operation in varied climatic conditions, topography, and a tunnel; and connects a major metropolis with an airport or other transit station. The proposed Demonstration System is well positioned to compete for funds under this program, since it meets the length, terrain, climatic, inter-modal, and commercial criteria set forth in the legislation.

Phase one of this federal program provides funding of between $7 and $10 million each for up to five projects for conceptual designs, and requires a 10% local match. Phase two provides grants of $40 to $50 million each for up to three of the projects for detailed system designs, and requires a 20% match. Phase three will fund construction of one of the projects, providing $500 million and requiring a 25% local match.

Unfortunately, though authorized by Congress and the president in 1991, the government did not appropriate funds in the subsequent budget. In anticipation of its funding, however, Governor Casey of Pennsylvania awarded a grant of $2 million to MAGLEV, Inc., half for preparation of the first-phase proposal for the Pittsburgh Demonstration System, and the remaining $1 million as the local match for phase one. MAGLEV, Inc., is therefore prepared to compete as soon as the federal government appropriates funds for the demonstration program.

Private sources will need to contribute to the local match for construction of the system. These contributions will most likely be in the form of investments at the airport and downtown Magports. Ultimately, however, construction of the Demonstration System depends on the government's appropriating funds for the demonstration program.

SUMMARY

- MAGLEV would provide an uncongested mode of travel that would greatly improve mobility.
- MAGLEV systems built to connect well with existing modes of transportation offer a needed remedy for the highway and air congestion, which is projected to cost between $50 and $70 billion annually by the year 2005.
- Highway programs attempting to mitigate this congestion cost $39 to $40 billion per year now, and $70 billion per year by 2005, while airport expansion solutions are estimated at $44 to $63 billion.
- Based on cost, energy efficiency, environmental impact, speed, safety, revenue readiness, maneuverability, and ride quality, a design based on the German MAGLEV System is the technology of choice.
- Numerous studies have estimated a potential MAGLEV market of over $200 billion.
- Pittsburgh's proximity and central location to a substantial portion of this market, as well as its extensive steel and manufacturing industries, bodes well for establishing it as the manufacturing center for this technology.
- An opportunity exists to transfer and improve this proven technology, thus making it both more cost-effective and more conducive to application within North America.
- Following existing rights-of-way outside of metropolitan areas resulted in essentially doubling run-times, and thus a decision was made to develop new rights-of-way except in situations that dictate otherwise (such as near metropolitan areas).
- Various potential financing sources were identified to fund construction of the Regional and Demonstration Systems. However, as with all public transportation systems, the opportunity for private investment is limited.

Mid-Atlantic Regional System:

- The capital cost for the 1,350-mile Regional System is just over $40 billion.
- Upon completion, the Regional System is expected to carry almost 19 million riders, resulting in farebox revenues of over $1 billion per year, and will cover operating and maintenance costs and contribute to retirement of the capital debt.
- Over 676,000 jobs will be created over the construction lifetime, of which 34% will be in the manufacturing field.
- Over $78 billion in direct economic benefits are estimated to result from manufacturing and construction of the Regional System.

Pittsburgh Suburban System:

- A Suburban System offering a cost-effective mode of local public transportation can easily be overlaid on a regional MAGLEV network.
- The incremental capital cost required to construct the off-line suburban stations on the Regional System lines is estimated to be $378 million.
- The farebox revenue for the suburban system is sufficient to pay the annual operation and maintenance cost, with some remaining for repayment of the capital debt.
- When completed, the Suburban System is forecast to carry 15 million passengers annually.

Pittsburgh Demonstration System:

- Four alternative Demonstration Systems alignments were evaluated, with capital costs between $490 and $595 million.
- The farebox revenue for the Demonstration System is anticipated to be $6 million annually, which is sufficient to pay the operating and maintenance costs with some left over for repayment of the capital debt.
- The Demonstration System is estmated to generate 9,300 jobs, resulting in $1 to $2 billion in economic benefits.
- No environmental conditions exist in any of the four corridors evaluated that cannot be addressed through the standard process of avoidance, minimization or mitigation.
- The Pittsburgh Demonstration System is well positioned to compete for the ISTEA funding, meeting the length, terrain, climatic, intermodal connectivity, and commercial operation criteria set forth in the legislation.
- The Demonstration System has a broad base of support among business, labor, and government in the area, which should serve to make it attractive as a federally supported demonstration system.

RECOMMENDATIONS

- ❒ An effort to secure a technology transfer and begin the Americanization of this technology must be completed.
- ❒ While a considerable effort has been put forth, to date no license has been secured from the German MAGLEV consortium This must become a critical priority.
- ❒ A finance-quality ridership analysis of the Regional System must be completed which looks at the short and long-range forecast, the regional versus the network approach to implementation, the integration of the airport access system, and a more detailed evaluation of the impact of a Suburban System over laid on the Regional System.
- ❒ Discussions need to begin with retail developers regarding station development to ensure that these opportunities are maximized.
- ❒ A franchise to build and operate the Demonstration System must be obtained from the appropriate authorizing authority.
- ❒ The Demonstration System must be added to the local Metropolitan Planning Organization's (MPO) Transportation Implementation Plan (TIP).
- ❒ A manufacturing conference needs to be held where it can be established which local companies have the interest and ability to produce the required MAGLEV components.
- ❒ An Operations Plan must be established which evaluates the ability to operate the Suburban System with the Regional System, and further optimizes utilization of the system.
- ❒ Discussions must begin with the major airlines to ensure that the integrated operations of the two systems are maximized.
- ❒ The federal government must take a more active role in promoting HSGT systems by providing funding support consistent with that granted to other modes of transportation.

1.0 INTRODUCTION

The principal modes of intercity passenger transportation in the United States are highway and air. Both modes are congested and are expected to become more congested in the future. High Speed Ground Transportation (HSGT) is an alternative which may ease the effects of congestion by providing alternatives and complements to these modes. HSGT divides into two general categories: high speed rail (HSR) and high speed MAGLEV. HSR is state of the art steel wheel on steel rail technologies with top speeds of at least 150 mph and high speed MAGLEV refers to future technologies levitated and propelled by magnetic forces with top speeds approaching 300 mph.

1.1 BACKGROUND

In response to the growing transportation crisis, Carnegie Mellon University established a High Speed Ground Transportation Center (HSGTC) in January, 1987. This was funded by grants from the Commonwealth of Pennsylvania. The initial objective of the center was to build a database on HSGT technologies and projects around the world.

In building that database, the HSGTC became aware of the rapid advance of HSGT hardware projects in Japan and Western Europe as well as a rapidly increasing interest in HSGT in the United States and Canada. It also recognized that the development in MAGLEV technologies, which had accelerated during the decade of the eighties, was now projected to be completed in the decade of the nineties, at which time commercial systems could begin operation. The HSGTC also recognized that the future of HSGT systems would probably be highway and airport oriented in addition to revitalizing passenger service from city center to city center.

Pittsburgh lies on the main travel corridor between the populous midwest and the even more populous east coast. Thus, an opportunity existed for implementation of a HSGT system extending to the midwest and the east coast out of a Pittsburgh hub which was based on existing MAGLEV technology and which could be engineered, manufactured and operated by firms in the region.

1.2 MAGLEV WORKING GROUP

In January 1988, the HSGTC decided to form a consortium of firms with regional interests and ties to explore the concept of a future transportation system in greater detail. This consortium, the Working Group, would represent operators, suppliers, developers, financial institutions, universities, labor and political representatives.

Members of the original Working Group included:

- AEG Transportation Systems, Inc.
- Allegheny County
- Michael Baker Corporation
- Carnegie Mellon University
- Duquesne Light Company
- Reed Smith Shaw & McClay
- Transrapid International
- Tri-State Conference on Steel
- Union Switch & Signal, Inc.
- United Steelworkers of America
- Urban Redevelopment Authority of Pittsburgh
- USX Corporation

Objectives of the Working Group included:

- Creating an industrial base in the Pittsburgh region in order to provide magnetic levitation and propulsion systems to the United States and abroad.
- Developing a regional transportation system based on magnetic levitation and propulsion technology in a private enterprise/public sector partnership eventually linking the midwest to the east coast.
- Integrating transportation and nodal economic development and redevelopment for the region for the twenty-first century, promoting HSGT and other new technologies that will provide for future growth, will improve mobility and will reduce infrastructure costs.

The MAGLEV project would result in economic development/redevelopment, increased mobility and job creation for the region. The organization of the Working Group is shown in Figure 1-1, MAGLEV Working Group Organization.

The first effort of the Working Group was the definition of a preliminary feasibility study to determine the project's probability for success. The conditions for feasibility were also spelled out as part of that effort. From the review of HSGT studies conducted in Ohio, Pennsylvania, Florida, Texas and California-Nevada, the Working Group concluded that it is unlikely that intercity systems can be built and operated solely from fare-box revenues with domestic private financing exclusively. In order for the project to be feasible, the following additional sources of capital and revenue may be necessary:

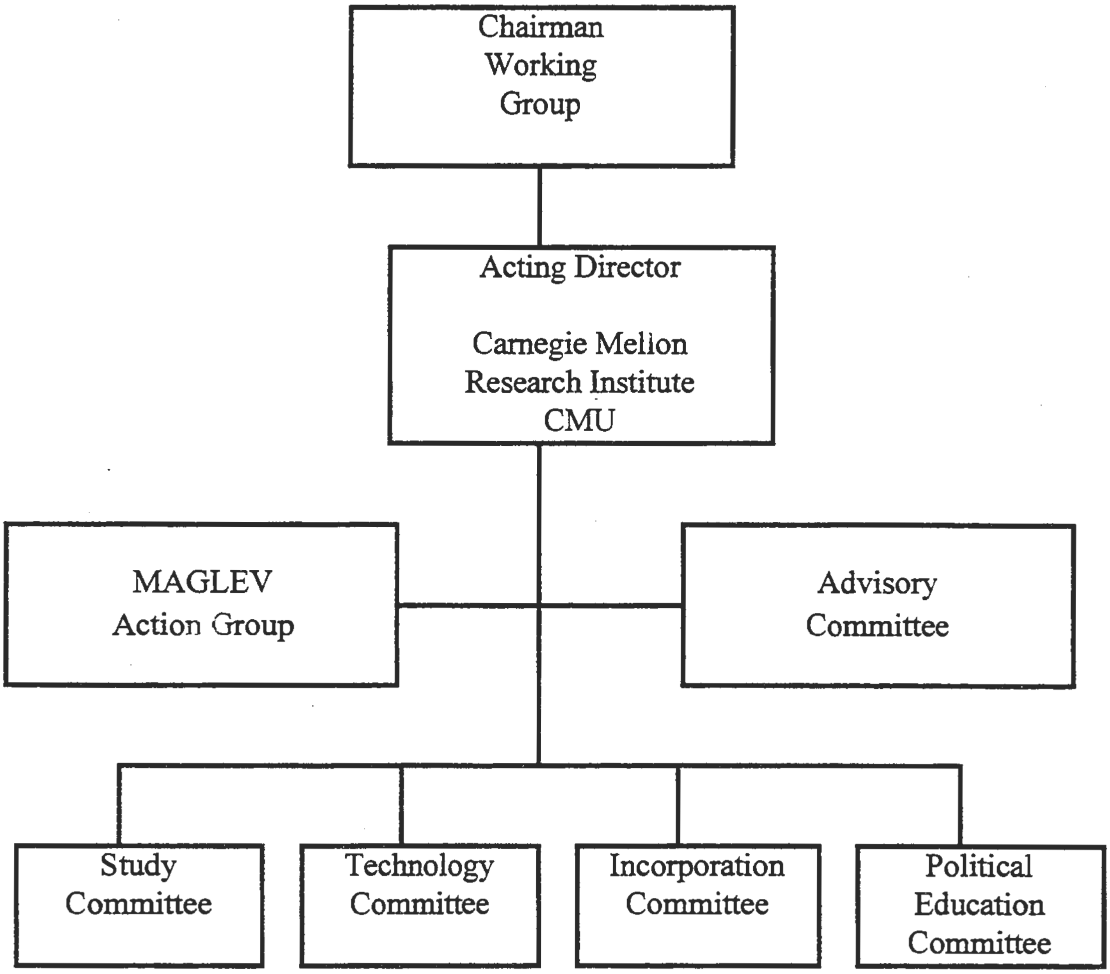
- Other sources of capital: Federal and state contributions on the costs of right-of-way and guideway, other government grants or loans, public pension funds with appropriate guarantees and foreign investment.
- Other sources of revenue: betterment levies on economic development generated by the magnetic levitation system, capturing some of the economics of manufacturing, freight revenues and operating subsidies.

Based on these findings, the Working Group considered the political and public acceptance of the project a primary concern and devoted attention to educating political and community leaders interested in manufacturing economic development and transportation in the region. The Group found substantial local interest and support for its objectives.

Of particular note, the Working Group determined that there is a high level of interest in MAGLEV technology in the Federal government, both among members of Congress and leaders in the previous Administration, and the Working Group concluded that it would pursue substantial Federal financial participation in developing a demonstration project in Pittsburgh.

FIGURE 1-1

MAGLEV WORKING GROUP ORGANIZATION



Study Committee	Technology Committee	Incorporation Committee	Political Education Committee
Michael Baker*	AEG Westinghouse*	Reed Smith*	Tri-State*
AEG Westinghouse County	CMU	CMU	Allegheny
Allegheny County	Reed Smith	Duquesne Light	CMU
Tri-State	US&S	Tri-State	URA
URA			USX
US&S			USWA

* Chair

1.3 DEMONSTRATION/DESIGN AND DEVELOPMENT PROGRAM

The next phase of the project is titled the Demonstration, Design & Development (DD&D) Program and consists of the following steps:

- Form a coalition with adjacent states and with the Federal government.
- Secure a license to engineer, manufacture and install the Transrapid system.
- Continue the review of competitive technologies.
- Continue to assess the domestic market for HSGT.
- Plan the Pittsburgh regional system to the same level of detail as was done for the demonstration in the preliminary feasibility study.
- Develop a financing plan for the demonstration project.
- Continue the education of political leaders and the public.
- Develop the manufacturing plan.
- Complete the conceptual engineering of the demonstration system.
- Evaluate the demonstration system's environmental impact.

To accomplish these tasks, the Working Group incorporated into MAGLEV, Inc., a private-public-labor partnership, whose members are shown below.

- AEG Transportation Systems, Inc.*
- Allegheny County**
- Carnegie Mellon University*
- Commonwealth of Pennsylvania**
- Duquesne Light Company*
- Michael Baker Corporation*
- Pittsburgh Building and Construction Trades Council*
- Reed Smith Shaw & McClay (contributing legal services)**
- Tri-State Conference on Manufacturing** (Formerly Tri-State Conference on Steel)
- United Steelworkers of America*
- Urban Redevelopment Authority of Pittsburgh**
- Wheeling Pittsburgh Steel Corporation*
- Price Waterhouse (contributing accountant)

* Shareholder/Board Member ** Contributing Board Member

The DD&D project operated from February 1990 through December, 1993. This DD&D report, the result of the DD&D program, addresses the manufacturing, building and operating of the Regional HSGT System and the conceptual engineering and environmental impact evaluation of the demonstration.

1.4 ORGANIZATION OF THE REPORT

Section 2 discusses some of the problems facing passenger transportation modes in the United States and how High Speed Ground Transportation (HSGT) systems offer an attractive solution for improving mobility by providing an alternative mode to the air and highway systems.

Section 3 provides an overview of the current HSGT technologies, high speed rail and MAGLEV, their state of development and the technology selection criteria used for the Regional System.

Section 4 reviews general market reports concerning HSGT and proposed corridor studies throughout the United States. The domestic market potential is evaluated to determine whether the opportunity exists to create a North American MAGLEV manufacturing center.

Section 5 describes the Mid-Atlantic Regional MAGLEV System. The Regional System's routes and the associated Suburban access system's locations are discussed and illustrated.

Section 6 provides an economic and financial analysis of the Regional and Suburban system. Cost estimates, revenue projections, and economic impacts are described.

Section 7 describes the Pittsburgh Demonstration System in detail. The Demonstration Line will be the first phase of the Regional System and is designed to verify capital and operating costs, assess environmental impacts, increase visibility of MAGLEV in the United States, and promote public acceptance for a new transportation mode.

Section 8 discusses financing strategies for the Regional System and in particular, for the Pittsburgh Demonstration System.

Section 9 provides the summary and conclusions for this report.

2.0 NEED FOR HIGH SPEED GROUND TRANSPORTATION

The modes of intercity passenger transportation in the United States are: highway, air, rail and bus. However, in terms of passenger-miles traveled, highway and air are the principal modes. Both of these modes are congested and are expected to become more congested in the future. High Speed Ground Transportation (HSGT) is an alternative which may ease the effects of congestion by providing alternatives and complements to these modes. This section presents a discussion of the nature of congestion and future modal alternatives to ease it, including applications of HSGT.

2.1 PASSENGER TRANSPORTATION CONGESTION

By reviewing the current and projected growth in congestion of the highway and air modes, the need for an alternative yet complementary mode of transportation becomes apparent.

2.1.1 HIGHWAY SYSTEM CONGESTION

Data developed during the preliminary feasibility study were taken from a "white paper" produced by the Federal Highway Administration entitled The Future National Highway Program: 1991 and Beyond (December, 1987). According to this report, annual vehicle-miles on the nation's highways were expected to increase from 1.6 trillion in 1985 to 2.6 trillion in 2005. There were several reasons for the increase: increases in licensed drivers, increases in households because of changing lifestyles, longer trip lengths because of continued suburban sprawl and the change in the nature of the economy from manufacturing to service based, thus requiring more travel.

Although more people have access to automobiles, the average speed during trips decreases because of increasing congestion. The FHWA estimated the increase in congestion between 1985 and 2005, using the Highway Capacity Model. Annual vehicle delay will increase from 2.7 billion vehicle-hours in 1985 to 11.9 billion vehicle-hours in 2005. An estimate of the cost of delay, in terms of fuel used and cost to the highway user, is shown in Table 2-1, Congestion on U.S. Highways. With the modest assumption of $3.00/hour for a person's time and $1.00/gallon of fuel, the congestion cost to the highway users will rise from $12.2B annually in 1985 to $46.5B in 2005, an increase of $34.3B in just 20 years. These are 1985 dollars. A report by the American Public Transit Association (APTA), Transit 2000, quotes this cost increase at $41 billion. Data on vehicle congestion show that in 1983, about 54% of peak-hour travel on urban interstates was congested. By definition, congestion occurs when the volume of traffic on a highway divided by the capacity of the highway is greater than 0.77. By 1987, this increased to 65%. If the trend continues, all peak-hour travel would be congested by the year 2005, as can be seen in Figure 2-1, Urban Interstate Congestion Trend.

TABLE 2-1
CONGESTION ON U.S. HIGHWAYS

	1985	2005
Vehicle-Miles (Trillions)	1.6	2.6
Delay (Billions of Vehicle Hours)	2.7	11.9
Urban Freeways	1.6	8.1
Signalized Arterials	1.1	3.8
Cost of Delay		
Billions of Person-Hours*	3.2	14.3
Billions of Gallons of Fuel**	0.8(1.3%)	3.6(4.4%)
Billions of Dollars***	12.2	46.5

Source: The Future National Highway Program, 1991 and Beyond, Working Paper No. 10, Urban and Suburban Highway Congestion, December, 1987.

* 1.2 persons per vehicle
** 0.3 gallons per vehicle-hour
( ) indicates % of total fuel
*** $3.00 per person-hour + $1.00/gallon fuel

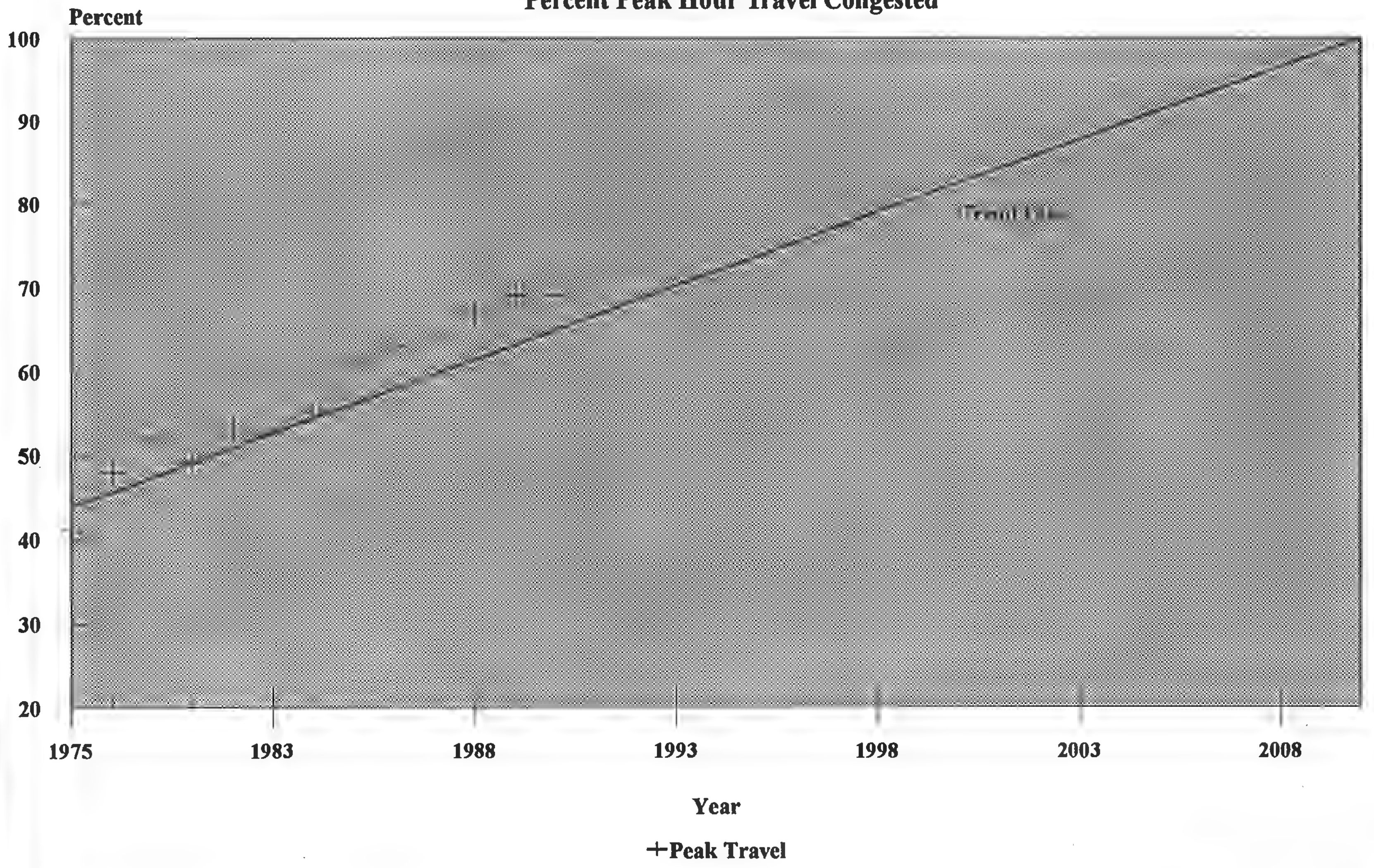
Calculations of total fuel:

1985: (27 MPG) 1.6T VMT/27 MPG = 59.3 B gallons
2005: (32 MPG) 2.6T VMT/32 MPG = 81.3 B gallons

All $ = 1985

URBAN INTERSTATE CONGESTION TRENDS

Percent Peak Hour Travel Congested



SOURCE: *Selected Highway Statistics and Charts,* 1990

FIGURE 2-1

In a more recent work, Traffic Congestion, Trends, Measures and Effects (November 1989), the United States General Accounting Office reviewed the FHWA study. They quote the work of Jeffrey Lindley's Urban Freeway Congestion: Quantification of the Problem and Effectiveness of Potential Solutions (January 1987), on urban freeway congestion which does not include signalized arterials. Table 2-2, Urban Freeway Congestion Statistics, summarizes that work.

The trend and historical vehicle miles traveled (VMT) on the highways is shown in Figure 2-2, Highway VMT. These are separated by passenger cars, trucks and buses. By the year 2005, the trend indicates 2.6 trillion VMT, the same number as projected by FHWA and upon which they based their delay numbers.

TABLE 2-2
URBAN FREEWAY CONGESTION STATISTICS

	1984	2005
Freeway Miles	15,335	15,335
Vehicle-Miles of Travel (millions)	276,645	410,987
Recurring Congested Vehicle-Miles of Travel (millions)	31,486	98,280
Recurring Delay (million vehicle-hours)	485	2048.6
Delay Due to Incidents (million vehicle-hours)	766.8	4857.5
Total Delay (million vehicle-hours)	1251.8	6906.1
Total Excess Fuel Consumption (million gallons)	1377.5	7317.1
Total User Cost ($billions)*	9.2	50.5

Source: Urban Freeway Congestion: Quantification of the Problem and Effectiveness of Potential Solutions, Jeffrey Lindley, ITE Journal, January, 1987, p. 29 (Table 1).

* Assumes fuel cost of $1.00/gal and average value of time of $6.25 per vehicle hour.

Table 2-3, Annual Congestion, Delay and Fuel Consumption, provides a breakdown of freeway data by urban area. For cities in the Regional area, Figure 2-3, Regional Freeway Data, shows both delay and excess fuel consumption, historical (1984) and projected (2005).

TABLE 2.3

Urban Area	Freeway Miles 1984	Freeway Miles 2005	Annual Vehicle-Miles (millions) 1984	Annual Vehicle-Miles (millions) 2005	Annual Recurring Congested Vehicle-Miles (millions) 1984	Annual Recurring Congested Vehicle-Miles (millions) 2005	Annual Recurring Delay Vehicle-Hours (millions) 1984	Annual Recurring Delay Vehicle-Hours (millions) 2005	Annual Incident Delay Vehicle-Hours (millions) 1984	Annual Incident Delay Vehicle-Hours (millions) 2005	Total Annual Excess Fuel (million gallons) 1984	Total Annual Excess Fuel (million gallons) 2005
New York	1,141	1,141	26,740	32,567	3,660	6,658	62.7	117.5	155.7	282.5	231.4	430.2
Los Angeles	647	647	27,131	33,768	5,370	9,406	78.3	180.8	94.7	229.1	191.3	438.1
Chicago	397	397	9,843	11,850	1,155	2,384	19.7	47.4	24.6	97.4	48.4	135.3
Philadelphia	362	362	6,238	9,573	428	1,727	4.9	35.1	10.2	73.8	17.4	115.9
San Francisco	602	602	22,071	29,791	4,262	9,638	72.9	208.5	95.6	349.6	182.1	589.6
Detroit	298	298	6,665	12,049	885	3,735	16.2	89.3	35.5	421.5	55.3	533.3
Boston	342	342	8,090	11,207	983	2,971	10.0	57.3	34.8	180.7	52.5	253.4
Houston	245	245	8,576	17,455	2,103	9,708	39.5	252.1	55.8	704.6	102.4	994.5
Washington	263	263	6,543	8,562	694	2,290	8.5	41.6	18.9	88.2	31.2	138.4
Dallas	418	418	9,763	20,223	1,039	7,637	16.3	169.0	28.9	578.0	49.6	791.1
Miami	195	195	4,599	8,158	203	3,182	0.3	69.2	2.5	163.7	5.1	247.4
Cleveland	332	332	5,046	6,635	348	824	6.1	15.6	4.3	11.6	11.2	28.8
St. Louis	248	248	5,086	7,148	413	1,182	3.8	19.3	4.4	16.0	9.8	38.7
Atlanta	249	249	6,456	9,130	743	1,915	15.8	45.5	16.7	56.8	34.6	107.6
Pittsburgh	207	207	2,301	2,927	154	324	1.9	6.5	5.5	14.7	8.4	22.6
Baltimore	195	195	3,974	6,105	285	1,837	2.9	33.1	6.8	58.7	11.3	98.4
Minneapolis	268	268	4,486	6,643	531	1,457	11.2	27.7	9.8	35.6	22.2	68.0
Seattle	230	230	5,874	9,937	925	3,187	18.5	76.3	25.0	197.2	46.8	286.2
San Diego	157	157	4,853	6,831	561	1,282	8.6	23.9	5.1	16.8	15.0	43.8
Tampa	37	37	870	1,289	40	277	0.1	4.1	0.4	11.2	1.1	17.0
Denver	179	179	3,390	4,650	456	942	7.5	19.2	7.6	26.5	16.4	48.3
Phoenix	43	43	1,013	1,612	69	372	0.2	6.8	0.8	13.7	1.4	22.2
Cincinnati	165	165	3,012	4,146	285	580	4.3	13.9	3.5	11.9	8.7	26.9
Milwaukee	107	107	2,146	2,848	177	491	1.9	8.5	1.8	7.6	4.3	17.2
Kansas City	277	277	3,324	4,417	172	492	1.9	7.2	5.9	11.8	9.1	21.0
Portland	136	136	2,418	3,521	116	569	0.5	8.8	3.6	24.2	6.0	35.9
New Orleans	60	60	1,702	2,073	340	616	7.7	12.6	10.3	44.7	19.1	61.1
Columbus	133	133	2,239	2,945	154	315	2.5	6.9	2.2	6.8	5.3	14.5
Norfolk	135	135	1,998	3,100	740	556	5.0	10.3	4.0	18.4	9.4	31.1
Sacramento	130	130	3,717	6,047	439	1,271	4.2	30.5	2.5	18.1	7.9	50.9
Buffalo	144	144	1,559	2,134	20	207	0.2	2.3	0.7	6.2	1.0	9.7
Indianapolis	139	139	2,237	3,924	0	572	0.0	7.9	0.2	12.3	0.2	23.1
San Antonio	150	150	2,768	5,662	391	2,189	5.2	56.7	5.7	157.5	12.6	223.4
Providence	150	150	1,667	2,331	86	238	0.5	4.0	0.6	2.1	1.5	6.7
Charlotte	37	37	665	1,830	71	993	1.3	23.3	2.2	116.5	3.9	146.8
Hartford	123	123	2,165	2,499	207	294	1.9	5.2	7.0	12.4	10.7	19.1
Salt Lake City	99	99	1,501	2,771	101	495	2.0	10.7	1.2	5.4	3.4	17.0
	9,040	9,040	212,726	308,358	28,606	82,813	445.0	1,754.6	695.0	4,065.8	1,248.0	6,153.2

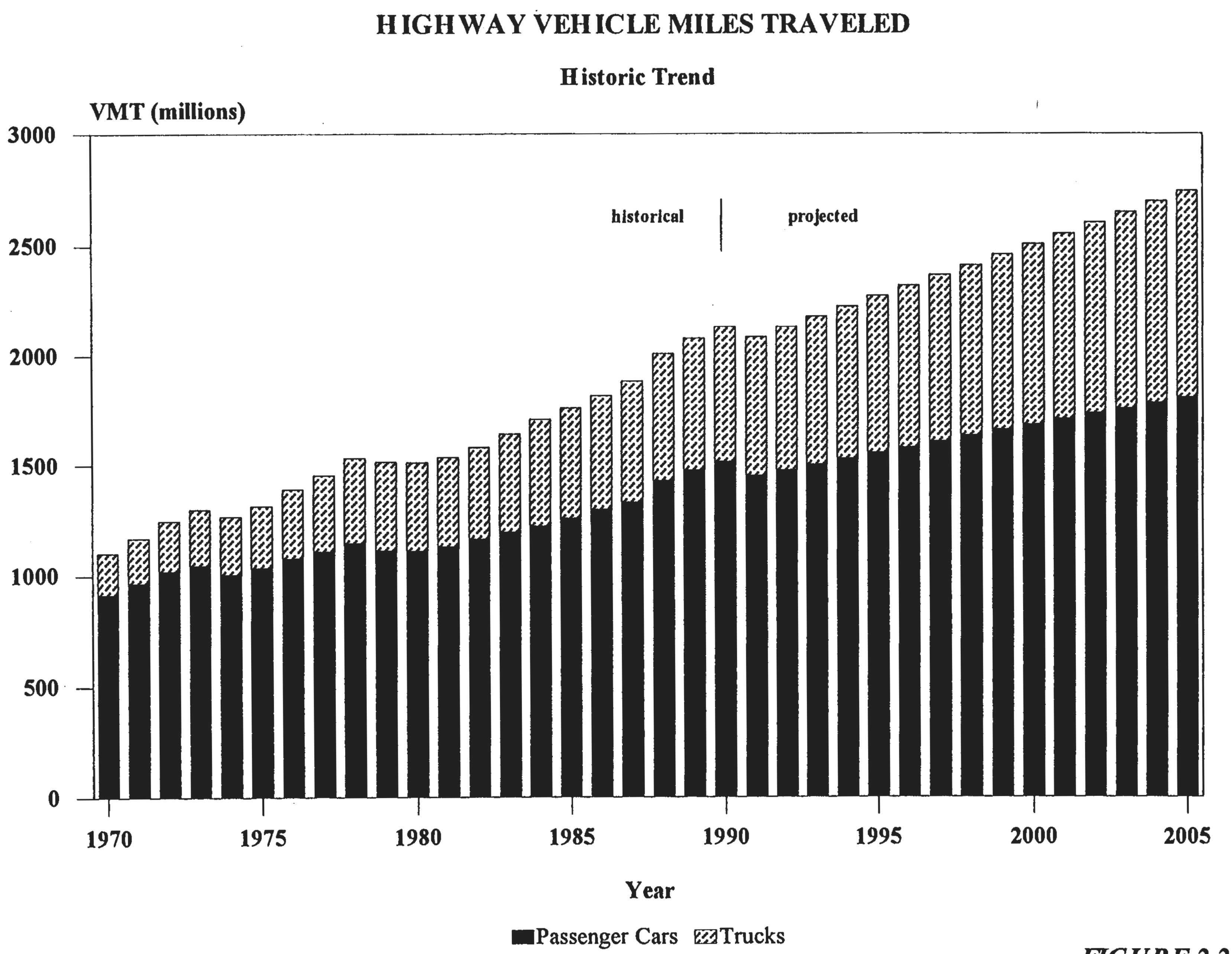
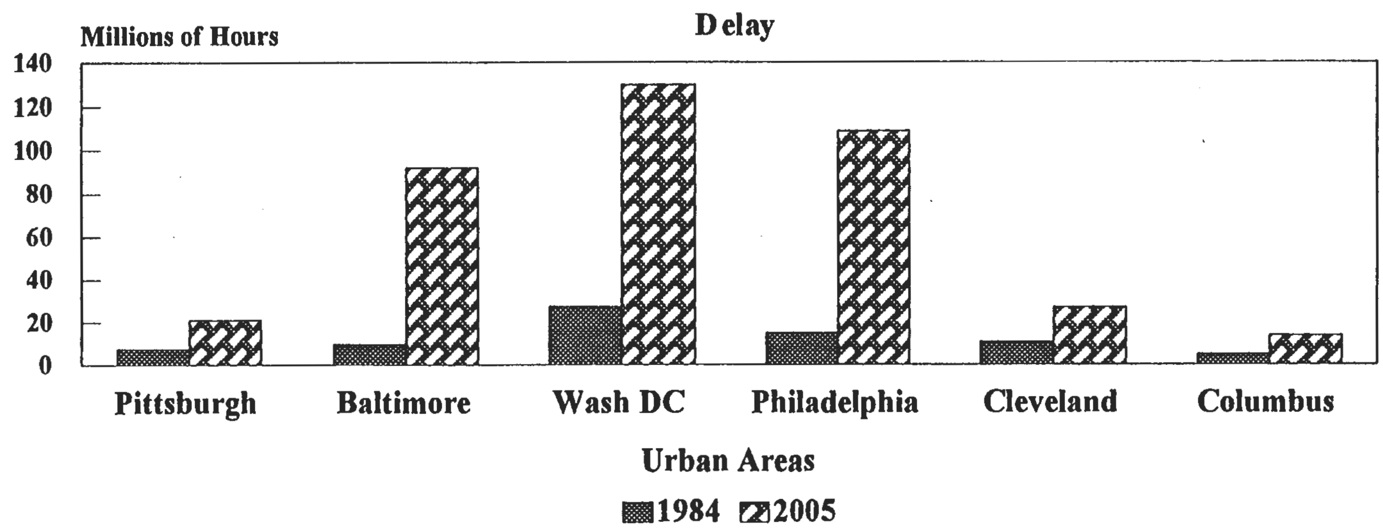
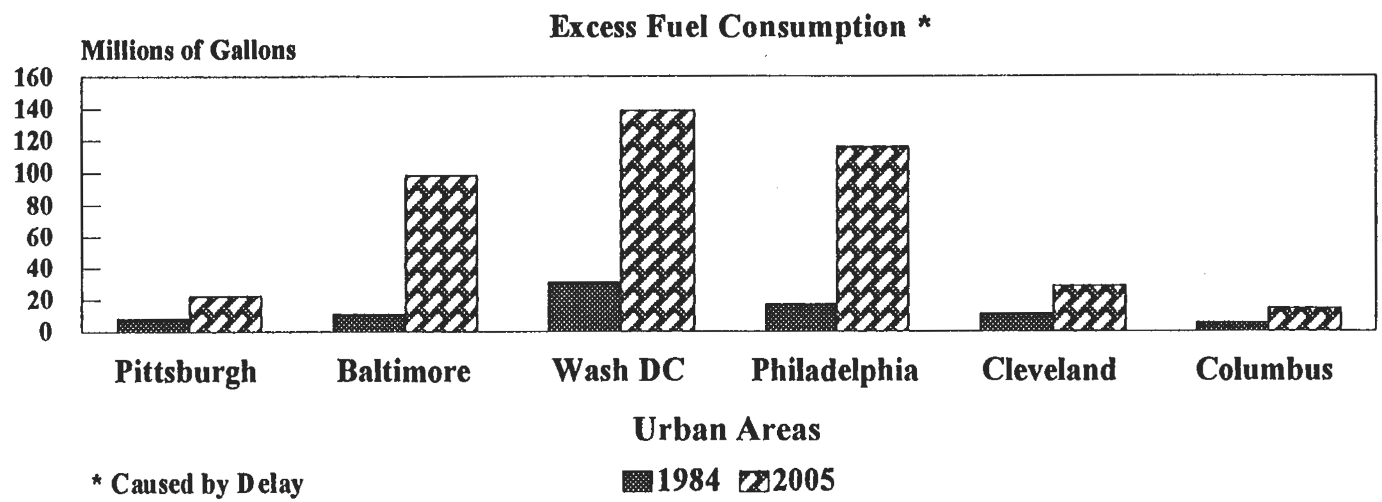

HIGHWAY VEHICLE MILES TRAVELED
Historic Trend
VMT (millions)
3000
2500
2000
1500
1000
500
0
historical
projected
1970
1975
1980
1985
1990
1995
2000
2005
Year
Passenger Cars
Trucks

FIGURE 2-2

REGIONAL FREEWAY DATA





* Caused by Delay

FIGURE 2-3

The cities in the Region experiencing the most serious delay are Washington, Philadelphia and Baltimore.

The total cost of vehicle delay in the year 2005 will lie somewhere between $40-$60 billion/year in 1985 dollars, which would translate to a rough range of $50 billion to $78 billion annually in 1993 dollars.

2.1.2 AIR SYSTEM CONGESTION

Air traffic in the U.S. is also congested with little hope of relief in the near future. The nation faces a rising crisis in aviation.

There are 6000 airports in this country but only 494, or 8% of these airports, have regularly scheduled passenger service as reported in Future Development of the U.S. Airport Network (1988). Of these 494 airports, only 280 are considered primary airports by the Federal Aviation Administration. These primary airports handle over 99% of the commercial passenger air traffic. The 10 busiest airports handle 40% of the traffic, the 25 busiest airports handle 67% of the traffic and the 100 busiest airports handle 95% of the traffic.

Figure 2-4, US Air Mode Activity (B), shows both historical, as well as projected, enplanements (passengers boarding commercial airlines) from the year 1985-1988 (historical) and from 1988-2005 (projected). This information is from Airport System Capacity, Strategic Choices, (1990). Although the reference only projects growth until the year 2000, the same growth rate was used to extend the projection to the year 2005. Enplanements are expected to increase from 406 million in 1985 to 1.04 billion by the year 2005. The validity of these forecasts is dependent on many factors, among which economic health of the U.S. in future years is prominent. This forecast is based on increases of gross national product, which are similar to those of the past.

Likewise, Figure 2-4(C) shows both the historical and projected revenue passenger-miles that have been and will be logged by the flying public between 1985-1988 (historical) and from 1989-2005 (projected). As in the case of enplanements, passenger-miles are projected to increase from 346 million in 1985 to 988 million by the year 2005.

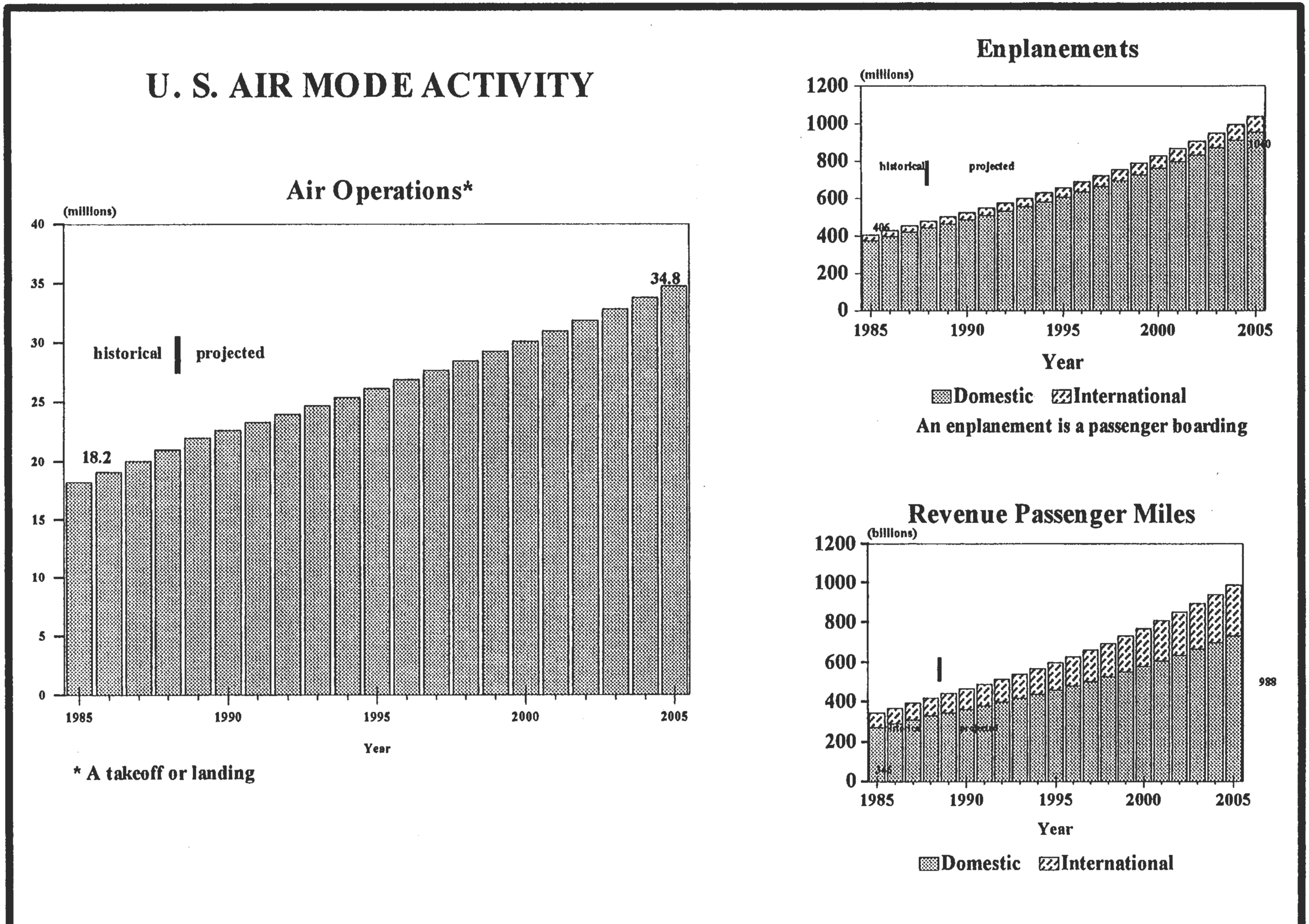

U. S. AIR MODE ACTIVITY
Air Operations*
(millions)
40
35
30
25
20
15
10
5
0
18.2
34.8
historical
projected
1985
1990
1995
2000
2005
Year
* A takeoff or landing
Enplanements
(millions)
1200
1000
800
600
400
200
0
historical
projected
406
1985
1990
1995
2000
2005
Year
Domestic
International
An enplanement is a passenger boarding
Revenue Passenger Miles
(billions)
1200
1000
800
600
400
200
0
988
1985
1990
1995
2000
2005
Year
Domestic
International

FIGURE 2.4

The measure of congestion in the air system is delay. Delay is generally measured on the basis of minutes of delay per air operation. An air operation is a takeoff or a landing. Figure 2-4(A) shows both the historical and projected air operations from 1985-1988 (historical) and from 1989-2005 (projected). Air operations are expected to grow from 18.2 million annually in 1985 to 34.8 million in 2005.

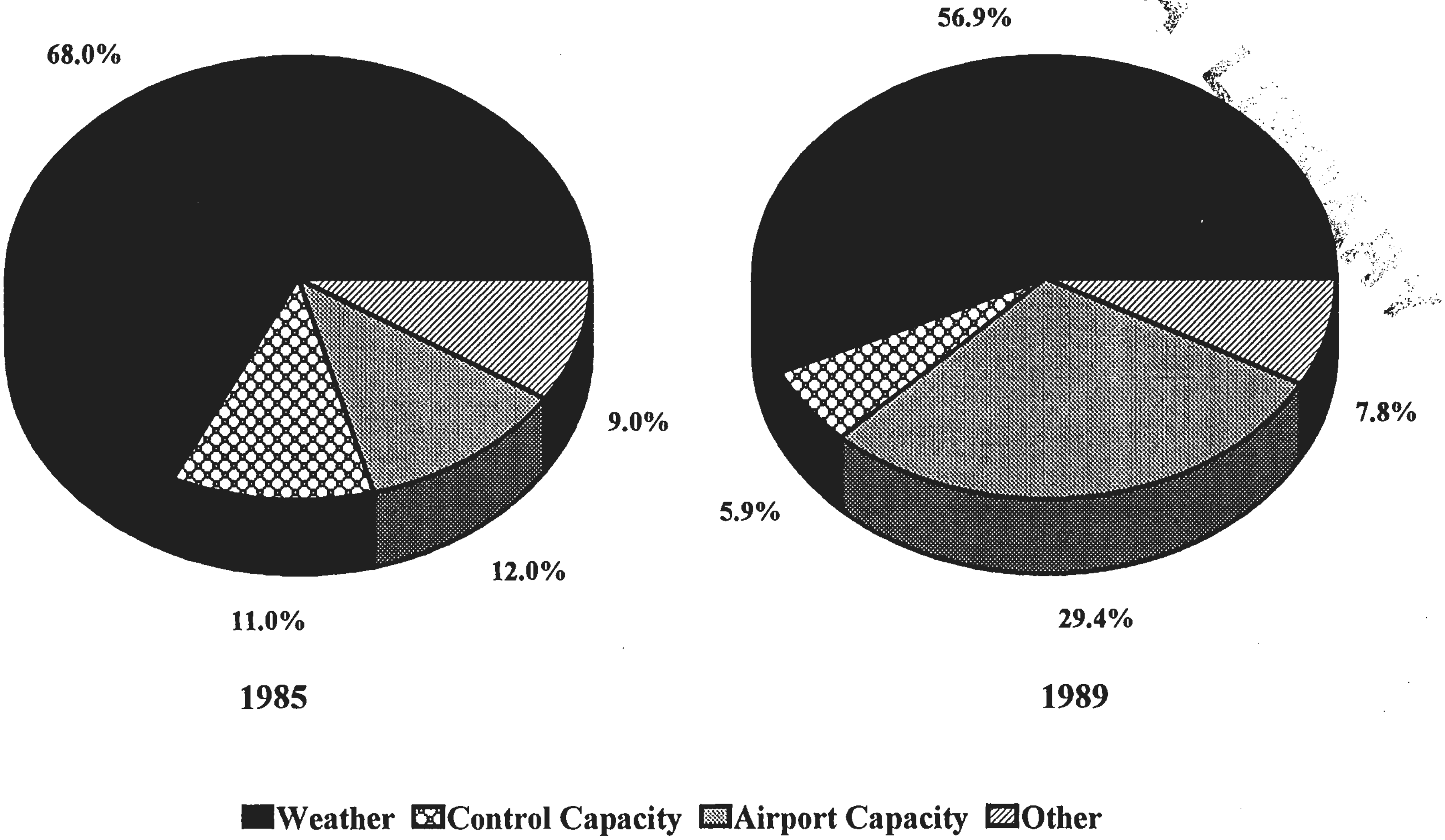
The relationship between air operations and airport system capacity is not a linear one. Demand represents the number of air operations. Since the capacity limit depends on many factors, some of which like the weather, are not controllable, it is not a well defined point. If the number of operations are less than the capacity limit, then delay rises slowly with the increasing number of operations. On the other hand, if the capacity limit is exceeded, the increase in delay with the number of operations rises quickly.

Delay is measured between optimal and actual travel times. It has many causes and contributing factors. Factors which contribute to delay include weather, air traffic control capacity and airport capacity. All of these factors are inter-related. The charts in Figure 2-5, Air System Delay, show the distribution of delay by cause for the year 1985 and 1989, according to Winds of Change, Domestic Air Transport Since Deregulation, (1991). It is clear that weather affects air system reliability the most. However, poor weather in any part of the country can now back up the whole air system. As air operations increase, the tax on the air system will become greater, assuming no added capacity. (The addition of capacity in the air mode will be discussed in Section 2.2.2.)

Airport delay levels were measured in 1986 and projected to 1996. The number of airports in a state of critical delay (greater than 8 minutes of delay per air operation) will rise from 14 in 1986 to 29 by the year 1996, assuming no capacity improvements.

Table 2-4, Air System Data Summary, summarizes the U.S. air system data, both historical (1986, 1988) and projected (1996, 2005).

AIR SYSTEM DELAY
By Cause



Distribution of delay greater than 15 minutes

FIGURE 2-5

The following observations are made between 1986 and 2005, assuming no capacity improvements:

- The number of enplanements and passenger miles will more than double.
- The number of air operations will nearly double.
- The hours and cost of air system delay will more than double.
- The number of airports with chronic delay will quadruple.

TABLE 2-4
AIR SYSTEM DATA SUMMARY
(HISTORICAL AND PROJECTED)

	1986	1988	1996	2005
Enplanements[1] (millions)	429.3	479.0	689.3	1,039.7
Passenger-Miles (billions)	369.3	420.5	628.9	987.8
Air Operations[2] (millions)	19.1	21.0	26.1	34.8
Hours of Delay[3] (millions)	1.15	2.03	1.81	2.4
Cost of Delay[4] ($billions)	5.0	8.8	7.9	10.4
Chronic Delay Airports[5]	11	15	29	45

Source: Airport Capacity Enhancement Plan 1988.

By the year 2005, with nearly 50 airports in a state of chronic delay, approximately 80% of the air passenger traffic will also be in a state of chronic delay. Thus, in 1986 dollars, the cost of delay will rise from $5.0 billion to $10 billion in the year 2005, which, when translated to 1993 dollars, will be over $13 billion.

The large airports involved in the Regional HSGT system are Cleveland (CLE), Greater Pittsburgh (PIT), Philadelphia (PHL), Baltimore International (BWI), Washington National (DCA) and Washington Dulles (IAD). Figure 2-6, Regional Airport Activity, shows the number of air operations (A) and the delay (B) at these airports for both 1986 and 1996 (projected). Baltimore, Philadelphia and Pittsburgh show substantial increases.

---

1 An enplanement is a passenger boarding an aircraft.
2 An air operation is an aircraft taking off or landing.
3 Delay is the difference between actual and optimal flight time.
4 Cost of delay is estimated at $4350 per hour of delay (Ref. Airport Capacity Enhancement Plan 1988, U.S. Department of Transportation, Transportation Systems Center, Cambridge, MA April 1988, PB88-234828).
5 A chronic delay is one in which the delay exceeds 8 minutes per operation.

REGIONAL AIRPORT ACTIVITY

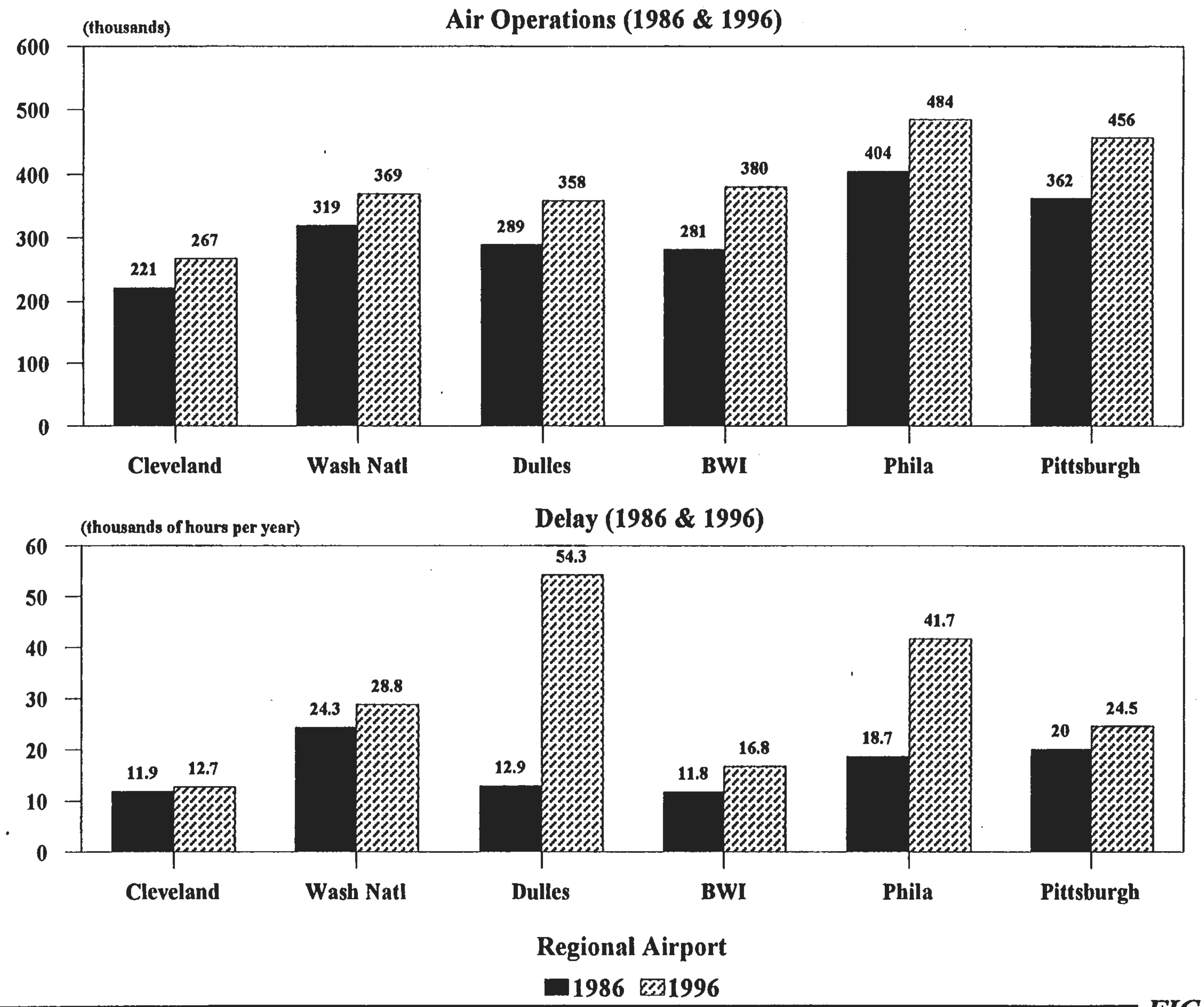


FIGURE 2-6

In 1988, Washington National, Washington Dulles and Philadelphia airports reached chronic delay stage (8 minutes of delay per operation).

2.1.3 OTHER MODES

For the country as a whole, along with the air and highway modes for intercity travel, intercity bus and train are also part of the supply to the market. Market share among all of the public carriers (air, bus and rail) is shown in Figure 2-7, Intercity Travel. There has been a 54% increase in the public carrier intercity market during the years 1980-88. Although AMTRAK has been gaining in absolute numbers of passenger miles, both AMTRAK and intercity bus have lost market share to the air mode. Intercity bus has dramatically lost market share (from 9.4% in 1980 to 5.1% in 1988), while AMTRAK only slightly (from 1.5% in 1980 to 1.3% in 1988). However, the air mode has increased substantially both in absolute and market share terms.

2.2 FUTURE ALTERNATIVES FOR MODAL EXPANSION

Modal solutions have been proposed to the mitigation of congestion in a particular mode as well as multimodal and intermodal solutions. This section examines the solutions.

2.2.1 HIGHWAY MODE EXPANSION

2.2.1.1 Highway Expenditures and Mileage

Selected Highway Statistics and Charts (1990), produced by FHWA contains much of the information on increased highway expenditures and mileage.

Figure 2-8, Highway Expenditures, shows the highway expenditures for all levels of government, both capital outlays and maintenance. Maintenance outlays remain rather flat at $19B per year in the period 1977-90 while capital outlays began to increase from 1984-87 and remain flat from 1987-90 at $30-35B ($1990).

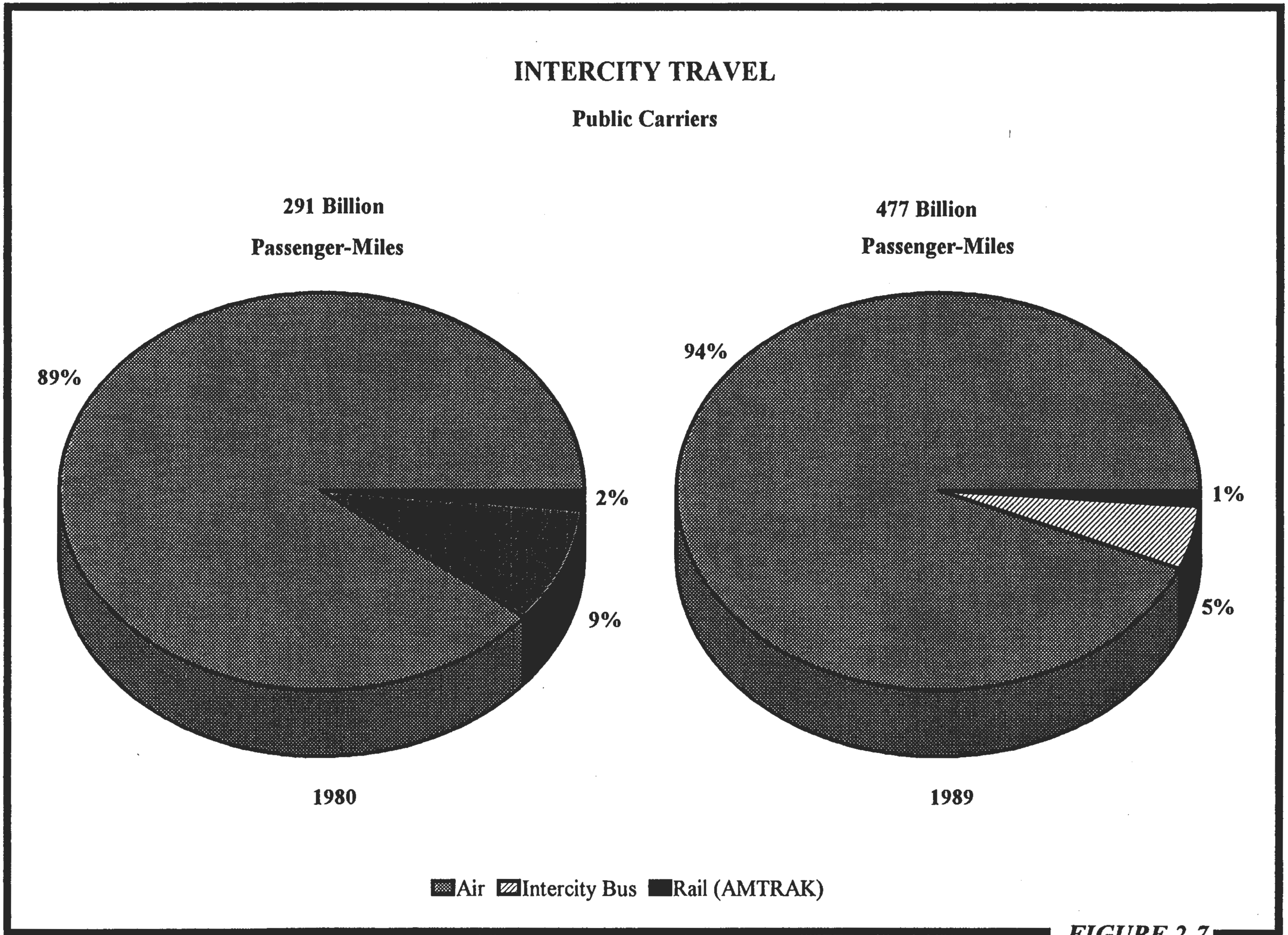

INTERCITY TRAVEL
Public Carriers
291 Billion
Passenger-Miles
477 Billion
Passenger-Miles
89%
2%
9%
94%
1%
5%
1980
1989
Air
Intercity Bus
Rail (AMTRAK)

FIGURE 2-7

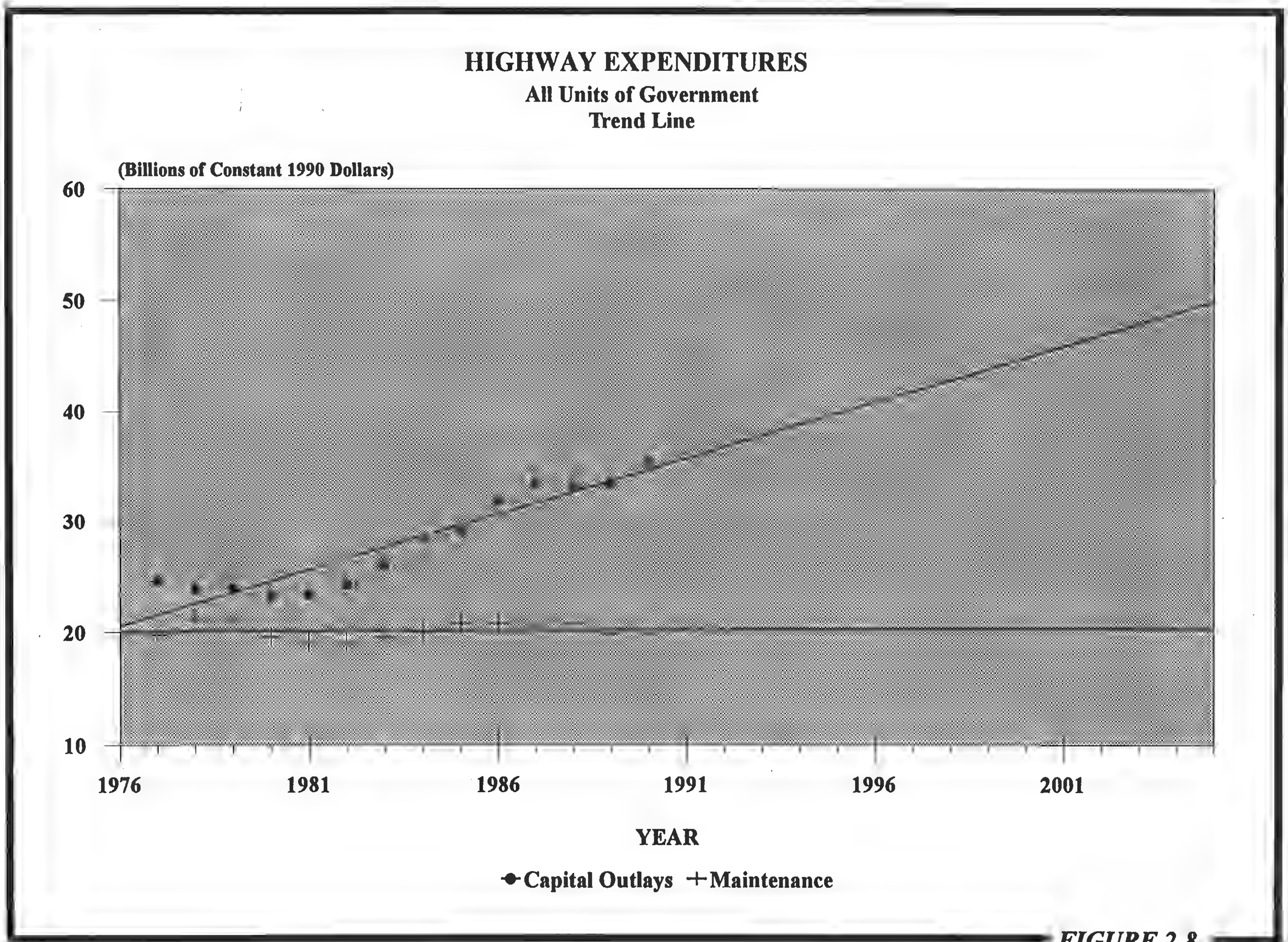

HIGHWAY EXPENDITURES
All Units of Government
Trend Line
(Billions of Constant 1990 Dollars)
60
50
40
30
20
10
1976
1981
1986
1991
1996
2001
YEAR
Capital Outlays
Maintenance

FIGURE 2-8

Trend line projections show that annual highway expenditures should reach $70 billion per year by the year 2005 in constant 1990 dollars. Maintenance accounts for $20 billion of that amount.

With the help of Table 2-5, Rough Estimates of Cost of Highway Spending Program, a rough estimate of the total expenditures needed to keep highway volume to capacity (VMT/paved mile) at 1990 levels can be made. All projections in the table are trend line projections, which assume that the future (1990-2005) will behave like the past (1977-1990).

The VMT/paved-mile ratio at the 1990 level is 0.879. Thus, the added capacity less the present trend capacity is the shortfall required to keep the future VMT/paved-mile ratio at 0.879. Adding the shortfall to the present program trend yields the total expenditures necessary to keep the ratio fixed with no increase in congestion. Thus, $417 billion will be required by 1995, $968 billion by 2000 and $1786 billion by 2005.

This estimate may be high because other strategies can mitigate congestion. However, it may be low because the average cost/paved-mile is more representative of rural roads and added lanes.

Numbers that are usually quoted for massive highway building programs are typically $100 billion per year. In this sense, the numbers agree.

2.2.1.2 Federal Efforts

The present thinking concerning future relief of highway congestion is explained in Traffic Congestion, Federal Efforts to Improve Mobility (December 1989) published by the General Accounting Office (GAO) of the United States. This report is summarized in this section.

Out of a total of 3.87 million route-miles of roads, approximately 849,000 are eligible for federal aid under the program. With only 22% of the route-miles, the federal aid roads carry 81.5% of VMT.

TABLE 2-5
ROUGH ESTIMATES OF COST OF HIGHWAY SPENDING PROGRAM TO KEEP CONGESTION AT 1990 LEVELS (NEW PAVING ONLY)

Year	VMT (millions)	Paved Miles (millions)	VMT/paved-mile (millions)	Paved Miles Rqd for VMT per paved mile at 1990 levels (millions)	Paved Mile Shortfall (millions)
1990	2.00	2.28	0.879	2.28	0.00
1995	2.22	2.43	0.914	2.53	0.095
2000	2.40	2.57	0.934	2.73	0.160
2005	2.65	2.72	0.974	3.01	1.294

Year	Cost per Paved Mile added (millions)	Accum Exp Present Trend ($billions)	Total Expenditures Rqd for VMT/paved mile @ 1990 levels	Accum Exp Rqd to Overcome Shortfall ($billions)
1990				
1995	1.375	287	417	130
2000	1.500	598	968	370
2005	1.625	936	1786	850

ACCUM EXPENDITURES FOR PRESENT TRENDS

Year	Present Trend Annual Exp ($billions) Capital	Maintenance	Total	Accumulative Expenditures ($billions)
1990	35.3	19.7	55.0	
1995	39.5	20.2	59.7	287
2000	44.7	20.2	64.9	598
2005	50.0	20.2	70.2	936

All 1990 constant dollars

Brief descriptions of the six sub-programs under the Federal Aid Highway Program (Surface Transportation and Uniform Relocation Assistance Act of 1987) appear below.

- Interstate - Primarily completion of system.
- Interstate 4R - Resurfacing, restoring, rehabilitating and reconstructing the system.
- Primary - Construction and reconstruction of primary class which includes principal and minor arterials.
- Urban - Metropolitan area (population over 200,000) roads. Funds can be used for construction, reconstruction, TSM and purchase of transit vehicles.
- Secondary - Rural and country roads (construction and reconstruction).
- Other - Congressionally requested projects.

During the years 1987-91, a total of $48 billion was authorized for the first five sub-programs. Sixty-one percent of the Federal money is targeted toward the interstate and primary road class.

There are three general categories for reducing congestion on the future highway system.

- Construction & Reconstruction
- Transportation System Management (TSM)
- Advanced Technology

As discussed in Section 2.1.1, the projection for VMT on this nation's roads continues to dramatically increase. As a result, congestion also continues to increase. There are several strategies for congestion mitigation that are presently being deployed.

Construction and Reconstruction

Construction and reconstruction activities are ongoing. These activities fall into the following categories:

- New construction - Involves adding new route-miles to the highway system.
- Reconstruction - Involves adding lanes (new capacity) to the system as well as maintenance.
- Major widening - Specifically includes adding lanes.
- Bridge work - Involves new bridges associated with new routes, bridge reconstruction and bridge maintenance.
- 3R - Involves resurfacing, restoring and rehabilitating.

The three improvements relating to increased capacity amounted to $3.9 billion of $7.8 billion in 1988.

Transportation System Management (TSM)

There are many Transportation System Management techniques designed to reduce VMT. As an incentive to use Federal aid funds for TSM, up to 10% of a state's Federal Aid Highway Funds can be used without state matching funds for several TSM techniques (traffic signals, pavement markings and signing improvements, as well as commuter carpooling, and vanpooling projects). In addition, FHWA officials view their role in TSM as that of a provider of technical assistance, training, information on research results, new products and innovative approaches.

In addition to the FHWA, the Federal Transportation Administration (FTA, formerly the Urban Mass Transportation Administration [UMTA]) administers Federal aid programs in local communities. It's grant-in-aid program is designed to increase mobility through mass transit. FTA proposes that TSM techniques (when combined with transit) can have a long term effect on mitigating congestion. Expansion of transit services and improvements in transit system performance can attract drivers out of their automobiles in the short run, but in the long run growth in VMT will more than offset these benefits.

The American Public Transit Association's (APTA) published goal for the decade of the nineties is to double ridership. It is interesting to examine the role that public transit might have on mitigation of highway congestion.

If public transit ridership is plotted as a percent of highway passenger-miles, it is easily seen from Figure 2-9, Public Transit Ridership, that transit ridership remains flat with possibilities of decline relative to the highway mode (1.4% in 2005) if current transportation policies continue. In the year 2000, highway ridership is estimated to be 3.32 trillion passenger-miles. Doubling public transit ridership will have little effect on congestion mitigation if present trends continue.

Advanced Technology

Advanced technology is not a new idea in the FHWA and FTA programs. The Urban Traffic Control Systems project and later, the National Signal Timing Optimization project, were both designed to test and implement advanced control systems that could increase the efficiency of flow movement through local streets.

The basic objective of the FHWA advanced technology program is to integrate the roads, which now exist, with the vehicles of the future into a smoothly running, efficient transportation system. One goal is to make roads so "smart" that they can guide "intelligent" vehicles without direction from the drivers. Although these again are noble, long range goals, experts in the field agree that it will not be until well into the twenty-first century that something like this will be demonstrated.

Electronic navigation systems are already under development by the auto makers. Screens may show, in real time, non-congested routes so that drivers may take these alternatives. Opponents suggest that it is not clear whether the added cost to the user would be worthwhile. Local traffic congestion announcers in helicopters already provide a similar function, albeit at a much lower level of sophistication.

In the conclusion of the GAO report, MAGLEV Vehicles and Superconductor Technology: Integration of High-Speed Ground Transportation into the Air Travel System, (April 1989), the following quote was underlined:

> "We recommend that the Secretary of Transportation set forth guidance in the planned national transportation policy to ensure a coordinated federal strategy toward improving freeway and roadway mobility and that this guidance note the need for appropriate evaluation mechanisms

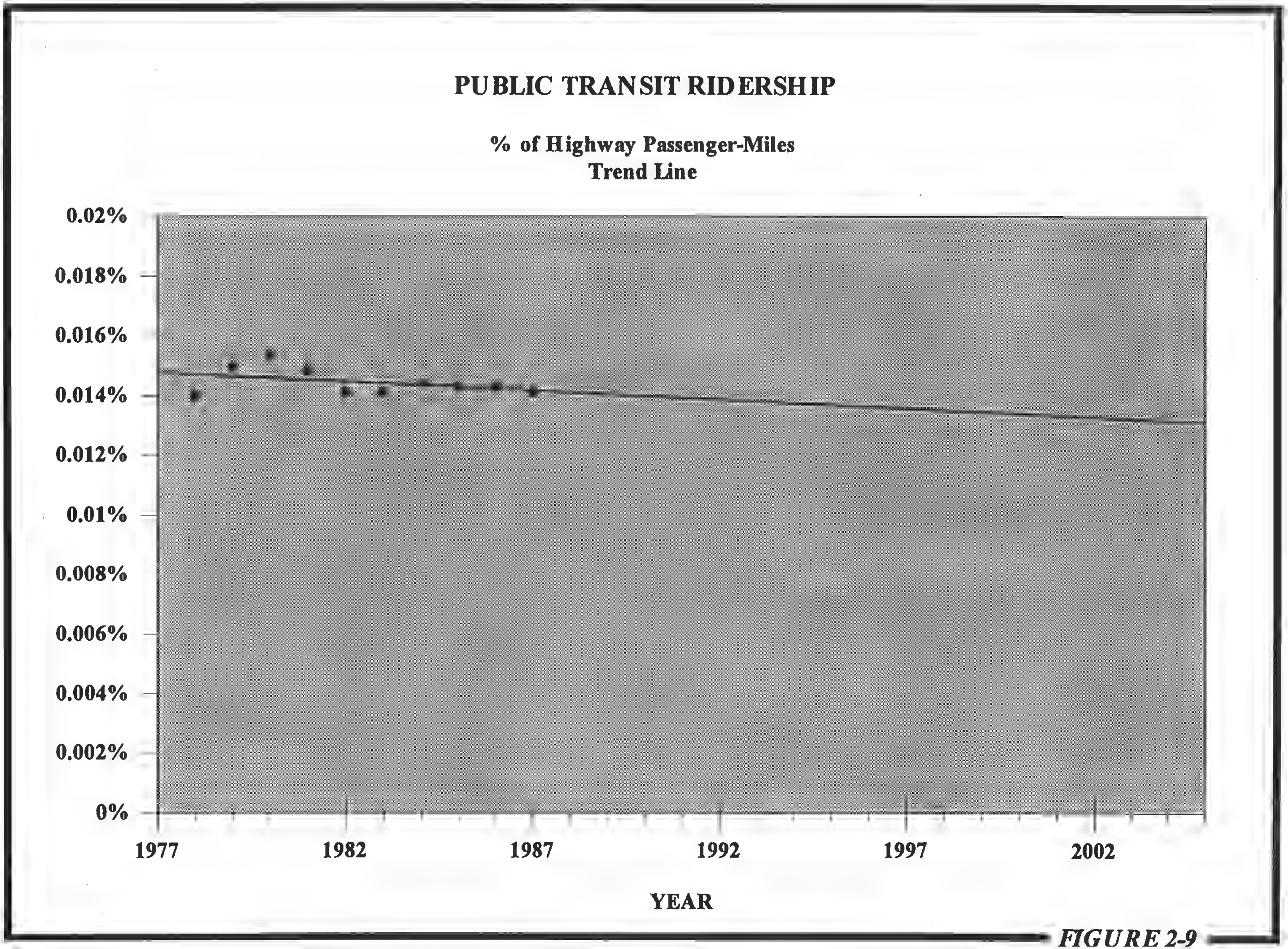

PUBLIC TRANSIT RIDERSHIP
% of Highway Passenger-Miles
Trend Line
0.02%
0.018%
0.016%
0.014%
0.012%
0.01%
0.008%
0.006%
0.004%
0.002%
0%
1977
1982
1987
1992
1997
2002
YEAR

FIGURE 2-9

to determine the effectiveness of key Federal congestion reduction programs and activities."

Without the ability to relate the effect of strategy deployment to congestion mitigation, strategies cannot be truly evaluated as to their cost/benefit.

2.2.1.3 Summary of Highway Mode Solutions

If the present trend continues, the accumulative expenditures on the highway program will be $936 billion ($1990) between 1990-2005. The VMT/paved-mile will still rise from 0.879 to 0.974. Congestion will still worsen. It is not clear at this point how TSM or advanced technology solutions will work. Thus, the urban portion of an interurban area trip will continue to get longer on the highways.

2.2.2 AIR MODE EXPANSION

2.2.2.1 Strategies for Air System Development

Some of the latest strategies for improving the air mode of travel in order to increase efficiency and reduce air mode congestion are reflected in a report entitled Airport System Capacity (1990). Most of the material presented in this section is extracted from that report and summarized.

The study committee, which produced the report, is a panel of experts whose chairman is Dr. Joseph M. Sussman, Director of the Center for Transportation Studies at the Massachusetts Institute of Technology. The panel was charged with the following four tasks:

1. Examine long term airport capacity needs and options to meet these needs
2. Formulate of alternative strategies for the future
3. Identify advantages and disadvantages of the strategies
4. Recommend strategies for further analysis and evaluation by the FAA.

The report does not present solutions, but rather plausible strategies for allowing the airport system to grow as demand and congestion increase.

The strategies considered consisted of mixtures of several options. Evaluation of the options was based on ten criteria which are listed below:

1. Capacity benefit: the extent of the increase in local airport and air system capacity,
2. Capital cost: the investment required in current dollars,
3. Operating cost: annual recurring costs,
4. Safety: level of assurance to exceed present air mode safety,
5. Passenger effects: the extent to which fares, delay, trip time, comfort, convenience, frequency and reliability of service is affected,
6. Industry effects: the extent to which airline cost, competition, flexibility of routes and choice of service points is affected,
7. Environmental effects: the extent to which noise, air pollution, landside congestion, community infringement, intrusion on natural settings and aesthetics are affected,
8. Local and regional effects: the influence on economic growth and community development both near the airport and on a metropolitan-wide basis,
9. Funding and financing: the availability of public and private sources of capital and financing mechanisms, and
10. Implementation: the required planning mechanisms, availability of airport sponsors, methods of implementation and management and operating concerns.

Options for accommodating air travel demand in the future are divided into three general categories; infrastructure supply (add airport capacity), demand management (improve existing capacity), and new technology (air and surface). Figure 2-10, Air Traffic Demand, lists the eight options considered in the report by general category.

Figure 2-11, Air Option Implementation Time, shows the implementation time suggested by the committee of experts for the eight options.

Under the category of air infrastructure supply, capacity improvements and establishing new hubs should be completed by the year 2005. Building new

AIR TRAFFIC DEMAND
Future Accommodation Options

AIR INFRASTRUCTURE SUPPLY

1. Airport Improvement
2. New Hub Airports
3. New Airports
4. New Transfer Airports

AIR DEMAND MANANGEMENT

5. Regulation
6. Economic Measures

NEW TECHNOLOGY

7. New Aviation Technology
8. High Speed Surface Technology

Source: *TRB Report 226*, 1990

FIGURE 2-10

AIR OPTION IMPLEMENTATION TIME

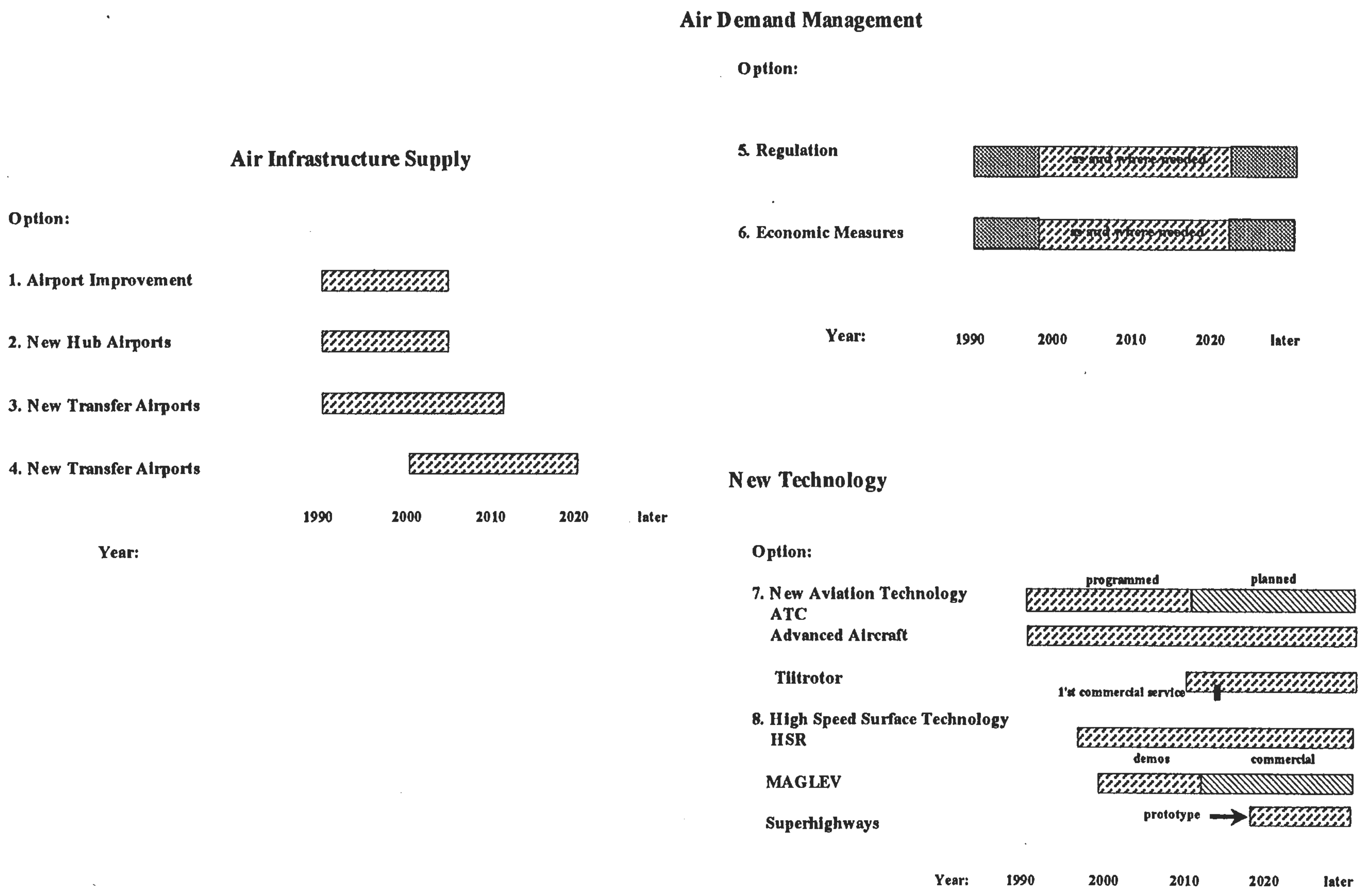


FIGURE 2-11

airports in large metropolitan areas should be completed by 2010, while building of transfer airports should occur from 2000-2020.

Under the category of demand management, methods would be applied as needed and where needed to meet severe congestion problems.

In the new technology area, there are two broad categories: aviation and high speed surface (same as HSGT). Under aviation, the programmed upgrades in air traffic control (ATC) will continue until 2010 whereas new upgrades, which are being planned, would be implemented beyond 2010. In terms of advanced aircraft, it is expected that new models will continue to be available every 20 years. If R&D on tilt rotor continues, the first commercial services would be implemented beyond 2010.

In terms of high speed surface systems, the forecast for commercial high speed rail will be the late 1990s while prototype MAGLEVs will be demonstrated from the late 1990s to 2010, after which commercial lines could be built. Super or smart highway prototypes will not be available until 2020.

2.2.2.2 Strategy Development and Evaluation

The expert panel developed forecasts of air activity based on three economic scenarios: high growth, maturing economy and economic difficulty. Growth of 200-400% over present operations may be likely by the year 2040.

The eight options shown in Figure 2-10 were combined in various forms into seven strategies (Figure 2-12, Strategy Definition). All strategies include Options 1 and 2. This is the present course of action. Strategy B is to build more airports. Strategies C and D are basically regulatory in nature. Strategies F and G are both revolutionary, and the committee felt that they could meet the air mode congestion problems of the future.

Rough capital costs estimates were made for each of the strategies. These, together with benefits, are shown in Figure 2-13, Strategy Capital Cost. There was no attempt to quantify rigorously the effects in terms of decreased delay because of increased capacity. However, the panel did speculate as to the effect

STRATEGY DEFINITION

STRATEGY	SUPPLY	REGULATION	TECHNOLOGY
A. Present Course	1,2	5	7,8 Fed R&D
B. More Airports	1,2,3	5	7,8 Fed R&D
C. Regulation	1,2	5	7,8 Fed R&D
D. Managed Air System	1,2,3	5	7,8 Fed R&D
E. Market Decision	1,2,3	6	7,8 Private Sector R&D
F. New Air System	1,2,4	5	7,8 High Level Fed R&D
G. New Air/ Land System	1,2	5,6	7,8 Deployment

OPTIONS:

1. Airport Improvement
2. New Hub Airports
3. New Airports
4. New Transfer Airports
5. Regulation
6. Economic Measures
7. New Aviation Technology
8. High Speed Surface Technology

FIGURE 2.12

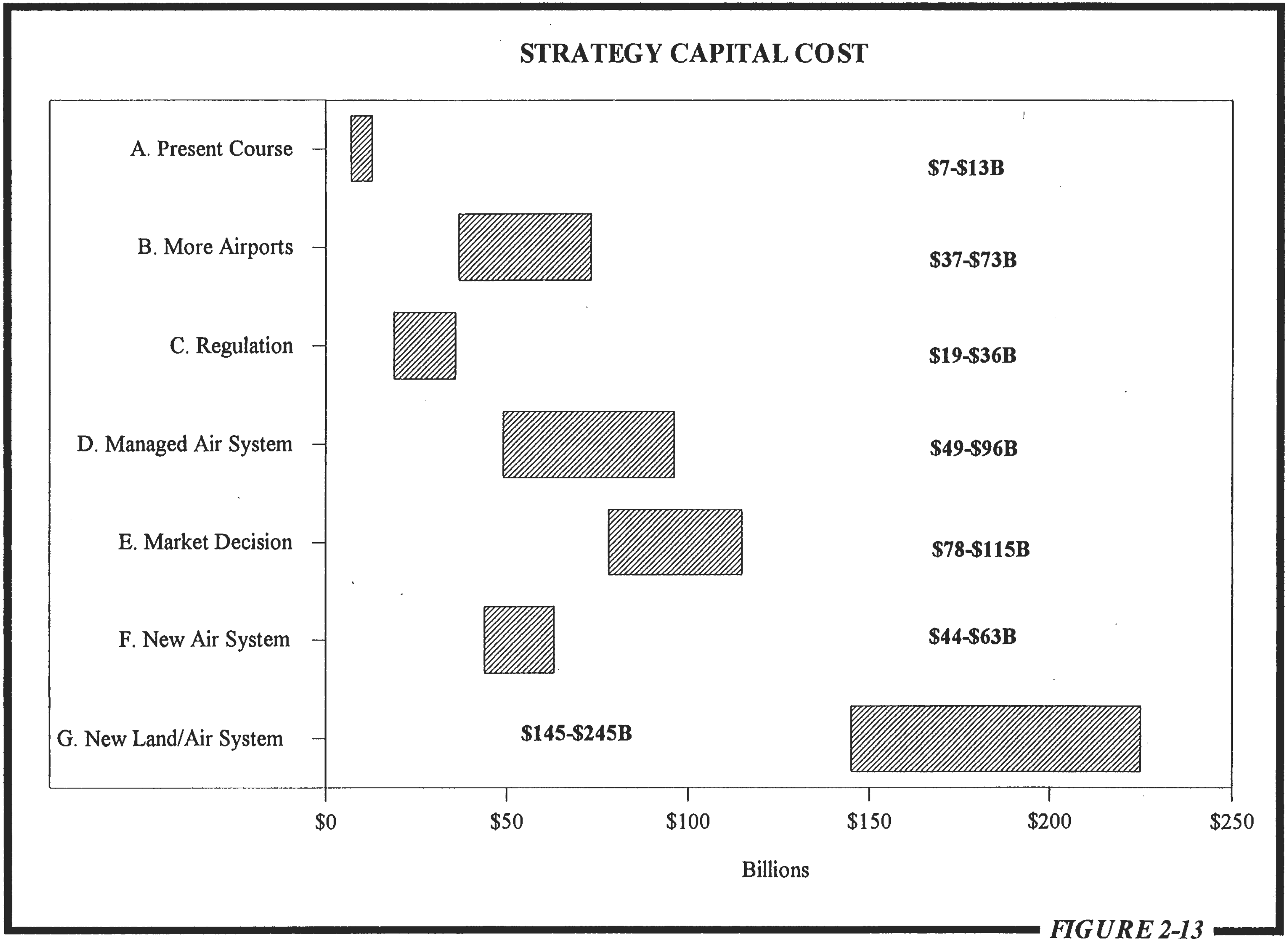

STRATEGY CAPITAL COST
A. Present Course
B. More Airports
C. Regulation
D. Managed Air System
E. Market Decision
F. New Air System
G. New Land/Air System
$7-$13B
$37-$73B
$19-$36B
$49-$96B
$78-$115B
$44-$63B
$145-$245B
$0
$50
$100
$150
$200
$250
Billions

FIGURE 2-13

on capacity, which directly influences congestion and delay. These benefits are summarized in Figure 2-14, Strategy Benefit.

2.2.2.3 Comments on the Report

Since this report was published in 1990, it did not have access to a regional approach to high speed ground transportation; consequently, most of the expertise is in the air mode.

It is clear, however, that congestion in the air system will continue to worsen and that new airports will be harder to build.

2.2.2.4 Pittsburgh International Airport Capacity Enhancement

Pittsburgh International Airport is the core of the regional MAGLEV system rendering capacity enhancement plans important. Forecasts according to Pittsburgh Aviation Facts, (1991-92) for the number of operations and enplanements are shown in Figure 2-15, Air Activity Forecast, for the years 1990, 1993 and 2003. Air freight movement forecasts are shown in Figure 2-16, Freight Movement.

The new Pittsburgh International Airport, operational for one year, is presently considering new runways (Airport Capacity Enhancement Plan, October 1991). At the projected level of operations for the year 2003, over 80,000 hours of operation delay will result if no runways are added.

2.2.3 HIGH SPEED GROUND TRANSPORTATION

For the purposes of this work, HSGT refers to systems with speeds of 150 MPH or higher. If the top speed of 125 MPH or higher were taken as the definition of HSGT, then AMTRAK's Northeast Corridor between Washington and New York would also qualify.

High speed ground transportation (HSGT) can play a large role in the future transportation system of the United States. HSGT consists of high speed rail,

STRATEGY BENEFIT

STRATEGY	BENEFIT
A. Present Course	Accommodates high growth to 2005
B. More Airports	Accommodates high growth to 2015 and economic difficulty to 2040
C. More Regulation	Delay 50% less
D. Managed Air System	Accommodates maturing economy growth to 2040
E. Market Decision	Same as B or D
F. New Air System	Accommodates highest demand
G. New Land/ Air System	Accommodates highest demand

FIGURE 2-14

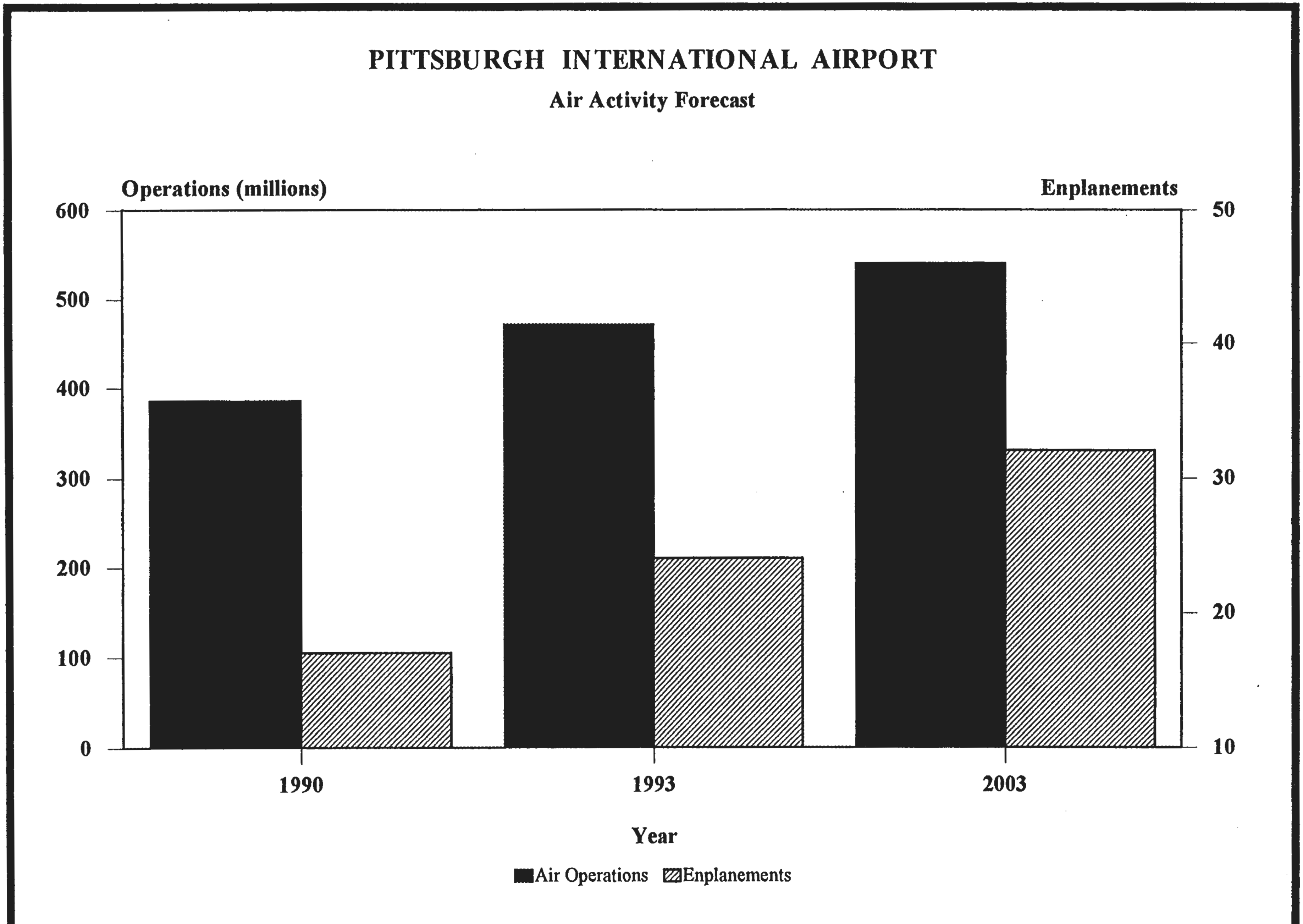

PITTSBURGH INTERNATIONAL AIRPORT
Air Activity Forecast
Operations (millions)
Enplanements
600
500
400
300
200
100
0
50
40
30
20
10
1990
1993
2003
Year
Air Operations
Enplanements

FIGURE 2-15

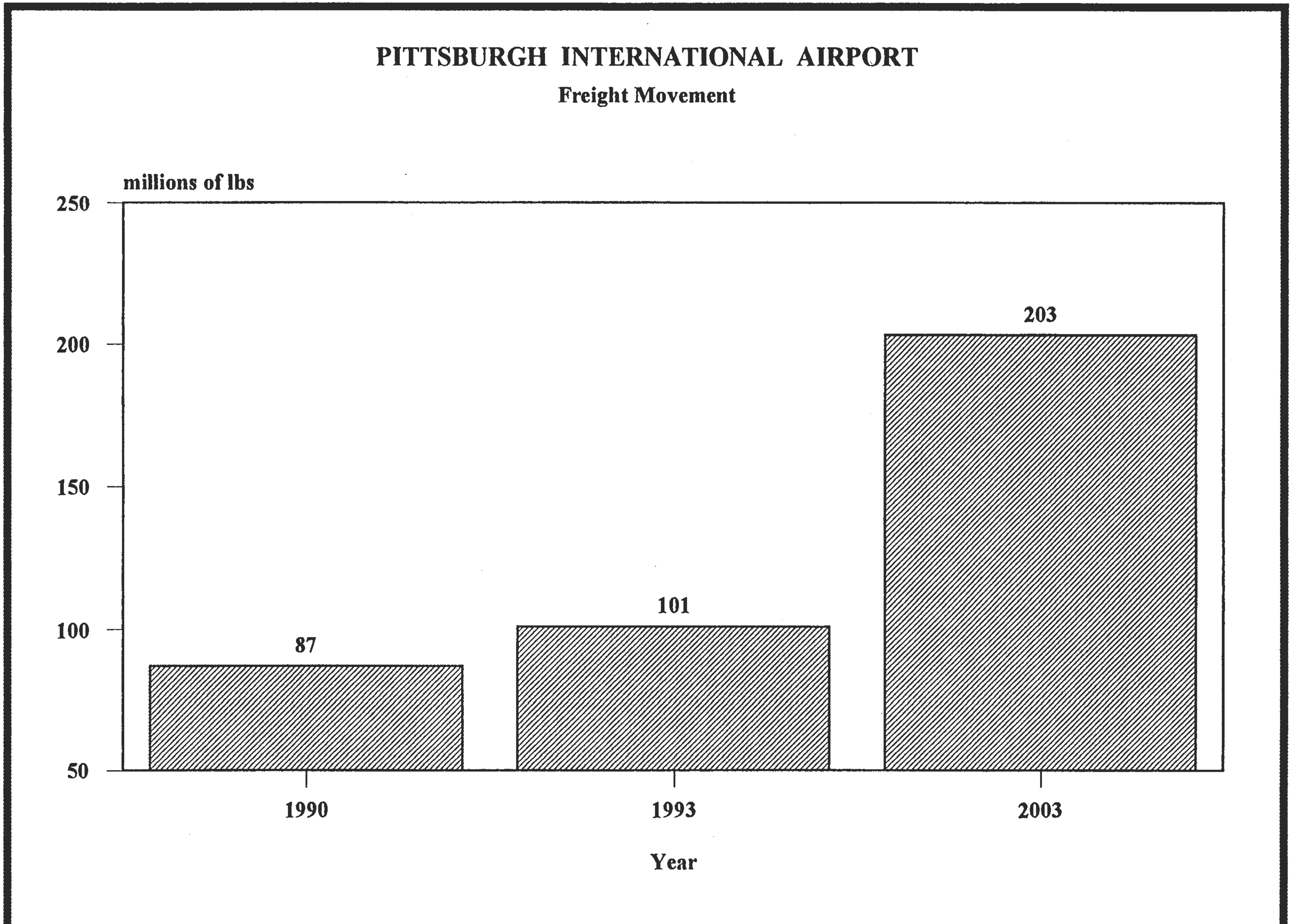

PITTSBURGH INTERNATIONAL AIRPORT
Freight Movement
millions of lbs
250
200
150
100
50
87
101
203
1990
1993
2003
Year

FIGURE 2-16

which is now in commercial service in Europe and Japan. High speed MAGLEV, in the prototype stage, is being developed in Germany and Japan.

HSGT systems which can link airports and metropolitan centers, with access to the urban and regional sprawl, may play a major role in helping to ease the worsening effects of the passenger transportation crisis in the twenty-first century. These systems can complement the air and highway modes, with proper interfacing.

Regional HSGT systems can utilize the airport of a major metropolitan area as a hub, and extend service to smaller cities or airports in the surrounding region. The hubbing concept now practiced at many of these major airports often can be handled more efficiently by HSGT freeing valuable airspace and airports for longer distance flights. As our economy becomes more strongly linked to those of other nations, demand for long distance and overseas flights will continue to increase rapidly.

Since regional HSGT lines will access the major airport through the suburban areas surrounding the major metropolitan airport, it is likely that these same lines can be used for suburban commuting and airport access on the ground side as well. Since the lines for the high speed regional service will be in place, the suburban commuter and airport access system can be obtained at a marginal capital cost increase over the regional system cost.

The nodes (stops) of these systems are prime candidates for more orderly economic development or redevelopment. Because the auto, taxi or feeder bus are the primary modes of transportation to the HSGT nodes, the interfaces must be well designed to accommodate the user.

Top speeds of the suburban commuter and airport access system are 150-250 MPH. Regional HSGT trains operate at these lower speeds while moving through the suburban areas as well. When outside of the urban areas, top speeds lie in the 200-300 MPH range.

The regional and suburban HSGT systems are further explained, conceptually, with the help of Figures 2-17, Conceptual Regional HSGT System, Regional Service, and 2-18, Suburban Service.

At the center of the regional HSGT system lies the airport and a major metropolitan area. The HSGT lines run outward connecting to smaller cities (either at airports or major highway junctions) and to adjacent major metropolitan airports and downtown's. The circled area shown in Figure 2-17 is the extent of the suburban HSGT system, which is detailed further in Figure 2-18. This system, which operates on the same regional high speed lines as shown in Figure 2-17, provides a HSGT commuter service for the urban sprawl of the major metropolitan area which includes the downtown, as well as an airport access system which is far superior to a congested urban highway system. The key to the success of such a system lies in the connectivity of the HSGT systems and the ability to provide an easy interface with the highway and air modes. All nodes, with the possible exception of the major airport and downtown, must have provisions for auto, bus, rail and taxi access, as well as major parking facilities.

Many of the nodes could handle baggage for the air carriers so that check-in could occur at the access node. The system could also carry high priority freight and mail similar to that now carried by airlines.

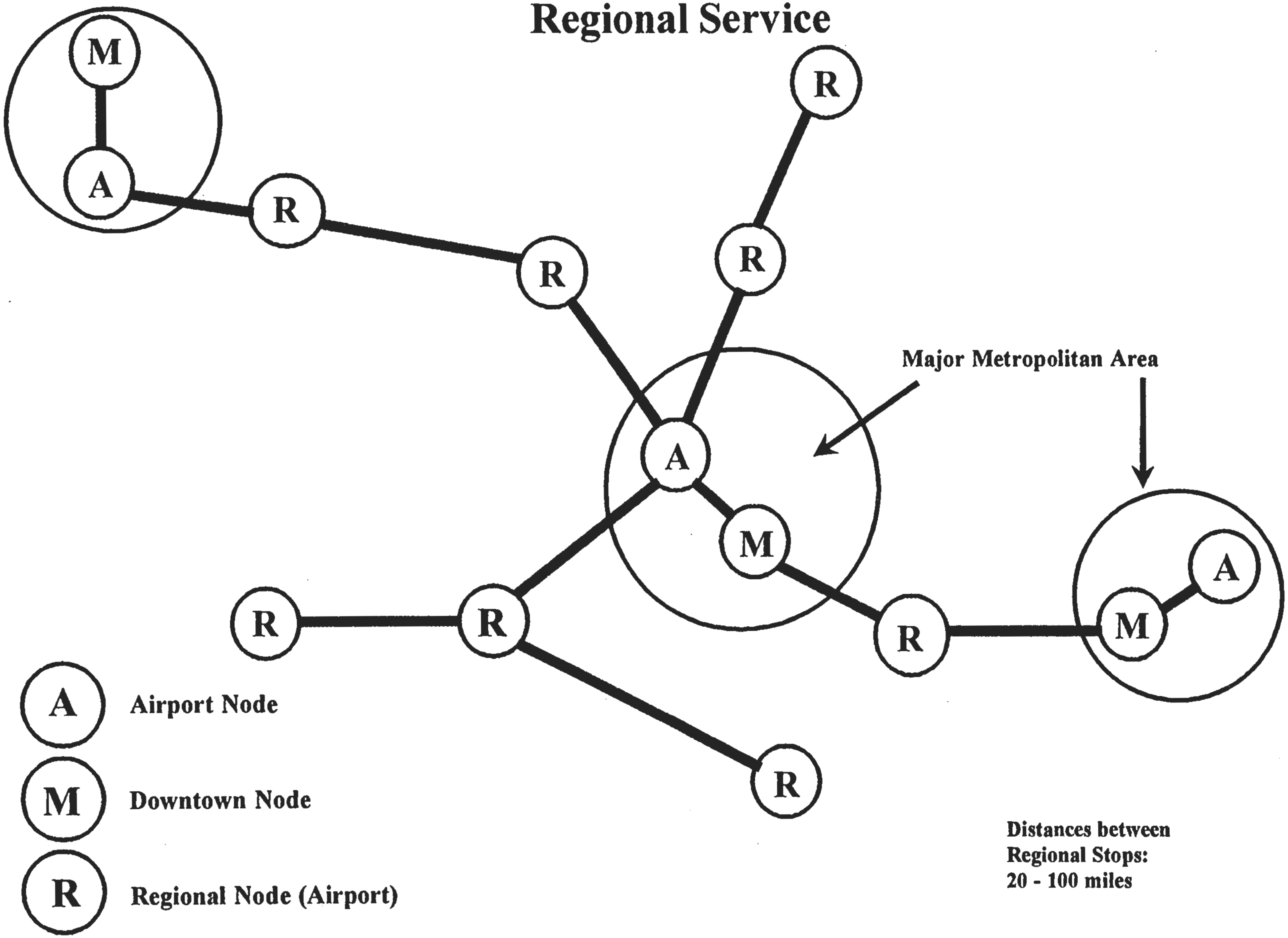
Although the regional concept is quite new, a network concept for HSGT, in which major metropolitan airports and their central business districts, are linked by HSGT, is being explored, MAGLEV Vehicles and Superconductor Technology: Integration of High-Speed Ground Transportation into the Air Travel System, (April 1989). These concepts are further developed in Section 2.3.1 and 2.3.2.

2.3 APPLICATION OF HIGH SPEED GROUND TRANSPORTATION

Before 1987, the traditional approach to deploying HSGT systems was city center to city center, where the cities were surrounded by large metropolitan areas with stops along the way. Although the routes followed railroads that presently existed, new right-of-way would be needed with the higher speed systems.

CONCEPTUAL REGIONAL HSGT SYSTEM

Regional Service



CONCEPTUAL REGIONAL HSGT SYSTEM

Suburban Service

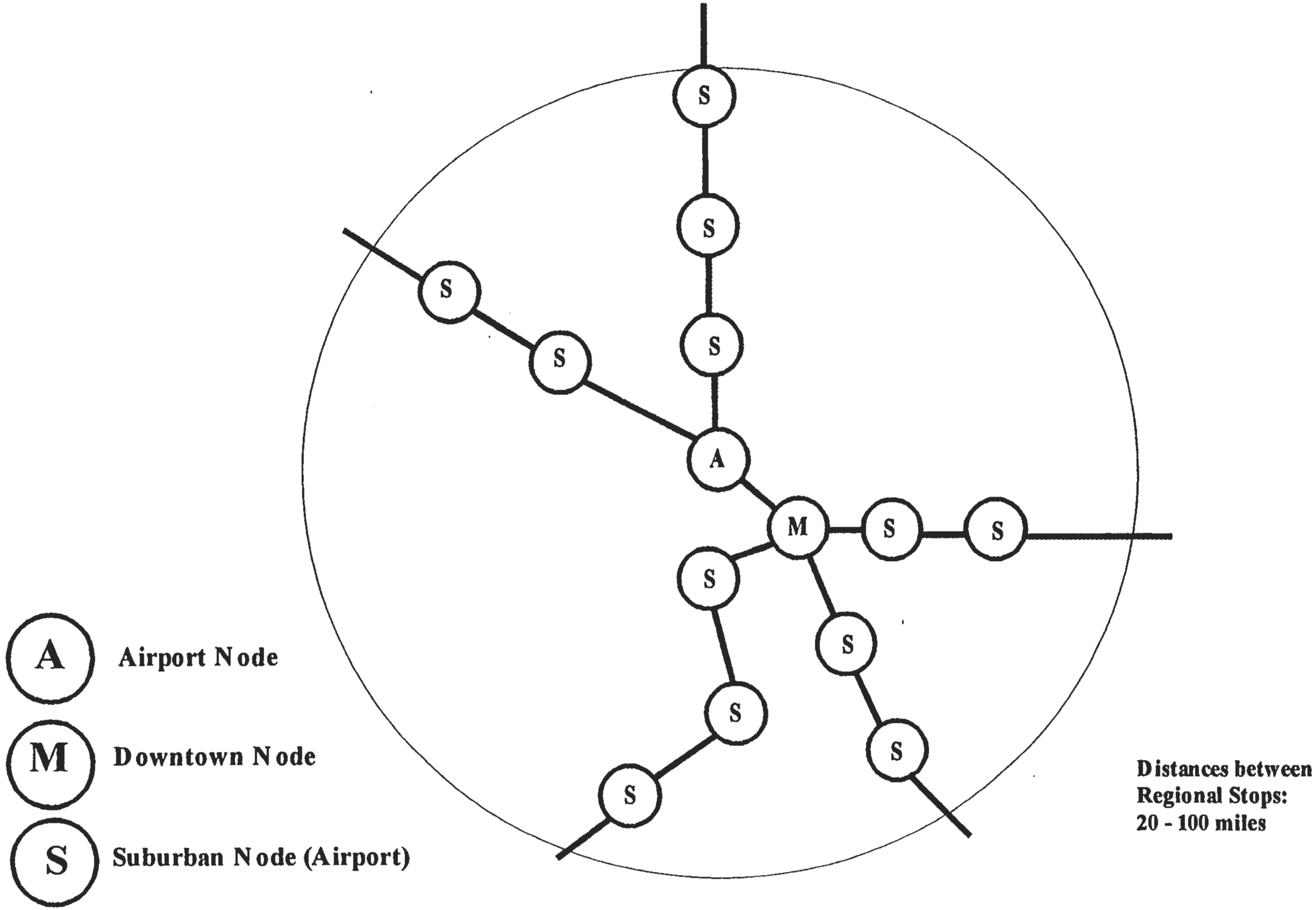


FIGURE 2-18

During these same years, technologies were also being proposed for airport access, from the center city to airport or airport to airport within short distances. These generally operate at lower speeds (150-200 mph) and were not linked with the intercity systems.

During 1987-88, two new approaches to HSGT were developed: the network approach and the regional approach. The network approach was proposed by Lawrence Johnson, MAGLEV Vehicles and Superconductor Technology: Integration of High-Speed Ground Transportation into the Air Travel System (April 1989) at Argonne National Laboratory and the regional approach was proposed by R.A. Uher, Statement of Richard A. Uher Before the Surface Transportation Subcommittee of the Committee on Commerce, Science and Transportation, United States Senate, (October 17, 1989, June 7, 1990) at Carnegie Mellon University. Each of these approaches is discussed separately.

2.3.1 NETWORK APPROACH

The network approach can be handled with any HSGT technology. However, when it was proposed, part of the proposal was to develop a MAGLEV system capable of top speeds of 300 mph. Figure 2-19, Conceptual Corridors for MAGLEV Systems, shows the latest version of the network presented in a 1989 paper by Lawrence Johnson, presented at the Ninth International Conference on High Speed Rail, Pittsburgh, PA (May 19, 1992).

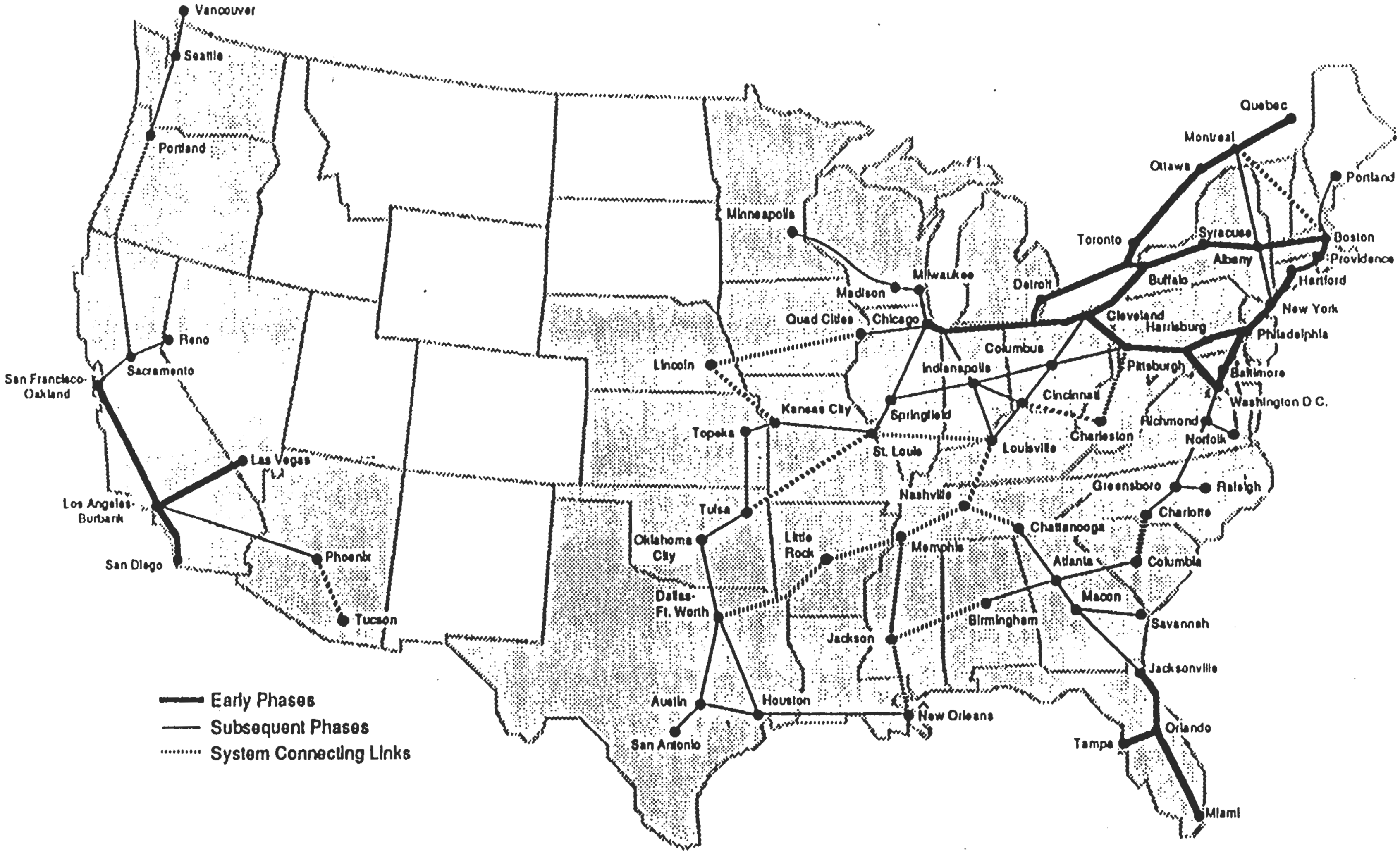
The basic idea is to connect airports and some regional stops in major metropolitan areas with HSGT lines, as shown in Figure 2-19. The markets to be served by this network lie between 100-600 miles where air travel is less efficient.

2.3.2 REGIONAL APPROACH

The regional approach to HSGT is based on the same hubbing concept used in the air system. The concept uses HSGT as an interface mode between the air and highway modes as to integrate all three modes to make them all more efficient.

High speed ground transportation systems, which can interface the airports with urban and regional sprawl, can meet the improved mobility need by providing

CONCEPTUAL CORRIDORS FOR MAGLEV SYSTEMS



(Extracted from Winglock: A Pot Pourri.of Thoughts Status of On-Going Work, L.R. Johnson, Argonne National Laboratory, presented at 9th International Conference on High Speed Rail, Pittsburgh, May 19, 1992)

FIGURE 2-19

alternatives and complements to the highway and air modes of travel (Uher, May 29-31, 1991). These systems can be used to control development, which in turn can reduce future infrastructure costs.

HSGT in the regional approach is in itself a mode which interfaces the other two modes: highway and air (Uher). Thus it is intermodal as well as modal. Initially, markets were assumed to be 100-600 miles apart based on a 2 hour travel time at 300 mph. Because average speeds of the system will probably be well under the 300 mph top speed (for MAGLEV), and because many of the spokes of the hub pass through mid-size cities where stops will be located, it is more likely that markets are in the 200-300 mile range.

2.3.2.1 Pittsburgh Regional System

Figure 2-20, Regional MAGLEV System, shows the Regional HSGT system concept. The system hubs out of the metropolitan area with two principal stops: the airport and downtown. Since the airport and downtown will ultimately be 10 minutes away, the downtown stop could function as an extension of the air terminal.

Figure 2-20 also shows a suburban system which is laid over the same regional lines. In all cases, the actual stops are off the main line with other arrangements made to intermix suburban, regional and intercity services. The services are as follows:

- Suburban
  Stopping at suburban and regional stops within the metropolitan area.
- Regional
  Stopping at all the major and intermediate stops within the region.
- Intercity
  Stopping at major city and airport stops within the region. An express regional service.

Concerning ridership, several kinds of trips must be considered.

- Major Airport Access
  Travel to a major metropolitan airport.
- Intercity Service Access
  Travel to a stop to access a HSGT regional express.
- Regional Service Access
  Travel to a stop to access the HSGT regional service.
- Suburban Commuting
  Travel between HSGT suburban stops within a major metropolitan area.
- Regional Commuting
  Travel between HSGT regional stops within the region.
- Intercity Travel
  Travel between HSGT major metropolitan areas (downtown and/or airport).

The intercity services shown on the regional system map of Figure 2-20 is the normal regional service, with all stops covered. The intercity service (regional express) will make very few stops.

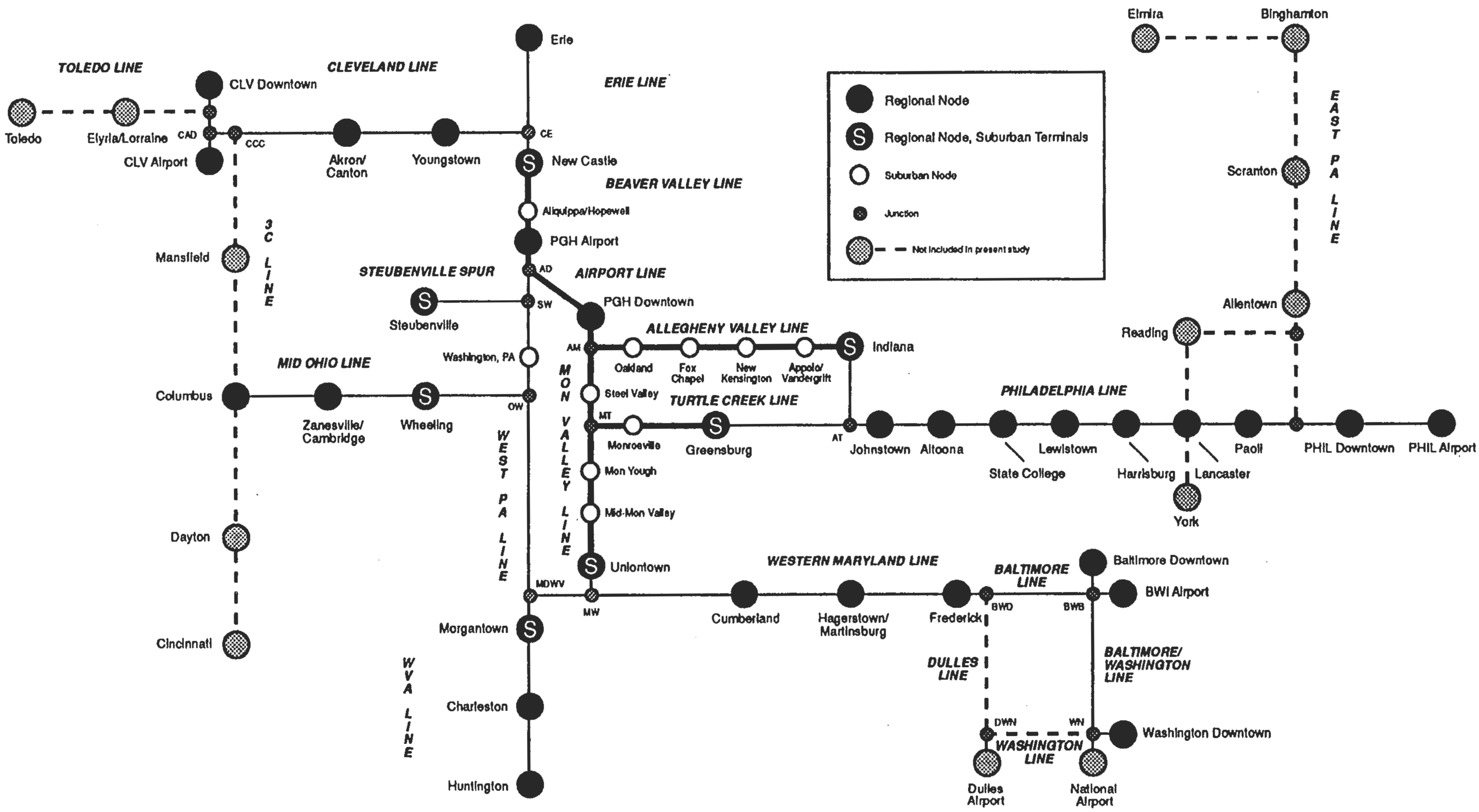
As previously indicated, a HSGT regional system will hub around a large metropolitan airport with spokes into the surrounding region. One scenario for building such a system is circular expansion. In other words, suburban service will be in place first, followed by an expanding regional service and then, finally, intercity service as the whole regional system is completed. Another scenario is to build one line at a time, initiating all three services simultaneously. Ultimately, economics may determine the final solution.

2.3.3 INTEGRATION OF HSGT WITH OTHER TRANSPORTATION MODES

2.3.3.1 Air Mode Integration

In order for HSGT systems of the future to attract high ridership, access between the HSGT mode and the air mode must be made as efficient as possible. The following goals lead to that efficiency:

Regional MAGLEV System
(Circa 2030)



(NOT TO SCALE)

- The physical proximity of the HSGT to the air terminal of the airport is important. Location of the stop inside the air terminal is the best case.
- Stops on the system will have baggage handling capability. Baggage is then checked from system entry to system exit, independent of the traveler's route (i.e. HSGT/Air/HSGT or HSGT entirely).
- Ticketing is integrated into the airline ticketing system so that origin to destination tickets can be issued.
- In the metropolitan area, one or more stops are designated as satellite air terminals of the major airport(s). These stops contain similar facilities such as ticketing, information services, and feeder services.
- As far as possible, regional stops outside the urban area should be close and possibly inside regional airports. (There is also a requirement that these stops be located near intersections or convergence points of major interstates or highways.)

2.3.3.2 Highway Mode Integration

Integration with the highway mode means providing quick and easy access to a stop with little impedance in transferring from highway to HSGT. The following goals can help to achieve this integration:

- Locate both suburban and regional stops near major roadways or major roadway intersections so that vehicle ingress or egress is simple and not congested.
- Design parking facilities with ease of transfer from highway mode to HSGT mode. Parking automation technology should be implemented where effective. (The cost of parking should be included in the fare structure.)
- Expand present car lease arrangements and rentals to include destination-end vehicles for frequent users.
- Devise planning and zoning to encourage development of major activity centers at HSGT stops. Integrate all modes of transportation into these stops.
- Integrate real time schedules of HSGT into the "smart" car of the future. This tells the rider how to opt for HSGT vs. the highway.

Most of the riders on any HSGT originate from highway modes. The more efficient the transfer zone is or is perceived between these two modes the higher the ridership on the HSGT mode.

2.3.3.3 Public Transportation

All public transportation access to the stop should be designed in such a way as to serve the stop in the best way without interfering with private automobile travel into the node.

Bus, taxi and paratransit service will be required. Public transit service should be scheduled together with the scheduling of the HSGT system to achieve maximum efficiency.

2.4 SUMMARY

With large expenditures in the highway and air modes of transportation, congestion continues to increase rapidly. Highway programs, which can mitigate congestion, cost $100 billion per year. Major air system programs, which can mitigate future air congestion, are expected to cost $44-63 billion; however, they do nothing for the congested trip to the airport.

HSGT systems, which interface the airports with highways and public transportation in city centers, may be the most cost effective solution to congestion mitigation, for travelers accessing major metropolitan airports as well as traveling regionally up to distances of about 300 miles. Building HSGT systems will entail capital costs of $200-250 billion over the next 40 years. By providing an uncongested mode of transportation, implementation of a HSGT system would greatly improve mobility and make intercity travel and trips to the airport more efficient.

3.0 HIGH SPEED GROUND TRANSPORTATION (HSGT) TECHNOLOGIES

High Speed Ground Transportation (HSGT) reflects all modes of inter-city transit traveling at speeds from 150 mph to over 300 mph with vehicles that operate on a fixed guideway or rail system. The two main categories of HSGT include High Speed Rail (HSR) and MAGnetic LEVitation and propulsion (MAGLEV) technologies. This chapter will describe several prominent HSR and MAGLEV systems either being developed or in operation worldwide.

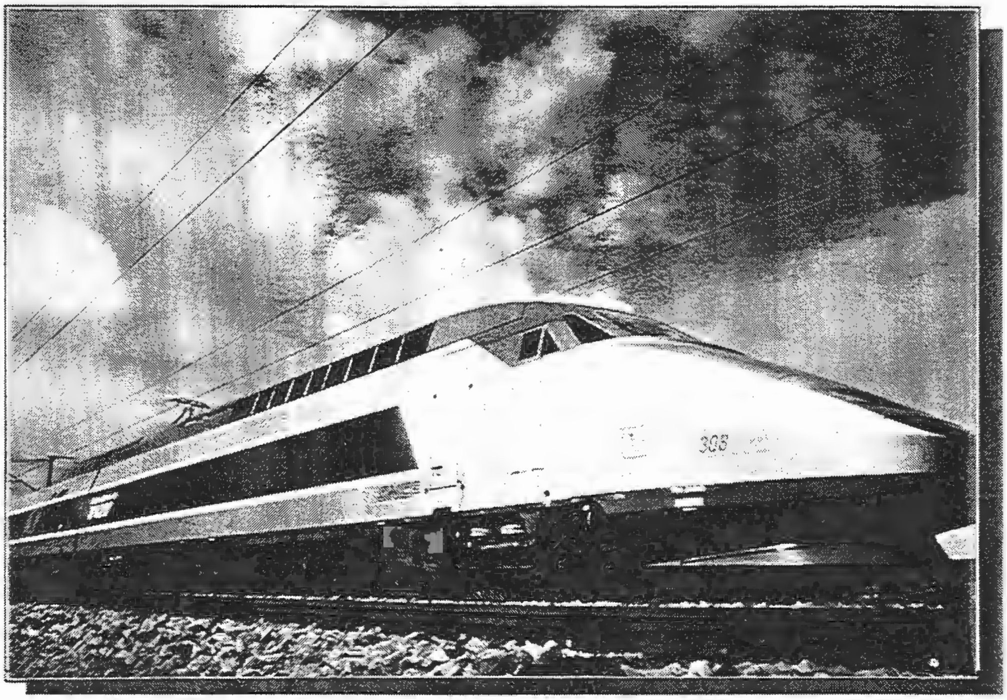
3.1 HIGH SPEED RAIL

HSR refers to steel wheel on steel rail with top speeds above 150 mph. This section will describe four of the foremost HSR systems operational today. Most of this information was obtained from three Federal Railroad Administration reports: Safety Relevant Observation on the TGV High Speed Train (July 1991); Safety Relevant Observations on the ICE High Speed Train (July 1991); and Safety Relevant Observation on the X2000 Tilting Train (March 1991). The Shinkansen section, Section 3.1.4, was based largely on a technical transmittal received from Mr. Tetsuya Fukunaga of the Long-Term Credit Bank of Japan, Ltd.

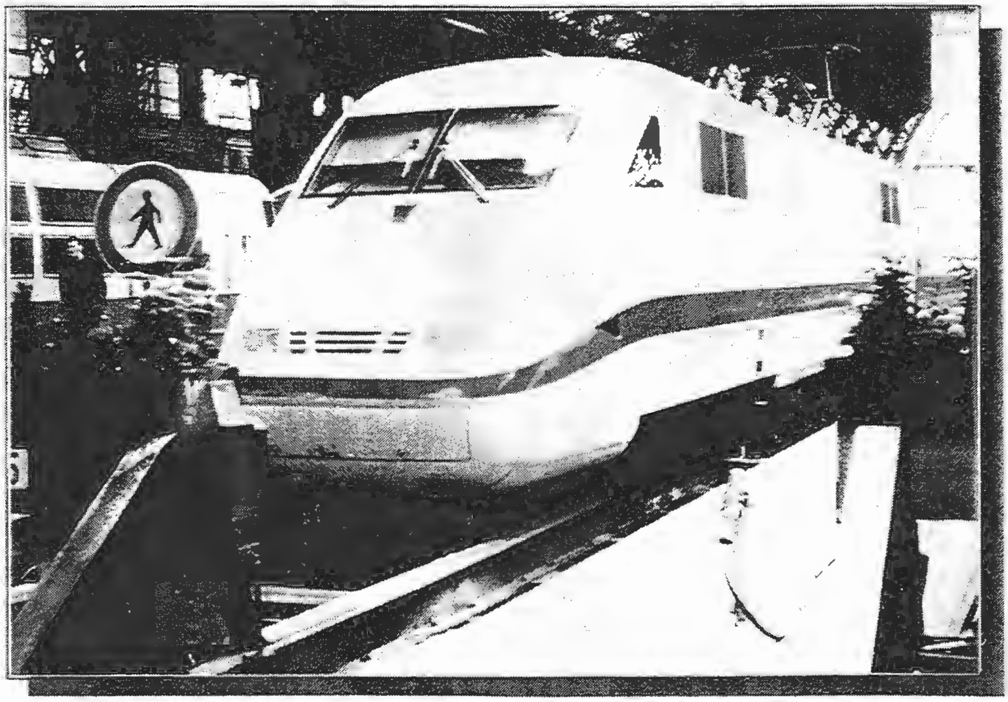
3.1.1 TGV ATLANTIQUE

The TGV (Train a Grande Vitesse or train with great speed) has been under development since the 1960's in France. The South-East line was the first TGV line to begin operation in 1981 with a maximum speed of 168 mph. Since then the Atlantique West and Southwest branches opened in 1989 and 1990, respectively, with top operational speeds of 186 mph. A specially modified TGV train holds the HSGT speed record with a trial run of 320 mph on May 18, 1990. Commercial service is unlikely to be run at this top speed.

The TGV Atlantique trains proposed for operation in the Texas project (described in Section 4.2.6) include eight articulated passenger cars between two power cars. This configuration allows for 317 passenger seats with a total train weight of 461



TGV
(France)



ICE
(Germany)

tons. The right-of-way (ROW) width is typically 100 ft for double-track operation. To reduce wear on the track structure and also to produce an acceptable ride quality, the minimum horizontal curve radius is kept above 14,500 ft. Vertical curves are similarly limited to 51,840 ft for crests and 43,300 ft for sags. The TGV is capable of climbing 3.5% grades (3.5 ft of rise for 100 ft of run). The French National Railway (SNCF) recommends fencing the entire length of any high speed passenger dedicated ROW.

Power for the TGV Atlantique system is supplied from the main power grid at 220 or 400 kV. A single phase feeder is split off of this supply line and delivered to each substation, where one of two redundant transformers is used to reduce the voltage to the catenary level of 25 kV. All voltages are at commercial frequency.

The TGV Atlantique trains are propelled by eight three-phase alternating-current (AC) synchronous motors each rated at 1475 hp. While the TGV Atlantique motors actually weigh less than their TGV South-East counterparts, they develop twice the power, enabling the reduction in required motors from 12 to 8.

One 1500 V and two 500 V DC lines, as well as two three-phase 480 V AC, 60 Hz lines are produced by the power cars to provide for the train's non-propulsion needs (heating, lighting, air-conditioning, etc.).

The braking system utilizes rheostatic, pneumatic and electro-pneumatic braking components. The rheostatic brakes utilized on the TGV Atlantique are considered fail-safe since on-board battery back-ups are maintained in case a loss of catenary power occurs. For normal operation conditions, the braking distance for a TGV Atlantique train initially traveling at 186 mph is 2.2 miles, whereas the maximum stopping distance under non-ideal conditions is taken to be 2.8 miles.

The status of the route as well as vital system information is provided to the operator via an automated cab signal system. Information provided to the operator via the cab signal system includes the train speed, allowable current and next block speed, pantograph condition and absolute stopping location. Intrusion detection devices tied into the signal system are deployed at locations where foreign objects are more likely to enter the ROW (such as at bridges that cross over the high speed system).

A computer monitoring system continuously reports performance of all vital components, and an inspection of vital safety functions is completed after each trip to Paris. Most major system components are inspected at least every 72 days. Equipment modularization significantly reduces maintenance costs.

Further research is currently being performed to develop the third and fourth generations of the TGV (TGV Atlantique is considered the second generation).

The TGV third generation will be a double-deck configuration with a targeted maximum operating speed of 199 to 211 mph. These trains will be able to transport passengers and their automobiles to their destinations, and are envisioned to be used extensively on the France to England Eurotunnel line.

The fourth generation TGV concerns a research program aimed at developing a train with a maximum operating speed of 217 mph. Work on this project centers on development of an eddy current linear magnetic brake for high speed slow-down that is not limited by the wheel/rail contact adhesion.

3.1.2 GERMAN INTER-CITY EXPRESS

The German Federal Ministry for Research and Technology (BMFT) invested over $300 million on railroad technology leading to development of the Inter-city Express (ICE) between 1972 and 1991. The goal of this work was to develop a high speed system that could operate both passenger and freight trains on upgraded and dedicated track. In 1984 the 120 class train set a speed record of 165 mph. In 1988, traveling on a dedicated high speed line, the ICE prototype also set a speed record of 252 mph. By 1991, the German Federal Railway (DB) had established over 311 miles of 137 mph track and 249 miles of 155 to 186 mph track.

The ICE train proposed for the Texas project reflected seven passenger cars with 378 seats between two power cars, but the two ICE power cars can handle as many as 14 intermediate passenger cars offering 840 seats. The total train weight for the proposed Texas train is 559 tons. The ROW width for the Texas project was typically 100 ft. To reduce wear and achieve an acceptable ride quality at the top operating speed of 200 mph, the horizontal curves were kept at a minimum of

14,173 ft for ballast track and 13,222 ft for slab track. To enable high speed operation through these curves, a maximum super elevation (the raising of the outside rail with respect to the inside rail) of 7.87 inches was permitted. The minimum radius for vertical curves at top speed was 52,000 ft for crests and 46,000 ft for sags. While the recommended maximum grade is 1.5%, an occasional grade of 4.0% is acceptable.

The ICE is powered by eight AC asynchronous four-pole squirrel cage induction motors each having a continuous power rating of 1609 hp. The operational power factors for these motors range from .8 to .9. Two pantographs (one on each power car) are used to draw power from the catenary under 174 mph, while only one is used above this speed due to catenary/pantograph dynamics.

Secondary windings on the main power car transformer provide auxiliary power at three different voltages: 885 V, 200 V and 1000 V. The 885 V is modified to produce three-phase AC power for the power car's motor needs (fans, compressors, etc.). The 200 V supplies low voltage auxiliary loads and recharges a battery supply used for safety related purposes. The 1000 V is used for heating, lighting, air-conditioning, etc.

The ICE braking system is comprised of electro-pneumatic and pneumatic friction disc brakes, dynamic regenerative brakes and electromagnetic rail brakes (which can potentially be modified to allow eddy current braking). All the braking systems interact with the anti-slide systems designed to ensure maximum braking while avoiding wheel sliding. While the friction disc brakes are typically controlled electro-pneumatically, during emergency situations they can be pneumatically operated. If the overhead catenary is receptive, the traction motors can simulate induction generators during regenerative braking. The power produced during regenerative braking is modified to be compatible with the catenary, and is returned to the grid. The normal operation braking rate from top speed is 1.1 mph per second or mphps, while the emergency rate is 2.9 mphps.

Computers and micro-processors continually monitor all safety-related components. Three different means to control train speed are available: fully automated speed control, manual speed selection and full manual operation. Inductive loops 9.84 ft., are installed inside each track to allow for continuous automatic train control. Due to the safety-related data being transmitted via the inductive loop system, wayside signals are generally omitted. Safety-relevant information supplied at least every second to the train from the wayside includes the distance to the next required stop, the braking curve utilized, line gradient, target distance and speed restrictions. Safe route control is ensured via audio-frequency track circuits. A central control location monitors the ICE train operations, but regularly scheduled traffic is handled automatically unless disturbances occur.

The ICE also has on-board diagnostics that check the status of all vehicle equipment. Any discrepancies are relayed to the maintenance facility, which prepares for reparations to the train before it arrives. Trains are also sent through a self-test procedure before being dispatched to improve train reliability.

3.1.3 ABB X2000

The Asea Brown Boveri Traction AB (ABB) X2000 train is a concept which utilizes an active tilting passenger compartment combined with self-steering trucks to allow significant speed increases while traversing horizontal curves. The effect of tilting the cabin is to offset the lateral acceleration felt by the passenger, while the self-steering truck reduces the wheel-rail force.

The primary market for this technology is for locations where speed upgrades between cities are necessary to attract riders but availability of new ROWs and/or cost of constructing entirely new ROW are prohibitive. Through the advanced design features implemented by ABB, the X2000 train is able to reduce travel times on slightly modified existing tracks by as much as 30%.

Development of the X2000 began in 1970 with a research program addressing the tilt train and self-steering truck technology. Between 1975 and 1982 a series of truck designs and tilt mechanisms were tested on an experimental train, the X-15. Tests were also performed to ensure that no adverse passenger reactions occurred as a result of the active tilting. By 1986 the development of the system was complete and the Swedish State Railways (SJ) ordered twenty X2000 trains. The first X2000 began operation on the Stockholm to Gothenburg line in 1990. The train was also tested on AMTRAK's Northeast Corridor.

The ABB X2000 train is typically a power car followed by four passenger cars and a driving trailer. Given this configuration, the total train weight is 380 tons and provides 268 seats. The maximum speed attained by the X2000 on the SJ system is limited to 130 mph, but the modified X2000 proposed for the Florida system is to travel at 150 mph.

Since the system is envisioned to operate over existing tracks, the on-board traction equipment will be modified to be compatible with the existing power distribution system.

The ABB X2000 trains utilize four 1100 hp three-phase AC asynchronous gate turn off (GTO) thryristor controlled motors. Two motors comprise an individual power module. The train can provide full speed with the loss of one power module, but acceleration is degraded. During braking the motors can be reversed to generate power that can be fed back into the overhead catenary system. The power factor throughout the operating speed range is near unity, resulting in better energy utilization.

Inverters located in the power car produce the 360 kW, 380 V, 50 Hz three-phase power used for non-traction purposes such as heating, lighting, air-conditioning, etc.

The ABB power car employs electro-pneumatic air and dynamic regenerative brakes, while the non-power cars utilize electro-pneumatic air and magnetic track rail brakes (the latter only used during emergency braking). The power car can only make use of the regenerative braking capability when the catenary line is receptive. The X-2000 can reach zero speed from 125 mph in .90 miles during normal operation and .68 miles during emergency braking.

The X2000 uses master and slave computers for various train functions. The master computer, located on the power car, controls the braking system, cab control and the converter control. The slave computers monitor and adjust the train tilting, maintain the automated braking portion of the brake system and transmit train operator commands.

3.1.4 SHINKANSEN 300 SERIES

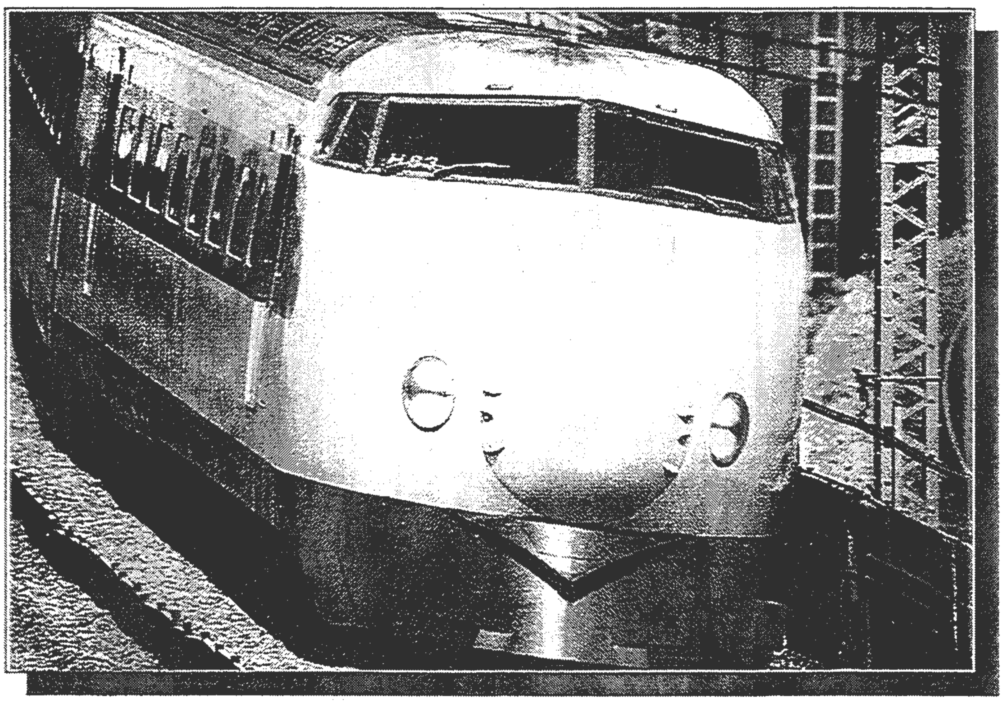
The Japanese Shinkansen was a precursor to HSR, with its original Series 0 cars beginning operation in 1964, at a maximum speed of 130 mph, between the two major cities of Tokyo and Osaka. Since then the Japanese have continued to develop their technology, and this work has culminated in the Series 100 and Series 300 cars. The Series 300 cars are the latest Shinkansen cars, and are the result of a major research and development program begun in 1988 by the Japanese Group (JR) Tokai. These trains are capable of speeds up to 168 mph, and enable trip-times between Tokyo and Osaka of under two and one-half hours. The Series 300 cars were subjected to a thorough two-year test program designed to verify that the noise, vibration, reliability and safety parameters were all within acceptable limits.

The Series 300 utilizes 10 motor cars with 6 trailers with a resultant total train weight of 783 tons. This configuration allows 1,123 second class and 200 first class passengers. This train is able to accelerate at the rate of .99 mphps.

The Shinkansen draws its power from an electrical system at 25 kV commercial frequency. Each of the 10 motor cars is equipped with four motors. The motors use a forced ventilation system and are three-phase AC asynchronous induction motors, each with a rating of 300 kW to produce a total train power of 12,000 kW. The power control is a variable voltage variable frequency system. When in a braking mode, the motors can be reversed to convert kinetic energy into electrical energy which can be returned to the system and utilized by other trains.

The introduction of the Series 300 has incorporated significant advances over the previous Shinkansen Series 100. While the Series 300 actually carries more passengers than the Series 100 (1323 vs 1321), the increased rating of the AC motors has enabled a reduction in the number of motors from 48 to 40. The motor reduction coupled with the aluminum body design has resulted in a 25% weight reduction from the Series 100 to the Series 300.

The Series 300 cars use two pantographs to collect the power from the catenary. The lighting, heating and air-conditioning needs of the Series 300 cars are met with two AC lines (100 and 440V) and one 100 V DC line.



Shinkansen
(Japan)

Several braking systems are employed on the Series 300 cars. The trailer cars are equipped with eddy current brakes. The power cars make use of electrically-controlled air brakes, as well as using the regenerative braking feature previously mentioned. A brake control system was developed that adjusts the braking rate to keep within the allowable limits based on the adhesion of the wheel-rail interface.

A redundant double-frequency automatic train control system is used to monitor and control operation of the trains throughout the system.

In March 1993, JR Tokai inaugurated hourly service between Tokyo and Osaka using 15 Series 300 trainsets, and this services was extended to Hakata.

3.2 HIGH SPEED MAGLEV

MAGLEV refers to transportation systems that run on fixed guideways and utilize magnetic forces to levitate or raise the vehicles. Levitation can be accomplished through either repulsion or attraction forces. MAGLEV systems use linear induction or linear synchronous motors for propulsion, and the active part of the motor can either be part of the vehicle (short stator) or part of the guideway (long stator). The main advantages of the long stator design are that their vehicles do not require contact power pick-up and also that the motor sections can be individually sized to ensure an adequate amount of power is available for the vehicle at all times. The primary advantage of the short stator system is the cost reduction associated with elimination of the stator cable windings that must run the length of the system for long stator systems. A power collection system is required. However, this will limit the top speed to 200 mph due to the requirement for contact propulsion power pick-up.

Since there is no contact between the vehicle and the guideway during operation, the resistance to movement (and consequently the energy consumption) is primarily due to air drag and the maintenance costs are anticipated to be low when compared to HSR. MAGLEV systems are typically categorized by the method of levitation used, either electromagnetic or electrodynamic.

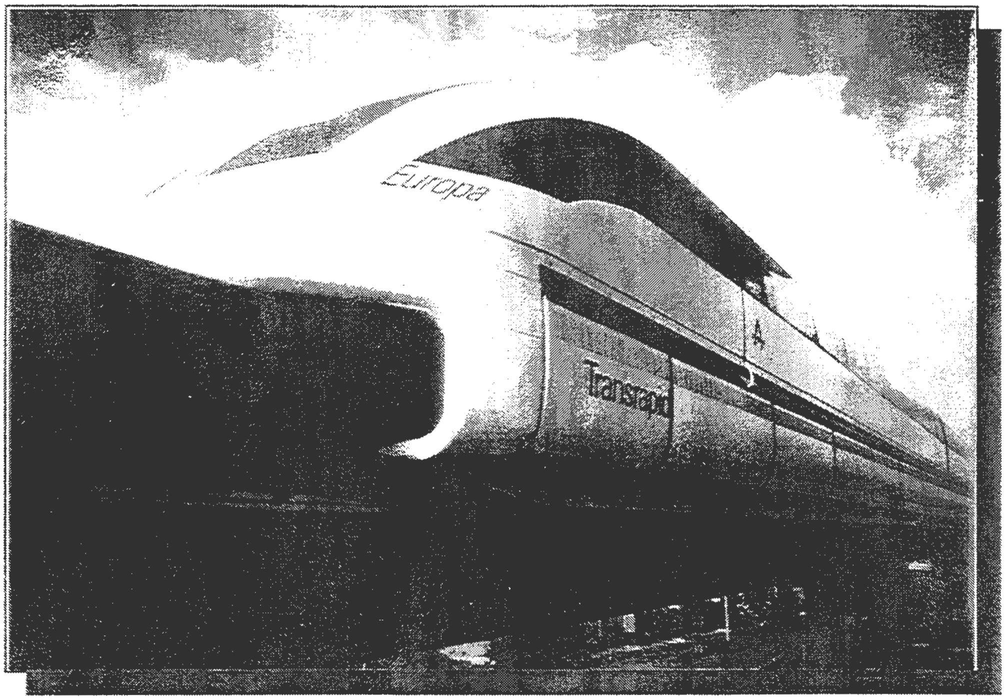
Electromagnetic suspension (EMS) systems utilize electromagnets located on-board the vehicle that are attracted to ferromagnetic materials on the guideway for their levitation, and are thus known as attractive MAGLEV systems. EMS systems must be actively stabilized. These systems must employ a feedback control loop that monitors the air gap and adjusts the power fed to the electromagnets so as to maintain the approximate 0.4 inch air gap.

Electrodynamic systems (EDS) use super conducting magnets on board the vehicle to develop large magnetic fields that interact with coils imbedded in the guideway. At speeds around 60 mph these coils develop enough induced current to produce a repelling magnetic field that raises the vehicle approximately 4 inches off the track. Below lift-off speed the vehicle runs on wheels which are retracted after levitation.

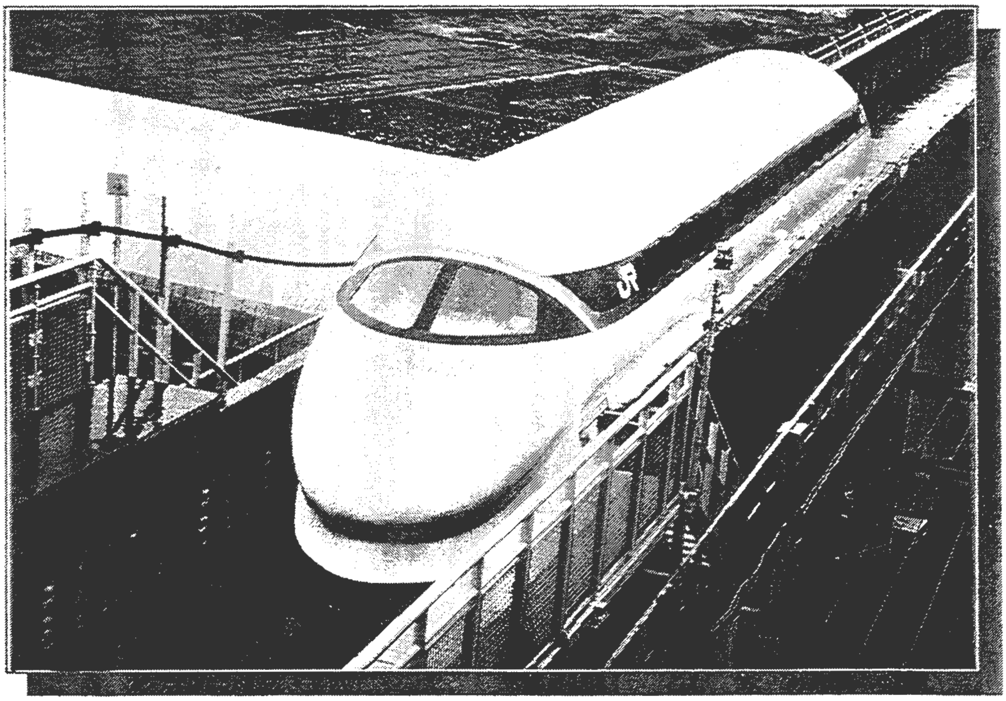
A discussion of the three furthest developed high speed MAGLEV systems is given below. A large portion of this information was derived from the following sources: the Transrapid MAGLEV System (1989); the FRA's Assessment of the Potential for Magnetic Levitation Transportation Systems in the Unites States (June 1990); and the Transportation Research Board's In Pursuit of Speed (1991).

3.2.1 TRANSRAPID

Development of a German MAGLEV system began in earnest around the late 1960's. MBB and Krauss-Maffei were given responsibility for development of an EMS system, while AEG, BBC and Siemens worked to produce an EDS system. In 1969 Krauss-Maffei produced the first working model of an EMS system, and in 1971 MBB constructed the first MAGLEV vehicle. In 1974 Krauss-Maffei was able to attain a speed of 125 mph with a short stator vehicle designated Transrapid 04. The first passenger MAGLEV vehicle was constructed by Thyssen Henschel in 1976 with a top speed of 22 mph. In 1977 the German Ministry for Research chose the EMS system over the EDS system, primarily due to the lower costs, reduced energy consumption, lower electromagnetic fields (EMF) and lack of need for landing gear associated with the EMS system. At the 1979 Transport Exposition in Hamburg, the Transrapid 05 carried 50,000 passengers on a 2953 ft guideway that allowed a top speed of 62 mph. Between 1979 and 1984 the first 12.7 miles of the Emsland Test Facility was constructed and shortly after this the Transrapid 06 (TR-06) vehicle began making runs on this track. By 1987 the 6.6 mile South Loop was completed. In 1989 the prototype



Transrapid TR-07
(Germany)



JNR MLU002
(Japan)

service vehicle Transrapid 07 (TR-07) was delivered, and in July 1992 it attained the highest speed to date of 280 mph on the test track.
The Transrapid system utilizes EMS for both levitation and guidance, and employs a long stator linear synchronous motor to attain its top operational speed of 311 mph. Above 62 mph the vehicle's auxiliary power (lights, heating/cooling, etc.) is entirely supplied by an electromagnet secondary winding that acts as a linear generator. Below 62 mph the linear generator is augmented by four 440 V on-board battery banks, which are charged by the linear generators when the vehicle is traveling at higher speeds.

The electrical distribution equipment utilized at the Transrapid test facility located in Emsland receives power from the public grid at 110 kV at commercial frequency. This power is first transformed to 20 kV, and then is sent through two rectifiers for a DC output of 1.2 kV. Two pulse-width modulated inverter systems take this power and produce an AC output ranging from 0 to 2027 V and 0 to 215 Hz. At motor frequencies above 55 Hz, an additional output transformer is needed to enable sufficient motor current by raising the output voltage to a maximum of 7800 V. A six-section TR-07 train keeps a motor efficiency and power factor of approximately .9 when traveling at 248 mph.

Each TR-07 section has a length of 84 ft, weighs 50 tons, holds 17.5 tons of cargo and can carry between 72 and 100 people depending on the cabin configuration. The maximum number of sections per train during revenue operation will be limited to 10. The maximum operational speed of 311 mph requires a horizontal radius of 21,425 ft when the guideway is banked at 12 degrees. The system is also capable of climbing 10% grades.

The Transrapid vehicle utilizes sixteen suspension and twelve guidance electromagnets. The suspension magnets also act as the synchronous magnets of the motor, and the distribution of these magnets along the entire length of the vehicle minimizes the force per cross-sectional area seen by the guideway, although the force is transmitted through the bolts holding the stator packs to the guideway. A sophisticated feedback control system monitors and maintains the 0.39 inch air gap between the vehicle's electromagnets and theguideway stator packs by modifying the current sent to the electromagnets. The vehicle shell utilizes aluminum and fiberglass to attain its high stiffness and low aerodynamic drag.

The Transrapid system uses three separate methods for braking the vehicle. The primary braking system involves reversing the current fed to the linear motor, thus producing a reverse thrust. The second braking method makes use of the electric drag generated by inducing eddy currents in the guide rails via the guidance magnets. This method is only effective above speeds of approximately 31 mph. During emergencies the train is slowed to near 30 mph through the use of eddy currents and aerodynamic drag, at which time the power to the suspension magnets is removed and the vehicle settles onto the low-friction skids, which brings the train to a comfortable stop.

The exceptional ride quality of the Transrapid system is achieved via two separate systems. The stiff primary suspension system is provided by the eight support magnets located on both sides of the vehicle, while the soft secondary suspension is supplied by sixteen pneumatic springs mounted between the levitation bogie and the vehicle.

The guideway is comprised of T-shaped steel beams supported by concrete columns. Attached to these beams are several functional components, including a long stator motor, guidance rails and low-friction skids. To minimize the cost of guideway construction, a computer integrated manufacturing process is implemented whereby the measurements taken at the construction site are input directly to the beam fabrication equipment.

Transfer from one guideway to another is accomplished using a bending steel beam switch. The bending of the steel beam is attained through the use of electro-mechanically or hydraulically actuated drives.

The signal and communication system employed by Transrapid entails a block-controlled, slotted wave guide system that involves information exchange at three levels: the vehicle, the decentralized wayside and the centralized wayside. The traffic control center monitors operational status, evaluates timetables and determines any required modifications to current operations.

3.2.2 JAPANESE NATIONAL RAILWAY CHUO LINEAR TRAIN

Development of the Japanese National Railway (JNR) Chuo Linear Train (CLT) began in the early 1960's with research on linear motor propulsion and levitation. In 1972, the JNR succeeded with test runs of both a linear synchronous motor (LSM200) and a linear induction motor (ML-100). In 1975 the JNR was able to achieve a speed of 37 mph with a test vehicle, (Underground Space, 1991/1992). In 1977, experiments began on a test track built in Miyazaki on the island of Kyushu. On this track in 1978, an unmanned vehicle attained a speed of 216 mph, and in 1979 a speed of 321 mph was reached, (RTRI Linear Motor Car MAGLEV, 1988). In 1979, the JNR also tested a helium refrigeration unit on-board the vehicle and simulated operation in a tunnel. The MLU001 test vehicle began operation on the newly constructed U-shaped test guideway in 1980, and manned test runs began in 1982. In 1983 a speed of 219 mph was attained with a three-vehicle train. In 1987 the MLU002 test vehicle began operation. Over 25,000 miles have since been logged on the Miyazaki test track. Currently, a $2.5 billion, 26.7 mile test facility is being built in the Yamanashi prefecture. This facility will enable the high speed testing that was impossible to perform at the Miyazaki test track, and will eventually be incorporated into a revenue line servicing Tokyo to Osaka.

The JNR CLT is an EDS system that uses superconductivity for levitation and a long stator linear synchronous motor for propulsion to attain its top operating speed of 311 mph. As the car accelerates, the superconductors induce eddy currents in the guideway coils that above 63 mph cause the vehicle to raise off the guideway about 4 inches. Below lift-off speed, the vehicle rides on retractable rubber wheels. The power for the super conducting magnets as well as the cryogenic cooling system is obtained from on-board batteries. Mutual attraction and repulsion between the super conducting magnets and the propulsion coils in the U-shaped guideway center the vehicle and restore it from any lateral deviation.

Superconductivity is the process whereby certain metals offer essentially no resistance to current when kept at temperatures near absolute zero. Therefore, the use of superconductors allows the generation of large currents (and consequently large magnetic fields) with relatively small amounts of power. The future JR* CLT revenue system is expected to need a 50 MW substation every 18 to 31 miles, which would enable operation of ten 14-car, 950 passenger revenue trains. JR is currently testing whether cyclo-converters or converter-inverters will provide the optimum method for producing the variable-frequency power needed for propulsion.

While the current and previous versions of the CLT placed the null-flux levitation coils on the bottom of the guideway, JR has stated that future versions will re-locate these coils onto the side of the guideway. This new configuration will offer a tighter suspension, a lower lift-off speed and a higher lift-to-drag ratio than the previous versions. It is likely, though, that a tighter suspension will necessitate development of a secondary suspension system.

There are four niobium-titanium alloy super conducting coils located in the corners of each of the vehicles. This location is advantageous in that the magnetic exposure of the passengers can be shielded and minimized. This also has the unfortunate effect of reducing the degrees of freedom of the vehicle, and thus makes it more difficult to produce an acceptable ride quality.

The cryogenic system cools the superconductor trains of a closed-helium gas system with an on-board Claude cycle refrigerator and a backup ground system.

The CT vehicle is designed to minimize the cross-sectional area and is made of carbon-fiber-reinforced-plastic and aluminum alloy to reduce the weight. The aerodynamic drag associated with the revenue vehicle is expected to be only 38,000 pounds at 311 mph.

The CLT employs three independent braking systems, including regenerative, dynamic and friction braking. JR is currently researching implementation of an aerodynamic braking system. This system would extend panels that would double or triple the drag associated with the vehicle. When traveling at 311 mph, the

* In 1987 the Japanese National Railways (JNR) was privatized and became the JR Group (JR).

addition of aerodynamic braking panels reduces the stopping distance from 11.3 miles to 3.8 miles.

The CLT switch is currently designed to be 230 ft long, and will consist of six wheel-mounted articulated sections.

In open territory, the CLT vehicle is expected to consume energy at the rate of 55 Wh/seat-km. While traveling in tunnels, it is expected to increase the energy consumption to 125 Wh/seat-km.

A centrally-located operation control facility will be used to monitor the state of the system, and will issue any necessary instructions should an unsafe condition develop.

3.2.3 JAPAN AIR LINES HSST

In the late 1960's the Japan Air Lines (JAL) began looking for transportation solutions to the interface problem that would exist with the opening of their new Tokyo International (Narita) Airport. After evaluating various existing possibilities, JAL made a decision in 1973 to develop its own MAGLEV using the Krauss-Maffei Transrapid design as a starting point. By 1975 their first vehicle, the HSST-01, was undergoing testing of the primary components (electromagnets, linear motor, power pick-up, etc.). In 1977 an eight-passenger test vehicle dubbed HSST-02 was built and evaluated on a one-mile test track at a top operational speed of 75 mph. JAL continued the MAGLEV evolution in 1984 with the HSST-03, which was used at two separate international expositions. In 1985 the HSST corporation took over the MAGLEV development from JAL, transferring the MAGLEV project staff to this new corporation. The HSST-04 was tested in 1987, and in 1988 the Japanese Ministry of Transport issued the first MAGLEV operating license to the HSST-05 (HSST-200). This two-car train carried about 1.3 million paying customers at the Yokohama Exposition held from March to October, 1989, (Magnetic Levitation and HSST).

The many years of development have led the JAL to a system that uses EMS for levitation and a short stator linear induction motor (LIM) to propel it. The motor and the on-board auxiliaries use power pickup from wayside rails. The use of the

short stator significantly reduces the cost of the guideway, but increases the weight of the vehicle and also results in a less efficient propulsion system (and consequently a higher operational cost).
The vehicle picks up power from the wayside rail at 750 V DC. Two 762 kVA power width modulated (PWM) inverters generate the 3-phase variable-voltage, variable frequency (VVVF) power needed by the LIM to propel the vehicle. The LIM propulsion efficiency is relatively low, ranging from .3 to .7. Compared to rotary induction motors, the LIM consumes 40% more energy. The EMS system is powered by a PWM converter fed by a 280 V DC source.

The HSST-05 two-car train has a length of 120 ft, weighs 43.5 tons empty and 59.4 tons loaded, and can carry up to 160 passengers. JAL intends on producing separate revenue vehicles aimed at commuter, intra-urban and inter-urban markets. These vehicles will vary in capacity as well as top operational speed.

Eight suspension magnets are employed on the HSST-05 two-car train and 32 air springs are used for secondary support of the cars. The suspension magnets are also utilized for lateral stability. The vehicle body is mostly comprised of aluminum alloy, with the nose being made of fiber-reinforced plastic.

The HSST-05 braking system utilizes eight mechanical brakes per train as well as reversal of the motors and regeneration.

HSST utilizes either 39 ft or 53 ft girders elevated to around 15 ft on single beams. A ferromagnetic rail is attached to the girder to provide the attraction for the suspension magnets on board the vehicle. Compensation mechanisms were included as part of the column design to enable adjustment to the guideway height should settling occur.

An early premise of the HSST system was that it only be built on single track guideways, thus precluding the need for switches. Subsequent evolution has, however, caused HSST to develop a hydraulically powered switch for dual guideway use.

The HSST operating control system is comprised of automatic train operation and train automatic stop control, using radio signals for communication. The operating control system is structured to be fail-safe. Honeycomb energy-absorbing structures are located at end stations should all braking systems fail.

3.3 TECHNOLOGY SELECTION JUSTIFICATION

During the Preliminary Feasibility Study performed by the MAGLEV Working Group and released in February of 1990 the Transrapid MAGLEV was chosen as the HSGT system of choice for application to the Regional System. This section will clarify the advantages that led to selecting the Transrapid system over other HSGT systems and conventional transportation modes.

3.3.1 ENERGY EFFICIENCY

The Transrapid system employs an efficient linear synchronous motor which is fed by utility-produced electricity. Considering a Transrapid TR07 six-car train traveling at 249 mph, the LSM is 93% efficient when converting the electrical power to mechanical power as described in Transrapid MAGLEV System (1989).

MAGLEV Vehicles and Superconductor Technology: Integration of High-Speed Ground Transportation into the Air Travel System (April 1989) an independent study performed by the Argonne National Laboratory determined that while traveling at 186 mph, the Transrapid TR07 train consumes 32% less energy per seat-mile than the TGV Atlantique. This report also indicated that the Transrapid system cruising at 300 mph would consume 700 BTU/seat-mile while a narrow-body aircraft traveling at 343 mph consumes nearly 5000 BTU/seat-mile, over a 700% increase in fuel consumption for just a 43 mph increase in speed.

MAGLEV and High Speed Rail System Environmental Energy and Economic Benefit Evaluation in Florida: A Comparative Analysis (August 13, 1990) completed by the Florida High Speed Rail Transportation Commission stated that the Transrapid system proposed for application in Orlando requires only 11% more energy than the ABB X2000 HSR system while operating at about 110% higher maximum speeds.

3.3.2 POLLUTION

Electrified HSGT systems are able to minimize harmful pollutants emitted into the atmosphere by utilizing power that is produced by electric utilities. These utilities are required to meet stringent regulations restricting discharge of pollutants such as hydrocarbons, carbon monoxide and dioxide, nitrogen oxide and particulates.

Emissions associated with HSGT systems are significantly below those experienced by the automobile or airplane. HSGT systems are estimated to release only 8 to 16% of the pollutants released by an automobile or airplane (Lynch, 1990).

3.3.3 NOISE

Since there is neither contact between the vehicle and the guideway nor a pantograph scraping against the catenary, MAGLEV systems are inherently quieter than HSR systems. Also, the MAGLEV noise is dominated by the aerodynamic component which falls in a frequency that is not as harsh to the human ear as the wheel-on-rail contact associated with a HSR train.

For example, when measured at 82 ft, the Transrapid system registered a noise level of 84 dB(A) at a speed of 249 mph (Alscher, July 1989), whereas the TGV logged a noise of 96 db(A) at a significantly reduced speed of 180 mph (Roth, June 15, 1990).

3.3.4 SPEED AND ACCELERATION

Higher speed and acceleration rates lead to shorter trip times and consequently increased ridership. The Transrapid system is capable of traveling up to 311 mph, and is able to accelerate to this top speed in 195 seconds, (Transrapid MAGLEV System (1989)). While a JNR model dubbed the ML-500 was able to attain a speed of 321 mph, the JR anticipates a maximum top speed similar to Transrapids' of near 311 mph for their revenue vehicles. The JAL HSST system, however, will most likely limit the top speed of their vehicles to near 186 mph due the excessive maintenance associated with any power pickup device running above this speed.

HSR systems must limit their top speed for several reasons, including the extra maintenance required to keep the track within the much more stringent tolerances and the arcing problem associated with power pickup at excessively high speeds. The top speed of the ABB X-2000 is only expected to be 150 mph (Safety Relevant Observations on the X2000 Tilting Train, FRA, March 1991). The TGV requires 330 seconds to accelerate to its top operating speed of 186 mph(4/1/92 transmittal received from Rail Transportation Systems, Inc.).

3.3.5 REVENUE READINESS

While there are currently no high speed MAGLEV systems in revenue operation, the Transrapid system has been approved for revenue application by the German safety licensing agency, TUV. Furthermore, since various domestic site-specific reports have recommended implementation of the Transrapid system, the Federal Railroad Administration (FRA) has completed several MAGLEV safety reviews, focusing on the German Transrapid system. These results indicate that the Transrapid system is ready for implementation.

In contrast, the relatively short and flat 4.3 mile Miyazaki test track has limited the development of the Japanese Railways (JR) Chuo Linear Train. The inability to turn at either end of the test track has prevented crucial endurance testing. A further development setback was experienced when a recent fire caused by a tire seizing demolished the only test vehicle.

In order to complete the necessary testing of the JR system, it was decided to construct a $2.3 billion test facility in the Yamanashi prefecture. This facility, however, is not to be completed until 1995, Supertrain (October 1990), at which point the required testing will begin. It is therefore unlikely that the JR system will be ready for revenue application until after the turn of the century.

3.3.6 ELECTROMAGNETIC FIELDS

Electric and magnetic fields are often collectively referred to as electromagnetic fields (EMF). Any charged particle creates an electric field around it, while magnetic fields can only occur when charged particles are in motion (i.e. when there is a current). EMF may be constant (DC field) or vary in magnitude and direction over time (AC field). The bulk of this section will focus on magnetic fields, since the electric fields associated with HSGT systems are expected to be similar to those found in most building environments, according to the Final Report on Magnetic Field Testing of TR07 MAGLEV Vehicle and System (February 1992).

Magnetic fields occur throughout the environment. The earth has an ambient magnetic field between .5 and 1 gauss (G). Many household appliances (hair dryer, toaster, can opener, etc.) register magnetic field levels between 10 and 30 G. Permanent magnets in refrigerators and acoustic speakers can generate magnetic fields between 500 and 1000 G. During a magnetic resonance imagery procedure, a patient may be exposed to as much as 20,000 G, (Electromagnetic Fields Health and Safety Issues for Rail Systems and Technologies (January 13, 1992)).

While many studies have been performed that attempt to establish the impact of EMF on biological systems, to date no conclusive evidence has been found. The EMF effects on some inanimate objects, however, have been quantified. Magnetic tapes, credit cards, etc. can be damaged at field levels between 50 and 1000 G, while some of the earlier pacemakers can be affected in the range of 10 to 20 G.

A study authorized by the Federal Railroad Administration (FRA) requested a thorough evaluation of the magnetic fields associated with the Transrapid TR07 system, Final Report on Magnetic Field Testing of TR07 MAGLEV Vehicle and System (February 1992). During this report measurements were made throughout the system for a wide spectrum of magnetic field frequencies (0 to 2560 cycles per second or Hz). The results of this study indicated that the TR07 vehicle DC magnetic field was comparable with the earth's magnetic field (.5 to 1 G), and the AC magnetic field peaked around .2 G for frequencies less than 45 Hz, while staying below .09 G for all other frequencies. A further finding in this report indicated that the magnetic fields measured for the TR07 vehicle were from one to three orders of magnitude below existing worldwide standards.

An evaluation of the EMFs generated by a super conducting MAGLEV system was completed during another study, MAGLEV Technology Assessment: MAGLEV Vehicle Magnetic Fields, (September 15, 1985). This study simulated the magnetic fields that would occur during operation of a JR revenue vehicle. The results of this report indicated a maximum unshielded magnetic field within the cabin of 400 G. The report also determined that placing passive steel sheets on the side and floor of the vehicle would reduce the magnetic field, but would also significantly increase the weight, magnetic drag, power consumption and braking distance of the vehicle.

3.3.7 SAFETY

Both HSR and MAGLEV systems offer exceptional safety. Through mid 1991, the TGV system has transported over 160 million people and the Japanese Shinkansens have transported over 4 billion people, both with no passenger fatalities resulting from operations on dedicated high speed lines, (Safety Relevant Observations on the TGV High Speed Train, (July 1991)). The Transrapid system was approved for revenue operation by the German safety licensing organization - TUV - after having logged over 62,000 miles on the Emsland test track.

The wrap-around design of the Transrapid vehicle essentially precludes derailment. Three separate redundant systems are involved in control of the vehicle: a central communication facility, a wayside system and an on-board system.

The Transrapid system has been the focus of two safety reports completed by the Federal Railroad Administration (FRA). These reports have focused on critical safety issues associated with the vehicle, guideway, passenger station, control/communication, plans/procedures, personnel and operational environment. As a result of these evaluations, the FRA concluded that "the German effort appears to ensure the same high level of safety for MAGLEV trains that is expected in the United States for similar ground transportation technologies, (Safety of High Speed Magnetic Levitation Transportation Systems: German High-Speed MAGLEV Train Safety Requirements - Potential for Application in the United States (February 1992)).

3.3.8 MANUFACTURING

As will be discussed in Section 5 of this report, the Transrapid system has developed a sophisticated CAD/CAM procedure for manufacturing their system. Considering one of the three project goals is development of a Pittsburgh MAGLEV manufacturing center, this sophisticated manufacturing process became an attractive quality of the Transrapid system.

3.3.9 ANCILLARY CONSIDERATIONS

The Transrapid continuous placement of electromagnets throughout the length of the vehicle coupled with the pneumatic secondary suspension system afford it an exceptionally smooth ride quality. The JR Chuo Linear Train suffers a relatively poor ride quality due to isolation of the levitation magnets into the corner of the vehicle.

The Transrapid system is able to maintain normal operation during inclement weather, including temperatures ranging from -13 to +104 degrees Fahrenheit, winds up to 56 mph, rain, fog, snow and ice, (Overview of MAGLEV Technology Assessment Trip, (August 1990)).

The Transrapid system is able to negotiate curves at a much higher speed than HSR systems due to the 12 degree cant of the guideway. The Transrapid vehicle can also climb 10% grades versus 3.5% for HSR systems. This increased maneuverability enables system implementation with minimal impact to the communities or the environment, as well as reduction in the amount of earthworks required.

On the Transrapid system there is no contact between the vehicle and the guideway. This contact-free operation enables a significant reduction in maintenance associated with the guideway and vehicle when compared to HSR and other MAGLEV systems.

The railroad has been evolving since the 19th century, and is a mature technology. Conversely, MAGLEV systems are still at a relatively early stage in their development cycle and offer the potential for further improvements that will make them even more attractive.

3.3.10 CONCLUSION

The Transrapid system offers a number of qualities that sets it above other forms of HSGT: energy efficiency; low pollution, noise and EMF emissions; high level of safety; good maneuverability and ride quality; and a sophisticated automated manufacturing system. Considering the importance of local manufacturing for this project, the advanced manufacturing process developed by Transrapid was influential in the decision to choose it as the technology. For these reasons the Transrapid system has been chosen for application to the Regional System.

4.0 DOMESTIC MARKET POTENTIAL FOR HSGT

One of the three goals associated with the Regional System has been to establish this region as the MAGLEV manufacturing center for North America. But establishing Pittsburgh as this manufacturing center requires investment to allow each manufacturer to modify and/or retrofit their equipment to enable production of a MAGLEV system. Such an endeavor would be practical if a significant market existed in North America.

During the Preliminary Feasibility Study it was determined that a significant potential market for HSGT did exist. While a more rigorous estimate of the HSGT potential markets was not deemed necessary for the present work, an overview of several government agency generic studies as well as a summary of several site-specific reports could provide a basis for establishing a better estimate of the domestic market potential.

4.1 GENERAL MARKET REPORTS

Several reports addressing HSGT implementation in a global fashion have been produced or funded by government agencies. These reports were used to form the basis for an updated estimate of the potential domestic market.

4.1.1 ARGONNE NATIONAL LABORATORY REPORT

In 1989 the Argonne National Laboratory (ANL), under contract to the US Department of Energy, produced a report to assess the technical and economic feasibility of implementing a high-speed MAGLEV system, as well as estimating the potential market that existed for such a system. The result of this effort was a report entitled "MAGLEV Vehicles and Superconductor Technology: Integration of High-Speed Ground Transportation into the Air Travel System". The approach of the ANL study involved developing a conceptual inter-city high-speed MAGLEV system that linked both the major metropolitan centers and their regional airports. Such a system would provide short to medium distance travel as well as serve as a feeder system for the regional airport. This MAGLEV system may also be time-competitive with airlines at distances up to 600 miles and would enable the regional airports to eliminate their short-haul flights. According to the report, this would both increase the airport capacity and reduce the air traffic congestion.

By identifying the 50 most heavily traveled air routes under 600 miles, ANL developed a conceptual market based on service to these cities. The ANL study recommended over 10,000 miles of MAGLEV guideway be constructed in two phases. The first phase of this MAGLEV market includes a triangular 2000 mile line connecting Chicago, Boston and Washington, DC, with New York, Philadelphia, Baltimore, Pittsburgh, Cleveland and Detroit as intermediate locations along the alignment. Assuming a double-guideway cost of $15 million/mile, the report estimated a construction cost of $30 billion.

4.1.2 TRANSPORTATION RESEARCH BOARD REPORT

In 1991, the U.S. Department of Transportation requested the National Research Council, under the direction of the Transportation Research Board (TRB), to perform a study assessing the ability of HSGT technologies to provide a solution for the burgeoning travel demand in high-density corridors. This study, "In Pursuit of Speed: New Options for Intercity Transport", (1991) utilized 19 experts from various HSGT-related fields to evaluate this topic.

Similar to the ANL report, the TRB work indicated that the most likely HSGT markets would develop around intercity markets spaced 150 to 500 miles apart that experience heavy congestion at their major airports. As an initial rough indicator of the potential market, the report identified 23 major airports which are experiencing significant congestion, and then determined that 21 of these airports have been included in recent studies for implementation of HSGT systems. While most of these studies suggested that enough potential demand existed to warrant further evaluations, they also indicated that the systems were not likely to be self-supporting, and further stated that while project applications have been received and franchises awarded in some corridors, no project has yet received financing.

The report highlights a more rigorous approach to establishing the potential market, based solely on the ability of the HSGT system to pay back its capital, operating and maintenance costs. The first step in this method involved developing a high, middle and low generic cost determination for HSGT systems. The second step applied these cost figures to the congested corridors mentioned above to establish capital, operating and maintenance costs reflective of the corridor. The third step assumed a range of fares (above, equal to and below air fares), and calculated the passenger volumes required to pay back the range of capital, operating and maintenance costs previously calculated (a 4% annual interest rate was used for the capital). The final step was to compare these break-even passenger volumes to the air volumes currently experienced for the corridors. The report concluded that the most favorable results were for the somewhat unlikely combination of fares kept high (above air fares) and costs assumed low. This case estimated that by the year 2010 the number of break-even city pairs would be 23 or 7, depending on whether the HSGT system captured all or half the projected air travel for the corridor, respectively. The report also stated that for the more likely case of lower fares (near the air-travel price) and best-estimate costs, a passenger volume of 6 million riders per year is required to attain a break-even condition. Currently only one city pair (Los Angeles to San Francisco with 6.25M/year) has this volume of air travel, and only four are projected to attain this volume by the year 2010.

While the TRB report noted that it appears likely that implementation of HSGT systems in most domestic corridors would require subsidies for capital, it also noted that the domestic highway and airport systems currently require significant subsidies (in the form of a 14 cents per gallon fuel tax and a 10% tax on airline tickets). Referencing Federal Highway and Federal Aviation reports that indicate an inability to construct the substantial increase in highways and airports needed to maintain current performance levels (which are already congested), the TRB report suggested that construction of HSGT systems could significantly reduce the highway and airport congestion. The report further noted that HSGT systems would not only reduce congestion, but would also be more energy efficient than automobiles or airplanes (thus reducing our dependency of foreign oil), would reduce the air pollution (since it uses electricity rather than combustion engines), would provide increased safety, and would offer economic development opportunities.

The report recommended that the U.S. Department of Transportation include HSGT systems along with conventional transportation systems when deciding future infrastructure congestion solutions.

4.1.3 FEDERAL RAILROAD ADMINISTRATION REPORT

In June of 1990 the Federal Railroad Administration (FRA) released its report on MAGLEV feasibility entitled "Assessment of the Potential for Magnetic Levitation Transportation Systems in the United States". This study evaluated various existing MAGLEV technologies and reported on their technical and economic feasibility.

The FRA report began its U.S. MAGLEV market appraisal by identifying city-pairs that are less than 500 miles apart and experience heavy air traffic volumes. It continued the evaluation by defining a series of routes that would serve these corridors. Once the routes were established, an estimate of future year person trips for each of the alignments was performed (using fares near the cost of airline tickets), thereby determining the anticipated revenues. Assuming MAGLEV costs are reflective of the Transrapid MAGLEV system, capital and operating/maintenance costs were then developed and compared to the previously calculated revenues. For those routes which were unable to pay back the capital costs, an evaluation of the external benefits of the system were used to determine if public financing of the capital is justifiable.

Assuming that right-of-way can be acquired at little or no cost, the FRA report stated that it may be possible to construct between 1000 and 3500 guideway miles of a MAGLEV system that will be able to pay back its capital and operating costs (assuming tax-free bond). The cost of these lines was estimated at between $15.2 and $54.7 billion for fixed facilities, and between $1.2 to $3.2 billion for the vehicles.

Another scenario evaluated involved paying all the annual operating and maintenance costs, but only repaying 50% of the capital cost (requiring that the remainder be covered by other forms of revenue generation, such as real estate capture or public financing). Assuming this approach enabled construction of

2300 to 6300 guideway miles, costing from $35 to $97 billion for fixed facilities and $3.7 to $6.8 billion for vehicles.

The report further stated that strategic implementation of a MAGLEV system would also result in a substantial reduction in public sector infrastructure costs through elimination of highway and airport construction projects that would have been required to meet the projected increase in travel demand. Operation of a MAGLEV system would also benefit the public by reducing the demand for petroleum and minimizing air pollution.

4.2 SPECIFIC CORRIDOR STUDIES

While the previous section discussed the overall domestic market potential as viewed by three separate government-funded reports, this section reviews several site-specific studies that have investigated the feasibility of implementing HSGT systems. The studies chosen for review reflect some of the more publicized projects completed to date, but are not to be considered an exhaustive review. Included in this review is a brief discussion of the corridor, the HSGT technologies evaluated, and the results and recommendations of the studies.

All costs shown in the following sections are in 1991 dollars.

4.2.1 PITTSBURGH TO PHILADELPHIA CORRIDOR

The Pennsylvania High Speed Intercity Rail Passenger Commission studied the feasibility of constructing a HSGT system between Philadelphia and Pittsburgh, with as many as eight intermediate stops (including Harrisburg, the state capital). The technologies evaluated in this study included upgraded rail, HSR (TGV) and MAGLEV (Transrapid).

The general engineering consultant, assuming double track or guideway for the entire length, developed a 315 mile alignment for the HSR and MAGLEV technologies, and a separate 340 mile alignment for upgraded rail. The cost associated with each of the technologies was estimated at $12.86, $8.74 and $3.25 billion for MAGLEV, HSR and upgraded rail, respectively. The owners of the MAGLEV technology, feeling that the consultants did not take advantage of the maneuverability of their technology, developed their own 240 mile single guideway with passing sidings MAGLEV alignment that extended from Pittsburgh to Harrisburg. This alignment costs $3.75 billion.

As a result of the study, the Commission recommended the Transrapid MAGLEV system be the technology of choice, and further suggested that the General Assembly take steps to authorize the implementation of the MAGLEV system and allow negotiations with the West German consortium to begin. Shortly after the report was issued, however, the Commission was dissolved and little activity occurred until the current study effort discussed in this report.

4.2.2 ANAHEIM TO LAS VEGAS CORRIDOR

In 1983 the Budd Company produced the first study evaluating the feasibility of constructing a HSGT system between Southern California and Nevada. The results of this study recommended a Transrapid MAGLEV system be built between Ontario, CA and Las Vegas, NV. The City of Las Vegas, however, expressing concern over the relationship between the Budd Company and Transrapid (the Budd Company is owned by Thyssen-Henschel, part owner of Transrapid), contracted with the Canadian Institute of Guided Ground Transport (CIGGT) to perform an independent assessment of the corridor and technology.

During this study, known as Phase II, the CIGGT completed a thorough evaluation of existing HSGT systems. For this evaluation the CIGGT chose the French TGV and Transrapid as representative systems on which to base its cost estimates.

The Phase II evaluation reflected a 231 mile alignment, 166 miles being single guideway, and 64 miles being double guideway to permit high-speed passing of trains. The study indicated a TGV cost of $2.64 billion and a Transrapid MAGLEV cost of $3.30 billion.

In 1988, upon completion of the Phase II report, the states of California and Nevada created the California-Nevada Super-Speed Ground Transportation Commission, whose primary purpose was both to secure rights-of-way and to award a franchise for operation of a HSGT system. A franchise was subsequently granted to Bechtel Corporation for a Transrapid MAGLEV system. In 1991, however, Bechtel withdrew its franchise due to funding questions associated with the project.

The Commission remains in operation, and is hopeful that a new franchise Request For Proposal (RFP) open to all technologies can be released within the near future.

4.2.3 CHICAGO TO MILWAUKEE TO MINNEAPOLIS/SAINT PAUL CORRIDOR

A study released in 1991 addressed the feasibility of implementing a HSGT system between Chicago and the Twin Cities with five intermediate stops (including Milwaukee). This study was completed by Transportation Management Systems with the Alfred Benesch Company (TMS/Benesch), and evaluated upgraded rail (British HST), HSR (French TGV) and MAGLEV (the Japanese super conducting system).

The analysis looked at two separate HSR and MAGLEV corridors between Chicago and the Twin Cities, and one upgraded rail alignment. Both the 435 mile northern alignment (with stops at Milwaukee and Green Bay, WI) and the 461 mile southern alignment (with stops at Milwaukee and Madison, WI) have a total of five intermediate stops. The 418 mile upgraded rail alignment mostly follows existing rights-of-way and serves the same cities as the southern alignment.

With a southern route cost of $1.03, $3.32 and $5.99 billion for upgraded rail, HSR and MAGLEV, respectively, the study showed this corridor to be environmentally, economically and financially advantageous to the northern route. While the study indicated that the upgraded rail technology offered the best financial scenario, it also reported that for a privately financed project the MAGLEV system would be economically superior.

The study ultimately recommended a detailed engineering/environmental analysis be performed to enable the program to proceed past the feasibility stage.

4.2.4 MIAMI TO ORLANDO TO TAMPA CORRIDOR

The Florida High Speed Rail Transportation Commission (FHSRTC), created in 1984, retained Barton-Aschman Associates to perform a baseline analysis of alternatives for the State of Florida. The study evaluated upgraded rail (Canadian LRC and English HST), HSR (French TGV and Japanese Series 961) and MAGLEV (German Transrapid and Japanese Superconductive).
A single 314 mile alignment between Miami and Tampa with a potential for three intermediate stations was defined and all three technologies applied to this corridor to establish costs. The report quoted capital costs of $3.15, $3.70 and $6.45 billion for upgraded rail, HSR and MAGLEV, respectively. The study stated that farebox revenues from any of the three HSGT technologies would be sufficient to cover operational costs, with different margins available to pay back the capital.

Subsequent to this report the FHSRTC released an RFP to design, implement and fund a HSGT system for the proposed corridor. Only two of the four proposals received by the Commission were accepted, and shortly thereafter the only remaining applicant was the Florida High Speed Rail Corporation (FHSRC) due to the withdrawal of the other applicant. The FHSRC advocated construction of a HSR system utilizing the Swedish ABB X-2000 technology.

The FHSRC proposal anticipated significant funds coming from real-estate development around the stations. This approach became implausible when property values plummeted, and in 1990 the FHSRC proposed to replace the real-estate development with a 2.5 cent increase in gas tax and an additional $2 license plate fee. This strategy was quickly dismissed. In 1991 the FHSRTC was dissolved and their responsibilities were transferred to the Florida Department of Transportation.

Currently the Florida DOT is performing further studies on the intercity alignments and markets, and is still confident that a HSGT system will be implemented within the Tampa to Miami corridor.

4.2.5 NEW YORK TO BUFFALO CORRIDOR

In 1991 the Grumman Corporation, under contract to the New York State Energy Research and Development Authority, completed a MAGLEV technical and economic evaluation of New York State corridors. The study focused on the MAGLEV potential to meet future New York State transportation needs cost-effectively and to establish what benefits New York State could hope to gain as a result of participating in MAGLEV development.

Grumman developed a 495 mile corridor between New York City and Buffalo that essentially follows the New York Thruway and includes three intermediate stops. After evaluating the existing HSGT technologies, Grumman determined that any conventional MAGLEV design applied to the circuitous New York Thruway corridor could not hope to realize an average operating speed anywhere near the maximum cruising speed (due to the lateral forces that would be exerted on the passengers). Therefore, the Grumman team proposed their own MAGLEV design featuring super-conducting magnets for levitation, a linear-synchronous motor for propulsion, and a 24 degree banking capability (12 degree guideway bank, 12 degree vehicle tilt). This banking system would reduce the lateral force and allow higher vehicle speeds through curves. Based on this technology, the report estimated a Grumman-design cross-state MAGLEV system cost of $11.12 billion.

As with most other corridor reports, the Grumman report indicated that the farebox revenues would be sufficient to cover operating and maintenance costs, but would not be enough to amortize the capital costs. The study recommended several more detailed reports be conducted to further ascertain the need for a New York State HSGT system, including a detailed market demand, a comprehensive economic analysis, and a refined route definition.

4.2.6 TEXAS TRIANGLE

The Texas Turnpike Authority, with financial assistance from the Federal Railroad Administration, retained Lichliter/Jameson and Associates to direct a study team led by Morrison Knudsen to produce a 1989 HSR study determining the economic and financial feasibility of constructing and operating a HSGT in the State of Texas. The study performed an evaluation of HSGT systems, and developed costs for an intermediate speed rail, HSR and MAGLEV system.

The Texas study created an alignment which essentially followed existing rights-of-way, as well as an alignment that mostly developed new rights-of-way. After evaluating the two alignments, the study team recommended the new rights-of-way alignment, which is a 619 mile triangle connecting Houston, San Antonio and Fort Worth/Dallas, with as many as four intermediate stations. Applying cost figures representative of a French TGV or German ICE system to this new rights-of-way alignment, the study determined a capital cost estimate of $5.05 billion. The study concluded that a HSR system constructed in three phases would be the optimal approach for Texas.

As a result of this study, the Texas High Speed Rail Authority (THSRA) put out an RFP for HSGT implementation in the State of Texas. The Texas High Speed Rail Corporation (THSRC), employing the French TGV technology, and the Texas FasTrac Corporation, proponents of the German ICE system, competed for the Texas HSGT franchise. In January of 1992, the THSRC was granted a 50-year franchise agreement.

The THSRC has since capitalized the corporation by securing $10 million in cash, and subsequently paid the $290 thousand franchise fee that will keep the THSRA in operation for another year. Although construction of the HSGT system was expected to start by 1995, with operations beginning in 1998, recent funding issues have delayed the schedule and raised concerns about the project's viability.

4.2.7 CLEVELAND TO COLUMBUS TO CINCINNATI CORRIDOR

The State of Ohio has been pursuing implementation of a HSGT system since the early 1970's. With the formation of the Ohio Rail Transportation Authority (ORTA) in 1975, Ohio has steadily moved toward development of the first domestic HSGT system. A study commissioned by ORTA and completed in 1977 recommended three Ohio corridors that appeared conducive to HSR implementation.

A Phase II report was completed in 1980 by Dalton, Dalton and Newport at the direction of ORTA. This study recommended a 567 mile Ohio HSR system be constructed at an estimated cost of $11.35 billion. This study also suggested a 1% increase in the Ohio sales tax to help offset capital costs. The sales tax increase was put to a voter referendum where it was rejected by a margin of two to one.

In 1983, the Governor of Ohio appointed a 15 member Ohio High Speed Rail Task Force charged with evaluating potential cost reductions to the Phase II study, as well as re-defining the economic impact, ridership and financial estimates. The Task Force completed a 19-month investigation, and in 1985 released a report that recommended construction of a $2.69 billion alignment extending 249 miles from Cleveland to Cincinnati through Columbus (3C corridor).

Subsequent to this report, the Ohio High Speed Rail Authority (OHSRA) was created in 1986 and given a legislative mandate to plan, develop and implement an intercity HSR system serving Cleveland, Columbus and Cincinnati. In 1988, the OHSRA commissioned a detailed study of ridership and revenue that estimated that 3.1 to 4.6 million passengers would utilize the 3C corridor by the year 2000, resulting in revenues ranging from $98 to $194 million annually. Based on this report, the OHSRA issued an RFP in 1989 requesting private sector firms to outline a process to finance, design, construct and operate Ohio's intercity HSR line.

The sole respondent to this RFP was the Ohio Railway Organization (ORO), a private corporation comprised of a variety of companies, including Parsons Brinckerhoff, URS, Wilbur Smith and Credit Lyonnais. This organization proposed a 260 mile HSR system along the 3C corridor costing $3.1 billion. A contract of mutual agreement between the OHSRA and the ORO was signed on August 29, 1990. The ORO presented a plan of action on September 24, 1991, to the OHSRA. This plan proposed to design, construct and implement an HSR system in the 3C corridor within a six-year period. While a franchise is expected to be awarded by the end of 1992, to date no financial commitment to provide the capital cost for the system has been secured.

4.2.8 SUMMARY OF SPECIFIC CORRIDOR REPORTS

Presented in Table 4-1, Performance Characteristics from Individual Corridor Studies, are some relevant characteristics for the specific corridors reviewed. These corridors are shown graphically in Figure 4-1, Domestic Corridor Studies. Noteworthy comments resulting from the specific corridor reports include:

- Of the projects reviewed, varieties of HSGT technologies were most often examined to establish which could best serve that corridor's needs.
- All studies indicated that estimated farebox revenues were able to exceed the anticipated operating and maintenance costs, but were unable to amortize the capital costs.
- Several domestic corridors have awarded HSGT franchises.
- No domestic HSGT project has yet developed the necessary capital to begin construction.

4.3 ESTIMATE OF POTENTIAL DOMESTIC MAGLEV MARKET

The general market reports evaluated in this study, estimated the domestic HSGT (not MAGLEV) market (HSR and MAGLEV are combined markets). The estimates need to take into account that some corridors have already chosen HSR as the technology, and should therefore not be included as potential MAGLEV markets.

A potential HSGT market of up to 10,000 miles was estimated. This potential will be modified and its cost quantified as shown below to develop a more realistic MAGLEV market projection:

1) Eliminate the mileage for those corridors that have awarded a franchise for a HSR system.
2) Subtract 75% of the inter-city mileage for those specific corridor studies that have recommended HSR or upgraded rail as the technology of choice.
3) Convert potential route miles to potential guideway-miles by increasing the route miles by 30% (i.e. 70% single guideway, 30% double guideway).

Table 4-1
Performance Characteristics from Individual Corridor Studies

Characteristic		Pittsburgh Harrisburg Philadelphia	Pittsburgh to Harrisburg	Anaheim to Las Vegas	Chicago Milwaukee Twin Cities	Miami Orlando Tampa	New York Albany Buffalo	Texas Triangle	ORTA Ohio Corridors	Ohio HSR Task Force 3C Corridor	Cleveland Columbus Cincinatti
Lead Management/Consultant		PBGF	Transrapid	CIGGT	TMS/B	B/A	Grumman	L/J	D/D&N	OHSRTF	ORO
Cost Base (year)		1986	1986	1984	1989	1983	1990	1988	1978	1985	1991
Route Length (km)	rail	547			673	505					
	hsr	507		372	700	505		996	912	401	418
	maglev	507	381	372	700	505	797				
Travel Time (hr:min)	rail	3:43			4:20	3:00-3:18					
	hsr	2:41		1:25	3:15	2:24-2:42		7:30	8:50	2:30	~2:15
	maglev	2:01	1:29	1:05	2:15	1:30-1:48	1:46-2:17				
Capital Cost ($B,1991)*	rail	$3.25			$1.03	$3.15					
	hsr	$8.74		$2.64	$3.32	$3.70		$5.05	$11.35	$2.69	$3.10
	maglev	$12.86	$3.75	$3.30	$5.99	$6.45	$11.12				
Operating Cost ($M,1991)*	rail	$122			$100	$76					
	hsr	$131		$87	$111	$80		$214	$209	$58	$61
	maglev	$130		$96	$136	$104	$165				
Basis for Ridership (year)		2000		1995	2000	2000	2000	1998	2000	1990	1991
Ridership (Millions)	rail	4.4			5.8	1.6-2.4					
	hsr	6.0		6.0	7.5	1.7-2.6		7.5	8.7	7.0	1.8
	maglev	6.9		7.1	8.5	1.8-2.9	4.5-4.7				
Revenue ($M,1991)*	rail	$181			$249	$106-$211					
	hsr	$237		$259	$370	$102-$227		$299	$304	$194	$88
	maglev	$280		$305	$450	$128-$255	$277-$312				
Capital Cost/km ($M/km,1991)*	rail	$5.94			$1.54	$6.24					
	hsr	$17.25		$7.11	$4.74	$7.33		$5.07	$12.44	$6.70	$7.41
	maglev	$25.38	$9.82	$8.89	$8.56	$12.76	$13.96				

* Individual study costs increased to account for inflation using actual values from University of Pittsburgh REMI model

Note: PBGF - Parsons-Brinckerhoff/Gannett-Fleming
CIGGT - Canadian Institute of Guided Ground Transport
TMS/B - Transportation Management Systems/Alfred Benesch & Company
B/A - Barton-Aschman Associates
L/J - Lichliter/Jameson & Associates
D/D&N - Dalton, Dalton & Newport
OHSRTF - Ohio High Speed Rail Task Force
ORO - Ohio Railway Organization

Domestic Corridor Studies

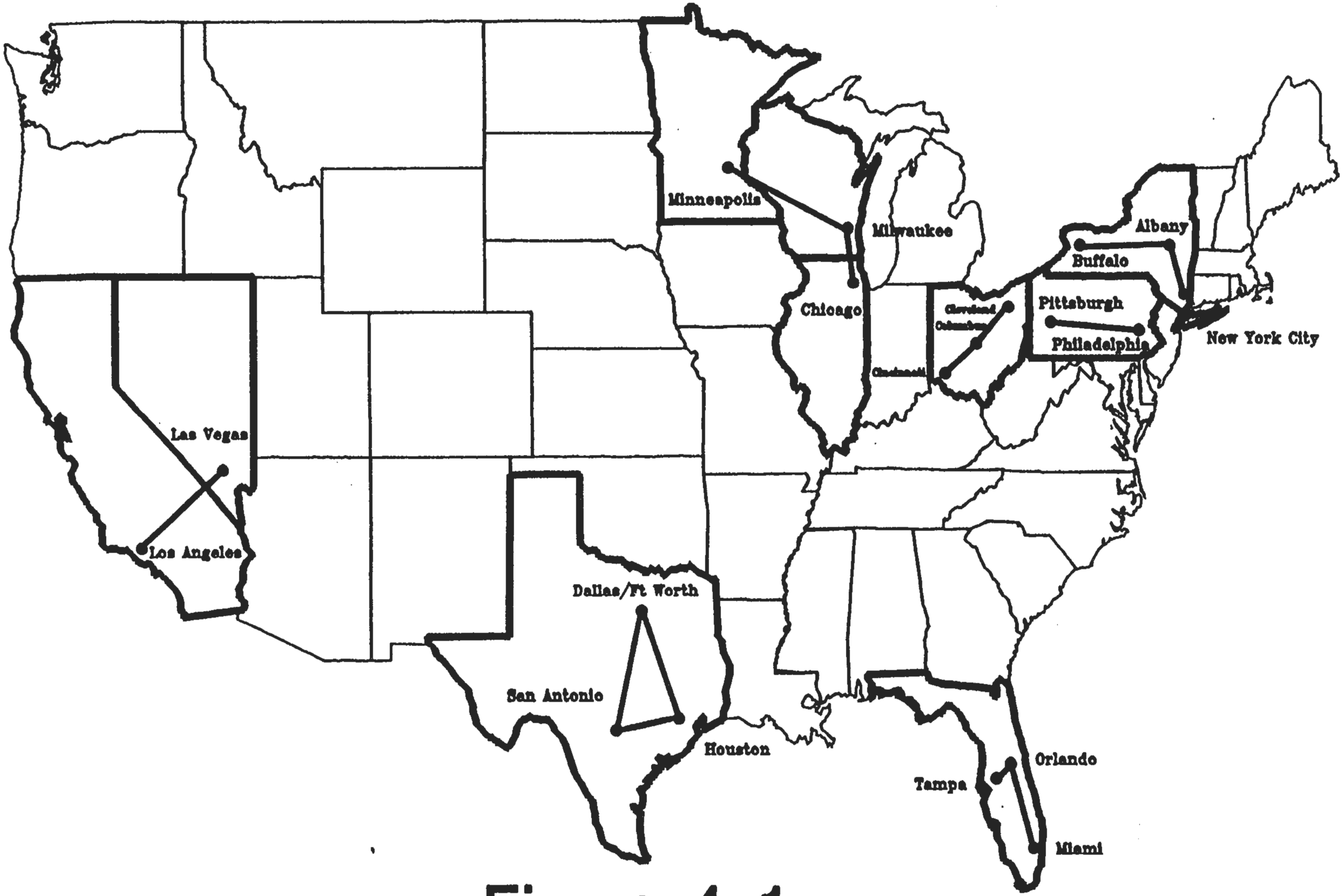


Figure 4-1

4) Calculate the fiscal market by multiplying the resultant guideway-miles by the per-mile cost generated in Section 7 of this report (i.e. $21 million per single guideway-mile, which is the estimated single-guideway cost based on the component costs used during this study.)

From the specific corridor reports, both the Texas and Florida projects have awarded a HSR franchise. The Chicago to Twin Cities and Ohio projects have recommended technologies other than MAGLEV. Therefore, 1500 miles and 840 miles must be eliminated from the estimate due to franchise awards and study recommendations. By removing these distances and increasing the estimate by 30% to allow for double-guideway passing sidings, there is still a potential 9880 miles of MAGLEV guideway. Assuming an all-inclusive single-guideway cost of $21 million per mile, the total market approaches $210 billion.

As shown in Figure 4-2, Potential MAGLEV Corridors, the majority of the tentative alignments are within 500 miles of Pittsburgh, which is favorable for establishing Pittsburgh as the manufacturing center for this technology.

Potential US Maglev Corridors

Figure 4-2

5.0 MID-ATLANTIC REGIONAL SYSTEM

The Mid-Atlantic Regional System refers to a 1300-mile HSGT alignment emanating from Pittsburgh to seven major city terminal points located in four states and the District of Columbia. The alignments developed will serve as the base for estimating the costs and revenues of the MAGLEV system, and will ultimately be used to determine the system's economic feasibility.

Although efforts to optimize these alignments while keeping them as realistic as possible were made, it should be noted that they are preliminary. The alignments were developed from United States Geological Survey maps at a scale of 1"=2000'. Future revisions, and probably wholesale modifications will be made during the development cycle. However, the level of detail used in the development of these alignments will enable a realistic assessment of the projected costs and revenues reflective of the system.

5.1 REGIONAL SYSTEM ROUTE DEFINITIONS

An approach to the development of the Regional System was selected which specified the type of rights-of-way to follow, reflected physical constraints imposed by the technology, and defined areas which should be avoided. This section describes the approach and why it was selected, as well as implementing it to develop the Regional System alignments.

5.1.1 CORRIDOR AND STATION SELECTION

HSGT systems can compete with existing modes of transportation at distances up to 600 miles. However, experts have established that the HSGT market-share peaks in the vicinity of 250 miles, (Assessment of the Potential for Magnetic Levitation Transportation Systems in the United States (June 1990). Therefore, in order to maximize the effectiveness of a regional HSGT system, targeting cities which lay within a 250 mile radius of Pittsburgh was imperative.

Metropolitan population and airline passenger information was gathered for those cities which were within a 250 mile radius of Pittsburgh. Since airline and

MAGLEV systems are expected to have similar travel times within the 250 mile distance, the number of current airline passengers between these cities and Pittsburgh gives a rough indication of the anticipated ridership a MAGLEV system would capture, assuming short-hop flights were eliminated. The metropolitan population will assist in determining the alignment destinations by defining the number of people accessing this new transportation mode. Figure 5-1, Metropolitan Data shows this information with circles delineating distances of 150 and 250 miles from Pittsburgh. From this information and input from the ridership consultant, COMSIS Corporation, the destination cities as well as the intermediate stop cities were chosen as shown in Figure 5-2, Cities Selected for MAGLEV Service.

5.1.2 ROUTE DEVELOPMENT PHYSICAL CONSTRAINTS

The ride quality, safety and efficiency of a HSGT system are all dependent on the physical constraints imposed while developing the alignment. These constraints include, but are not limited to: horizontal and vertical curving radii versus speed; maximum allowable grade; and distances between stations.

The impact on the alignment development resulting from each of these conditions was evaluated. The Regional System alignments defined reflect consideration of these constraints.

5.1.3 USING NEW VERSUS EXISTING RIGHTS-OF-WAY

Many studies have recommended extensive use of existing Rights-of-Way (ROW) to minimize the cost of the system (potentially low to no charge for purchase/use of land) and to avoid the potential difficulties associated with procuring new ROW (eminent domain, environmental constraints, community opposition, etc.). However, implementation of a MAGLEV system within a highway, railroad or other ROW could also create as many problems as it solves. For example, at 300 mph a MAGLEV system could not follow the horizontal or vertical profile of an existing highway or railroad that was designed for speeds approaching 70 mph without either major modifications to the ROW or significant reductions in performance of the MAGLEV system. Therefore, an evaluation was undertaken to determine the most attractive approach.

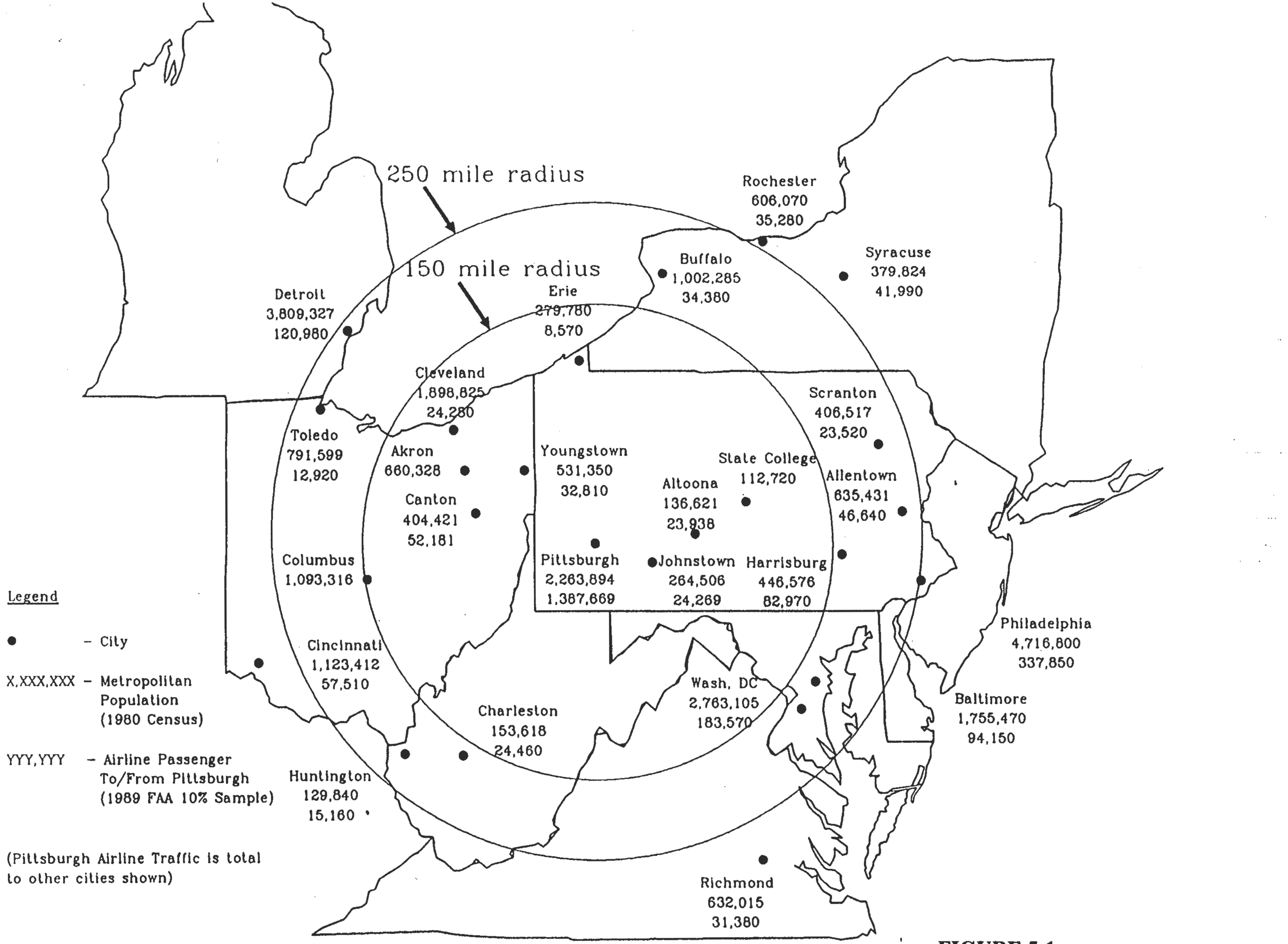


FIGURE 5-1
METROPOLITAN DATA

CITIES SELECTED FOR MAGLEV SERVICE

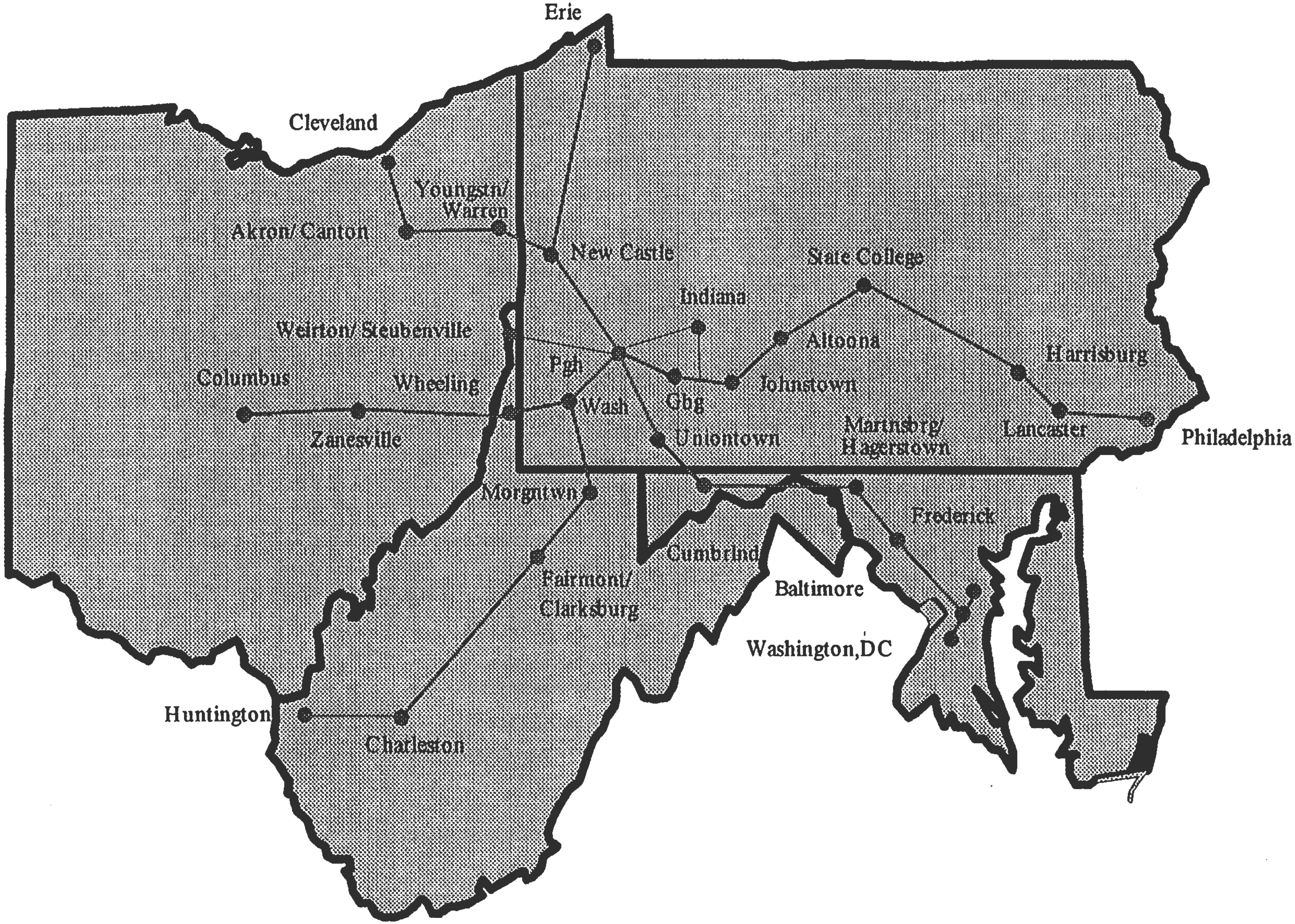


FIGURE 5-2

Two separate evaluations were performed attempting to determine the optimal approach. The first procedure involved developing two high-speed alignments (150 and 250 mph minimum speed) which attempted to follow existing ROWs. These alignments were then evaluated to ascertain what percentage of the alignment lay outside the existing ROW.

The second procedure involved simulating operation of a high-speed MAGLEV system operating entirely within an existing highway/railroad ROW, thereby causing reduced performance of the MAGLEV system. This was then compared to another simulation which assumed operation of the MAGLEV system along a new ROW.

The results of the first procedure indicated that the MAGLEV system would have to leave the existing ROW for about 20% and 45% of the alignment for the 150 and 250 mph routes, respectively. The second procedure indicated that run times would almost double when the system must follow the existing ROW when compared to new ROW alignments.

Therefore, a decision was made to develop the Regional System alignments using new ROW except where conditions dictate existing ROW must be used (such as through metropolitan areas where new ROW would be costly and sparse).

5.1.4 REGIONAL SYSTEM ALIGNMENTS

The Mid-Atlantic Regional System alignments were developed on United States Geological Survey (USGS) topographical maps at a scale of 1" = 2000'. The main criteria used in development of these alignments are shown below:

- When outside metropolitan areas, develop new ROW and keep speed above 250 mph.
- When approaching a metropolitan area containing a station, use existing ROW as needed.
- Minimize required earthworks, tunnels and bridges by avoiding sharp changes in terrain.
- Avoid Federal, State and Local Parks.
- Avoid Federal, State and Local Gamelands.

- Avoid communities, businesses and residential areas.
- Avoid churches, cemeteries, schools and hospitals.
- Cross major roads and rivers perpendicular to their path.

The procedure followed for the Regional System alignment definition involved two engineering teams. The process began with the first engineering team reviewing the USGS maps, identifying major impediments, and then developing several alternative alignments which connect a city pair. Once completed, this alignment was then reviewed by a second engineering team looking for potential problem areas or improvements. The first engineering team then made modifications to the existing alignment based on these recommendations. This process continued until both teams agreed that the alignment was optimized.

The Regional System developed using the above procedure is shown in Figure 5-3, Pittsburgh Regional System. These alignments represent over 1300 miles of ROW traveling through four states and the District of Columbia. For ease of description and reference, the lines were grouped into three distinct segments: the North Line extending from Pittsburgh, PA to Cleveland, OH and Erie, PA; the East Line extending from Pittsburgh, PA to Philadelphia, PA and Baltimore, MD/Washington, DC; and the Southwest Line extending from Pittsburgh, PA to Steubenville, OH/Weirton, WV, Columbus, OH and Huntington, WV. A short description of these alignments is included below.

The RS North Line refers to the alignment that leaves the Pittsburgh International Airport traveling north to Cleveland, OH and Erie, PA. This line contains a total of five regional stops, including New Castle and Erie in Pennsylvania, and Youngstown/Warren, Akron/Canton and Cleveland in Ohio.

The Regional System Southwest Line relates to an alignment that leaves the Pittsburgh International Airport for ultimate destinations in Columbus, OH, Huntington, WV and Steubenville, OH/Weirton, WV. This line contains a total of nine regional stops, including Washington in Pennsylvania, Wheeling, Morgantown, Clarksburg, Charlestown and Huntington in West Virginia, and Steubenville (Weirton, WV), Zanesville and Columbus in Ohio.
The RS East Line refers to an alignment that leaves the Pittsburgh Internatinal Airport for terminating stations in Philadelphia, PA, Baltimore, MD and

Figure 5-3 - Pittsburgh Regional System

Washington, DC. This line contains a total of seventeen regional stops, including Downtown Pittsburgh, Greensburg, Johnstown, Altoona, State College, Harrisburg, Lancaster, Paoli, Philadelphia, Philadelphia International Airport and Uniontown in Pennsylvania, Cumberland, MD, Martinsburg, WV, and Frederick, Baltimore, and Baltimore-Washington International Airport (BWI) in Maryland and Washington in the District of Columbia.

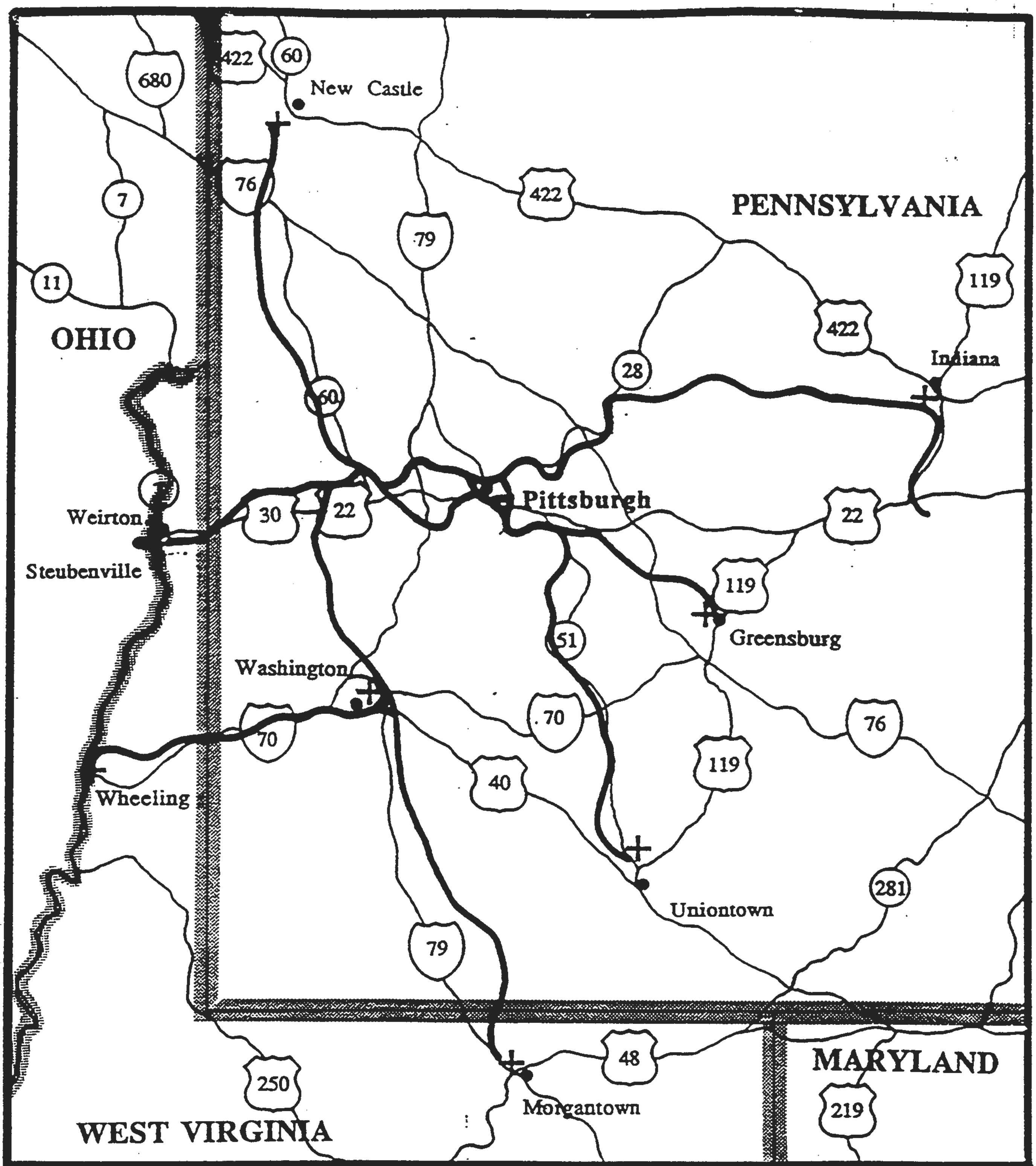
The Philadelphia Branch of the East Line primarily follows the alignment developed during the Pennsylvania High Speed Commission Study. From Greensburg to Harrisburg the alignment developed by Transrapid was mostly followed, while between Harrisburg and Philadelphia the Parsons Brinkerhoff/Gannett Fleming route was emulated.

The Pittsburgh Suburban System has been developed to establish the relationship between costs and revenues associated with overlaying a high-speed Suburban System on top of the Regional System, thus using the Suburban System as a feeder for the Regional System, a feeder for the Pittsburgh International Airport, and also as a commuter system for the metropolitan area.

The only new line developed for the Suburban System extends to the north and east, and eventually connects back with the Philadelphia Branch near Blairsville, PA. Including this line, there are a total of nineteen stations, including Downtown Pittsburgh and the Airport from the Demonstration System, New Castle and Aliquippa/Hopewell from the North Line, Steubenville/Weirton, Washington (PA), Wheeling and Morgantown from the Southwest Line, Steel Valley, Mon Yough, Mid-Mon Valley, Uniontown, Monroeville and Greensburg from the East Line, and Oakland, Fox Chapel, New Kensington, Apollo/Vandergrift and Indiana from the Northeast Allegheny Valley Line. A map of the defined Suburban System is shown in Figure 5-4, Pittsburgh Suburban System, and Figure 2-20 shows the locations of the Suburban stations.

5.2 REGIONAL SYSTEM COMPUTER SIMULATION

A computer simulation of the Regional System was completed to estimate operating parameters such as run-times and energy consumption. This section will briefly describe the methodology used and then will present some of the results.



PITTSBURGH SUBURBAN SYSTEM

FIGURE 5-4

5.2.1 COMPUTER SIMULATION DESCRIPTION

The Train Performance Simulator (TPS) is a software package which is used to imitate operation of a transit system. The TPS utilizes data which describes the corridor (grades, curves, speed restrictions and station locations all versus distance) as well as the physical and propulsion characteristics of the train that will be operating on this corridor. This data is used by the TPS to simulate the motion of the train along the corridor, and output of the TPS reflects the run-times and energy consumption for the train.

For the purposes of this study, the TPS will be used to simulate operation of the Transrapid trains on the Mid-Atlantic Regional System and the Pittsburgh Suburban and Demonstration Systems. The output energy consumption for the various segments will be used to assist in calculating operational costs, while the run-times will be used as input during the ridership evaluation.

5.2.2 COMPUTER SIMULATION RESULTS

Simulation results reflecting distances traveled versus run-times are shown in Tables 5-1 to 5-22, Regional System Operations. These tables reflect 5-car trains operating over alignments with grades up to 10%.

5.3 CONCLUSIONS

The following conclusions have resulted from this evaluation:

- All alignments were developed to ensure high-speed operation.
- Corridor development used new ROWs outside of metropolitan areas to enable consistent high-speed operation.
- Use of maximum grades up to 10% negligibly impacts energy consumption and run-times.

TABLE 5-1

REGIONAL SYSTEM NORMAL OPERATION
CLEVELAND LINE

			1 Pgh Airprt	2 New Castle	3 Yngstwn/ Warren	4 Akron/ Canton	5 Clev Airprt
1	Pittsburgh Airport, PA	Miles Hrs:Min		40 00:14	60 00:28	103 00:42	134 00:55
2	New Castle, PA	Miles Hrs:Min	40 00:14		21 00:11	64 00:26	94 00:38
3	Youngstown/Warren, OH	Miles Hrs:Min	60 00:28	21 00:11		43 00:12	73 00:24
4	Akron/Canton, OH	Miles Hrs:Min	103 00:42	64 00:26	43 00:12		30 00:10
5	Cleveland Airport, OH	Miles Hrs:Min	134 00:55	94 00:38	73 00:24	30 00:10	

TABLE 5-2

REGIONAL SYSTEM NORMAL OPERATION
ERIE LINE

			1 Pgh Airport	2 New Castle	3 Erie
1	Pittsburgh Airport, PA	Miles Hrs:Min		40 00:14	120 00:38
2	New Castle, PA	Miles Hrs:Min	40 00:14		80 00:21
3	Erie, PA	Miles Hrs:Min	120 00:38	80 00:21	

TABLE 5-3

REGIONAL SYSTEM NORMAL OPERATION
PHILADELPHIA LINE VIA TURTLE CREEK LINE

			1 Pgh Airprt	2 Pgh Dtwn	3 Grnsbrg	4 Jhnstwn	5 Altna	6 St Col	7 Lwstn	8 Harsbrg	9 Lancstr	10 Gr Val/ Paoli	11 Phil Dntwn	12 Phil Airprt
1	Pittsburgh Airport, PA	Miles		18	49	88	122	160	192	256	290	330	355	361
		Hrs:Min		00:08	00:27	00:44	00:58	01:12	01:26	01:47	02:00	02:14	02:29	02:36
2	Pittsburgh Downtown, PA	Miles	18		30	70	104	142	174	238	272	312	337	343
		Hrs:Min	00:08		00:17	00:33	00:47	01:01	01:15	01:37	01:50	02:03	02:19	02:25
3	Greensburg, PA	Miles	49	30		40	74	111	143	207	242	281	306	313
		Hrs:Min	00:27	00:17		00:14	00:28	00:42	00:56	01:18	01:30	01:44	02:00	02:06
4	Johnstown, PA	Miles	88	70	40		34	72	103	168	202	242	266	273
		Hrs:Min	00:44	00:33	00:14		00:11	00:25	00:40	01:01	01:14	01:28	01:43	01:50
5	Altoona, PA	Miles	122	104	74	34		38	69	134	168	208	232	239
		Hrs:Min	00:58	00:47	00:28	00:11		00:11	00:26	00:47	01:00	01:14	01:29	01:36
6	State College, PA	Miles	160	142	111	72	38		32	96	130	170	195	201
		Hrs:Min	01:12	01:01	00:42	00:25	00:11		00:12	00:33	00:46	01:00	01:15	01:22
7	Lewistown, PA	Miles	192	174	143	103	69	32		64	99	138	163	170
		Hrs:Min	01:26	01:15	00:56	00:40	00:26	00:12		00:19	00:32	00:45	01:01	01:08
8	Harrisburg, PA	Miles	256	238	207	168	134	96	64		34	74	99	105
		Hrs:Min	01:47	01:37	01:18	01:01	00:47	00:33	00:19		00:10	00:24	00:39	00:46
9	Lancaster, PA	Miles	290	272	242	202	168	130	99	34		40	64	71
		Hrs:Min	02:00	01:50	01:30	01:14	01:00	00:46	00:32	00:10		00:11	00:27	00:33
10	Greater Valley/Paoli, PA	Miles	330	312	281	242	208	170	138	74	40		25	31
		Hrs:Min	02:14	02:03	01:44	01:28	01:14	01:00	00:45	00:24	00:11		00:13	00:20
11	Philadelphia Downtown, PA	Miles	355	337	306	266	232	195	163	99	64	25		6
		Hrs:Min	02:29	02:19	02:00	01:43	01:29	01:15	01:01	00:39	00:27	00:13		00:04
12	Philadelphia Airport, PA	Miles	361	343	313	273	239	201	170	105	71	31	6	
		Hrs:Min	02:36	02:25	02:06	01:50	01:36	01:22	01:08	00:46	00:33	00:20	00:04	

TABLE 5-4

REGIONAL SYSTEM NORMAL OPERATION
PHILADELPHIA LINE VIA ALLEGHENY VALLEY LINE

			1 Pgh Airport	2 Pgh Dtwn	3 Indna	4 Jhnstwn	5 Altna	6 St Col	7 Lwstn	8 Harsbrg	9 Lancstr	10 Gr Val/ Paoli	11 Phil Dntwn	12 Phil Airprt
1	Pittsburgh Airport, PA	Miles		18	76	107	141	178	210	274	309	348	373	380
		Hrs:Min		00:08	00:31	00:45	00:59	01:13	01:28	01:49	02:02	02:16	02:31	02:38
2	Pittsburgh Downtown, PA	Miles	18		58	89	123	160	192	256	291	330	355	361
		Hrs:Min	00:08		00:21	00:35	00:49	01:03	01:17	01:38	01:51	02:05	02:20	02:27
3	Indiana, PA	Miles	76	58		30	64	102	134	198	232	272	297	303
		Hrs:Min	00:31	00:21		00:11	00:25	00:39	00:54	01:15	01:28	01:42	01:57	02:04
4	Johnstown, PA	Miles	107	89	30		34	72	103	168	202	242	266	273
		Hrs:Min	00:45	00:35	00:11		00:11	00:25	00:40	01:01	01:14	01:28	01:43	01:50
5	Altoona, PA	Miles	141	123	64	34		38	69	134	168	208	232	239
		Hrs:Min	00:59	00:49	00:25	00:11		00:11	00:26	00:47	01:00	01:14	01:29	01:36
6	State College, PA	Miles	178	160	102	72	38		32	96	130	170	195	201
		Hrs:Min	01:13	01:03	00:39	00:25	00:11		00:12	00:33	00:46	01:00	01:15	01:22
7	Lewistown, PA	Miles	210	192	134	103	69	32		64	99	138	163	170
		Hrs:Min	01:28	01:17	00:54	00:40	00:26	00:12		00:19	00:32	00:45	01:01	01:08
8	Harrisburg, PA	Miles	274	256	198	168	134	96	64		34	74	99	105
		Hrs:Min	01:49	01:38	01:15	01:01	00:47	00:33	00:19		00:10	00:24	00:39	00:46
9	Lancaster, PA	Miles	309	291	232	202	168	130	99	34		40	64	71
		Hrs:Min	02:02	01:51	01:28	01:14	01:00	00:46	00:32	00:10		00:11	00:27	00:33
10	Greater Valley/Paoli, PA	Miles	348	330	272	242	208	170	138	74	40		25	31
		Hrs:Min	02:16	02:05	01:42	01:28	01:14	01:00	00:45	00:24	00:11		00:13	00:20
11	Philadelphia Downtown, PA	Miles	373	355	297	266	232	195	163	99	64	25		6
		Hrs:Min	02:31	02:20	01:57	01:43	01:29	01:15	01:01	00:39	00:27	00:13		00:04
12	Philadelphia Airport, PA	Miles	380	361	303	273	239	201	170	105	71	31	6	
		Hrs:Min	02:38	02:27	02:04	01:50	01:36	01:22	01:08	00:46	00:33	00:20	00:04	

TABLE 5-5

REGIONAL SYSTEM NORMAL OPERATION
BALTIMORE LINE

			1 Pgh Airprt	2 Pgh Dtwn	3 Untwn	4 Cmbrlnd	5 Mrtnbg	6 Fredrck	7 Balt-Wash Airprt	8 Balt Dtwn	9
1	Pittsburgh Airport, PA	Miles		18	67	134	183	214	260	270	29
		Hrs:Min		00:08	00:30	00:54	01:12	01:25	01:41	01:49	00:12
2	Pittsburg Downtown, PA	Miles	18		49	116	165	196	242	252	0
		Hrs:Min	00:08		00:19	00:43	01:01	01:15	01:30	01:38	00:00
3	Uniontown, PA	Miles	67	49		67	116	147	193	203	0
		Hrs:Min	00:30	00:19		00:22	00:40	00:53	01:08	01:17	00:00
4	Cumberland, MD	Miles	134	116	67		49	81	126	136	0
		Hrs:Min	00:54	00:43	00:22		00:16	00:29	00:44	00:53	00:00
5	Martinsburg, WV	Miles	183	165	116	49		31	77	87	0
		Hrs:Min	01:12	01:01	00:40	00:16		00:11	00:26	00:35	00:00
6	Frederick, MD	Miles	214	196	147	81	31		46	56	0
		Hrs:Min	01:25	01:15	00:53	00:29	00:11		00:13	00:21	00:00
7	Baltimore-Washington Airport, MD	Miles	260	242	193	126	77	46		10	0
		Hrs:Min	01:41	01:30	01:08	00:44	00:26	00:13		00:06	00:00
8	Baltimore Downtown, MD	Miles	270	252	203	136	87	56	10		0
		Hrs:Min	01:49	01:38	01:17	00:53	00:35	00:21	00:06		00:00

TABLE 5-6

REGIONAL SYSTEM NORMAL OPERATION
BALTIMORE/WASHINGTON LINE

		1 Balt- Wash Airprt	2 Wash Dtwn
1 Baltimore-Washington Airport, MD	Miles Hrs:Min		29 00:12
2 Washington Downtown, DC	Miles Hrs:Min	29 00:12	

TABLE 5-7

REGIONAL SYSTEM NORMAL OPERATION
WEST VIRGINIA LINE

			1 Pgh Airprt	2 Wash	3 Mrgntwn	4 Clksbg	5 Chrlstn	6 Hntgtn
1	Pittsburgh Airport, PA	Miles		26	66	98	205	251
		Hrs:Min		00:10	00:24	00:37	01:06	01:28
2	Washington, PA	Miles	26		40	73	180	226
		Hrs:Min	00:10		00:12	00:24	00:54	01:16
3	Morgantown, WV	Miles	66	40		32	139	185
		Hrs:Min	00:24	00:12		00:10	00:40	01:02
4	Clarksburg, WV	Miles	98	73	32		107	153
		Hrs:Min	00:37	00:24	00:10		00:27	00:49
5	Charlestown, WV	Miles	205	180	139	107		46
		Hrs:Min	01:06	00:54	00:40	00:27		00:19
6	Huntington, WV	Miles	251	226	185	153	46	
		Hrs:Min	01:28	01:16	01:02	00:49	00:19	

TABLE 5-8

REGIONAL SYSTEM NORMAL OPERATION
MID OHIO LINE

			1 Pgh Airprt	2 Wash	3 Whlg	4 Znsvle	5 Clmbus
1	Pittsburgh Airport, PA	Miles Hrs:Min		26 00:10	58 00:27	129 00:49	183 01:08
2	Washington, PA	Miles Hrs:Min	26 00:10		32 00:15	104 00:36	158 00:56
3	Wheeling, WV	Miles Hrs:Min	58 00:27	32 00:15		71 00:19	125 00:39
4	Zanesville, OH	Miles Hrs:Min	129 00:49	104 00:36	71 00:19		54 00:17
5	Columbus, OH	Miles Hrs:Min	183 01:08	158 00:56	125 00:39	54 00:17	

TABLE 5-9

REGIONAL SYSTEM NORMAL OPERATION
STEUBENVILLE SPUR

			1 Pgh Airprt	2 Wrtn/Stbnvl
1	Pittsburgh Airport, PA	Miles Hrs:Min		22 00:12
2	Weirton,WV/Steubenville,OH	Miles Hrs:Min	22 00:12	

TABLE 5-10

SUBURBAN SYSTEM NORMAL OPERATION
ALLEGHENY VALLEY LINE

		1 Pgh Airprt	2 Pgh Dtwn	3 Oaklnd	4 Fox Chpl	5 New Ken	6 Apollo/Van	7 Indna
1 Pittsburgh Airport	Miles Hrs:Min		18 00:08	22 00:13	30 00:21	41 00:29	53 00:38	76 00:49
2 Pittsburgh Downtown	Miles Hrs:Min	18 00:08		4 00:03	12 00:10	23 00:19	34 00:27	58 00:38
3 Oakland	Miles Hrs:Min	22 00:13	4 00:03		7 00:05	19 00:14	30 00:22	54 00:33
4 Fox Chapel	Miles Hrs:Min	30 00:21	12 00:10	7 00:05		12 00:06	23 00:14	47 00:25
5 New Kensington	Miles Hrs:Min	41 00:29	23 00:19	19 00:14	12 00:06		11 00:06	35 00:17
6 Apollo/Vandergrift	Miles Hrs:Min	53 00:38	34 00:27	30 00:22	23 00:14	11 00:06		24 00:08
7 Indiana	Miles Hrs:Min	76 00:49	58 00:38	54 00:33	47 00:25	35 00:17	24 00:08	

TABLE 5-11

SUBURBAN SYSTEM NORMAL OPERATION
TURTLE CREEK LINE

			1 Pgh Airprt	2 Pgh Dtwn	3 Steel Val	4 Monrvl	5 Grnsbrg
1	Pittsburgh Airport	Miles		18	25	34	49
		Hrs:Min		00:08	00:15	00:23	00:35
2	Pittsburgh Downtown	Miles	18		7	16	30
		Hrs:Min	00:08		00:04	00:12	00:25
3	Steel Valley	Miles	25	7		9	23
		Hrs:Min	00:15	00:04		00:06	00:18
4	Monroeville	Miles	34	16	9		15
		Hrs:Min	00:23	00:12	00:06		00:10
5	Greensburg	Miles	49	30	23	15	
		Hrs:Min	00:35	00:25	00:18	00:10	

TABLE 5-12

SUBURBAN SYSTEM NORMAL OPERATION
MON VALLEY LINE

		1 Pgh Airprt	2 Pgh Dtwn	3 Steel Val	4 Mon-Ygh	5 Mid-Mon Val	6 Uniontwn
1 Pittsburgh Airport	Miles		18	25	32	39	67
	Hrs:Min		00:08	00:15	00:22	00:28	00:42
2 Pittsburgh Downtown	Miles	18		7	14	21	49
	Hrs:Min	00:08		00:04	00:11	00:17	00:31
3 Steel Valley	Miles	25	7		7	14	42
	Hrs:Min	00:15	00:04		00:04	00:10	00:25
4 Mon-Yough	Miles	32	14	7		7	35
	Hrs:Min	00:22	00:11	00:04		00:04	00:18
5 Mid-Mon Valley	Miles	39	21	14	7		28
	Hrs:Min	00:28	00:17	00:10	00:04		00:12
6 Uniontown	Miles	67	49	42	35	28	
	Hrs:Min	00:42	00:31	00:25	00:18	00:12	

TABLE 5-13

SUBURBAN SYSTEM NORMAL OPERATION
WVA LINE

			1 Pgh Airprt	2 Wash	3 Mrgntwn
1	Pittsburgh Airport	Miles Hrs:Min		26 00:10	66 00:24
2	Washington	Miles Hrs:Min	26 00:10		40 00:12
3	Morgantown, WV	Miles Hrs:Min	66 00:24	40 00:12	

TABLE 5-14

SUBURBAN SYSTEM NORMAL OPERATION
MID OHIO LINE

			1 Pgh Airprt	2 Wash	3 Wheeling
1	Pittsburgh Airport	Miles Hrs:Min		26 00:10	58 00:27
2	Washington	Miles Hrs:Min	26 00:10		32 00:15
3	Wheeling, WV	Miles Hrs:Min	58 00:27	32 00:15	

TABLE 5-15

SUBURBAN SYSTEM NORMAL OPERATION
STEUBENVILLE SPUR

			1 Pgh Airprt	2 Wrtn/Stbnvl
1	Pittsburgh Airport	Miles Hrs:Min		22 00:12
2	Weirton,WV/Steubenville,OH	Miles Hrs:Min	22 00:12	

TABLE 5-16

SUBURBAN SYSTEM NORMAL OPERATION
BEAVER VALLEY LINE

			1 Pgh Airprt	2 Alqpa	3 New Castle
1	Pittsburgh Airport	Miles Hrs:Min		9 00:05	40 00:17
2	Aliquippa	Miles Hrs:Min	9 00:05		31 00:10
3	New Castle	Miles Hrs:Min	40 00:17	31 00:10	

TABLE 5-17

REGIONAL SYSTEM EXPRESS OPERATION
CLEVELAND LINE

		1 Pgh Airport	2 Clev Airprt
1 Pittsburgh Airport, PA	Miles Hrs:Min		134 00:36
2 Cleveland Airport, OH	Miles Hrs:Min	134 00:36	

TABLE 5-18

REGIONAL SYSTEM EXPRESS OPERATION
ERIE LINE

			1 Pgh Airprt	2 Erie
1	Pittsburgh Airport, PA	Miles Hrs:Min		120 00:32
2	Erie, PA	Miles Hrs:Min	120 00:32	

TABLE 5-19

REGIONAL SYSTEM EXPRESS OPERATION
PHILADELPHIA LINE

			1 Pgh Airprt	2 Pgh Dtwn	3 Hrsbrg	4 Phil Dtwn	5 Phil Airprt
1	Pittsburgh Airport, PA	Miles Hrs:Min		18 00:08	251 01:20	349 01:51	356 01:58
2	Pittsburgh Downtown, PA	Miles Hrs:Min	18 00:08		232 01:09	331 01:41	338 01:48
3	Harrisburg, PA	Miles Hrs:Min	251 01:20	232 01:09		99 00:30	105 00:37
4	Philadelphia Downtown, PA	Miles Hrs:Min	349 01:51	331 01:41	99 00:30		6 00:04
5	Philadelphia Airport, PA	Miles Hrs:Min	356 01:58	338 01:48	105 00:37	6 00:04	

TABLE 5-20

REGIONAL SYSTEM EXPRESS OPERATION
WESTERN MARYLAND LINE

			1 Pgh Airprt	2 Pgh Dtwn	3 Cmbrlnd	4 Balt-Wash Airprt
1	Pittsburgh Airport, PA	Miles		18	134	260
		Hrs:Min		00:08	00:47	01:21
2	Pittsburgh Downtown, PA	Miles	18		116	242
		Hrs:Min	00:08		00:36	01:10
3	Cumberland, MD	Miles	134	116		126
		Hrs:Min	00:47	00:36		00:33
4	Baltimore-Washington Airport, MD	Miles	260	242	126	
		Hrs:Min	01:21	01:10	00:33	

TABLE 5-21

REGIONAL SYSTEM EXPRESS OPERATION
WVA LINE

		1 Pgh Airprt	2 Chrlstn
1 Pittsburgh Airport, PA	Miles Hrs:Min		205 00:51
2 Charleston, WV	Miles Hrs:Min	205 00:51	

TABLE 5-22

REGIONAL SYSTEM EXPRESS OPERATION
MID OHIO LINE

			1 Pgh Airprt	2 Colmbs
1	Pittsburgh Airport, PA	Miles Hrs:Min		183 00:50
2	Columbus, OH	Miles Hrs:Min	183 00:50	

6.0 ECONOMIC AND FINANCIAL ANALYSIS

The economic and financial analysis is a preliminary attempt to estimate the costs, revenues and economic benefits that may be realized from the manufacturing and construction of the Regional System.

Computer models obtained from third-party vendors were utilized for passenger revenue analysis and economic development impacts. A third computer model was utilized in order to coordinate the data from the existing models, generate capital costs, generate operating and maintenance costs and provide preliminary economic analysis of the Regional system.

6.1 ECONOMIC MODEL

An "economic model" was used in order to analyze the quantitative aspects of the regional system. The economic model is a computer program that generates information regarding costs, revenues and the projected cash flows that can be obtained in the future. The model can be utilized to analyze various scenarios in order to determine the optimal construction and operation schedule of the Regional system. The economic model's input files currently include output files generated from three external models; COMSIS Corporation's MINUTP, Regional Economic Models, Inc. (REMI), and Carnegie Mellon University's Train Performance Simulator. The MINUTP model is a travel demand forecasting model that generates an origin-destination output file that is used by the economic model for revenue forecasts and fleet capacity calculations. The REMI model is an Input-Output model used to forecast the economic effects caused by external events such as large-scale construction projects. The Train Performance Simulator provided the energy and station-to-station travel time requirements for each section of the Regional lines and is used in the calculation of the operating and maintenance costs.

The analysis phase is an iterative process. First, a variety of operating scenarios were run through MINUTP varying running times, frequency of service, and fares. Each of these runs produced forecasted origin-destination reports for the proposed system. The passenger revenue module generates passenger revenue and link volumes for each station pair in the Regional system. The link volumes are used to produce vehicle requirements and station sizes for the capital cost module.

Next, the capital costs for the system are calculated using alignment data, unit cost data, and the construction schedule. The origin-destination reports and the associated operation scenario, energy requirements, and the unit cost data is used by the O&M cost module to generate operating and maintenance costs.

The calculated capital and O&M costs are then divided into the industry classifications where the expenditures are expected to occur and output by the report generator module. This file is then used as input to the REMI module. The results of the REMI model are then input into the Economic Development module. Finally, the report generator module calculates the projected cash flow summary.

Figure 6-1 shows a data flow diagram of the process followed for the economic and financial analysis. The circles represent computer modules internal to the economic model and the external computer models that are used. The open-ended boxes represent data files. The solid directional arrows represent a flow of information between the modules and models.

6.1.1 COSTS

Costs can be broken into three general categories; capital costs, operating costs, and debt service costs. Each of the costs are briefly described below along with the methods of estimation.

6.1.1.1 Capital Costs

Capital costs include all of the costs required before service can begin and in general are one-time costs. These costs include the following seven categories of costs: guideway, special construction (land acquisition and civil works), equipment/facilities, station and M&O facilities, vehicle, "other items", and construction management. These categories are further broken into the individual components that comprise each category.

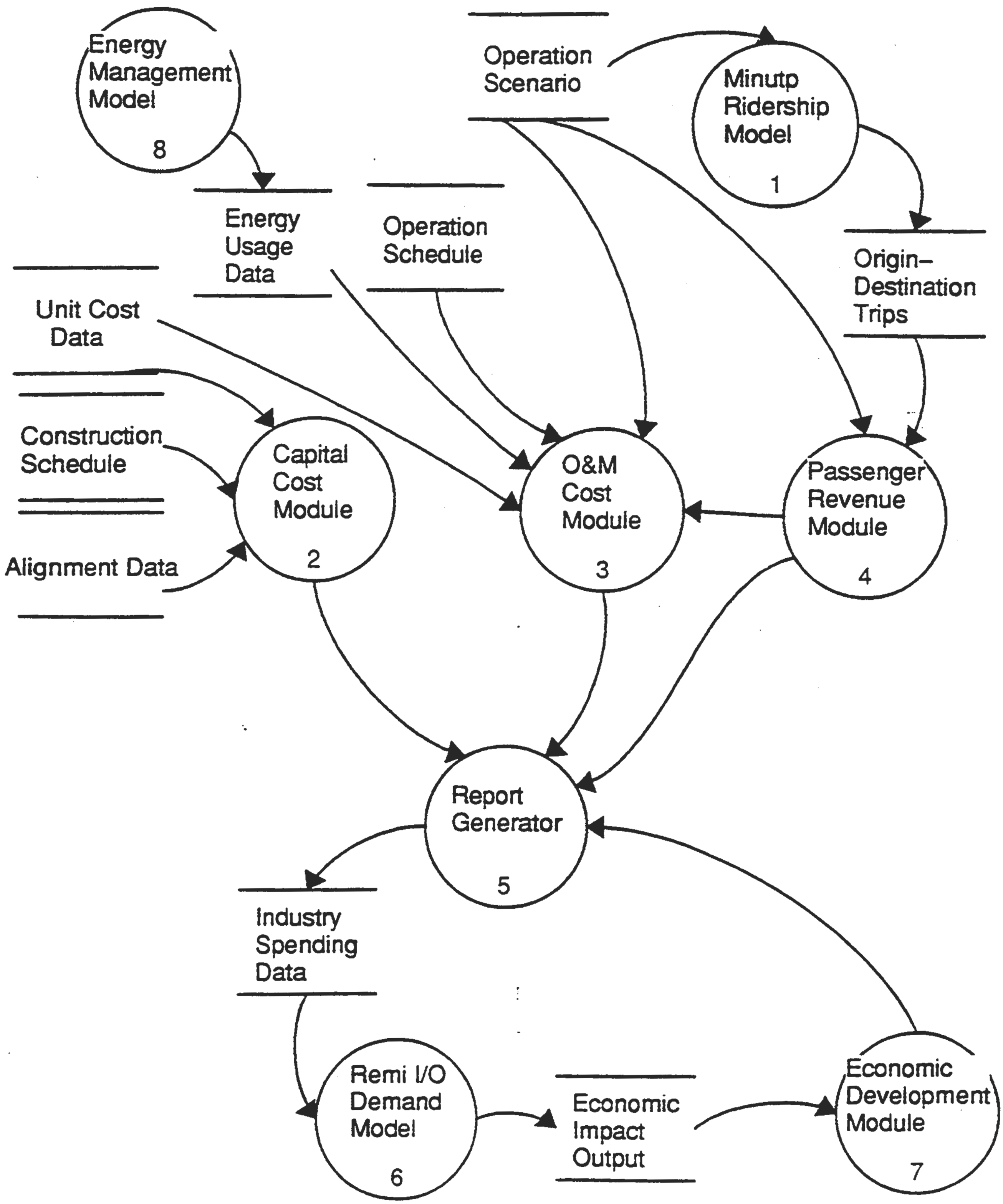

Energy Management Model
8
Operation Scenario
Minutp Ridership Model
1
Energy Usage Data
Operation Schedule
Origin–Destination Trips
Unit Cost Data
Construction Schedule
Capital Cost Module
2
O&M Cost Module
3
Passenger Revenue Module
4
Alignment Data
Report Generator
5
Industry Spending Data
Remi I/O Demand Model
6
Economic Impact Output
Economic Development Module
7

FIGURE 6-1

In addition to the seven categories of costs, there are startup costs for plants, machinery and engineering services prior to the construction of the MAGLEV system.

Capital costs are computed by the economic model using alignment data for each segment generated from topographical maps, switch configuration data, station configuration data, vehicle requirements, and miscellaneous cost estimates. The unit cost values were provided primarily by Michael Baker Jr., Inc. and are derived from a combination of current construction practices and estimates provided by Transrapid International, local metal fabrication firms and CMU.

6.1.1.2 Operating and Maintenance Costs

Operating and maintenance costs reflect the expenses associated with running the system using two different models.

The first model divides O&M costs into four basic types: transportation, maintenance, energy, and administrative. These O&M costs are developed using internally generated estimates obtained from AEG Westinghouse, Transrapid, and CMU.

Transportation costs are computed based on a combination of estimated train schedules, estimated train crew personnel costs, and estimated traffic control costs. Personnel costs reflect those of the Pittsburgh area for the new Midfield Terminal at the Pittsburgh International Airport that opened in October 1992.

Maintenance costs are computed based on the alignment data, estimated train schedules and estimated maintenance costs provided by Transrapid.

Energy costs are computed by Carnegie Mellon's Energy Management Model (EMM), which is described in Section 6.3.1, System Running Times, of this report. The results of the EMM are used as input by the economic model along with energy unit cost estimates obtained from Duquesne Light. This model also provides running times which are used in the demand model to determine ridership.

Administrative costs are computed as an incremental percentage of costs based on the estimates of the other three sub-components of the operating costs.

The second model was developed by the Transportation Research Board (TRB) in the study "In Pursuit of Speed". The TRB model is used to validate O&M costs for reasonableness.

6.1.1.3 Debt Service Costs

Debt service costs are computed by the economic model based on the cumulative capital debt in each time period at an interest rate that can be varied by the user. Capital debt (CD) can be defined as the total capital costs (CC) and the capital debt service (CDS) incurred through the current period less any capital subsidies (CS) and capital repayments (CR) from previous periods (CD = CC + CDS - CS - CR).

6.1.2 REVENUES

The primary source of revenues for the regional system occurs from transportation revenue. Transportation revenue can be further divided into passenger revenue and freight revenue. The single largest source of operational revenue for the Regional system will be provided by passenger revenue. Passenger revenue is computed by the economic model based on the origin-destination data, link volumes, link distances between stations, and the fare structure used to generate the origin-destination reports.

Other revenue can also be realized from high priority freight and development around stations.

6.1.3 ECONOMIC BENEFITS

The economic benefits resulting from infrastructure construction may occur in many areas but the amount of new job creation and increased economic output are the two primary measures of interest.

Utilizing the economic model, various construction and operating scenarios were developed and the expenditures required by time period and industry were calculated. This data is then input into the REMI model and a variety of forecast data is output. The output is analyzed and growth factors are calculated based on standardized units of investment (e.g. per billion dollars or per million dollars).

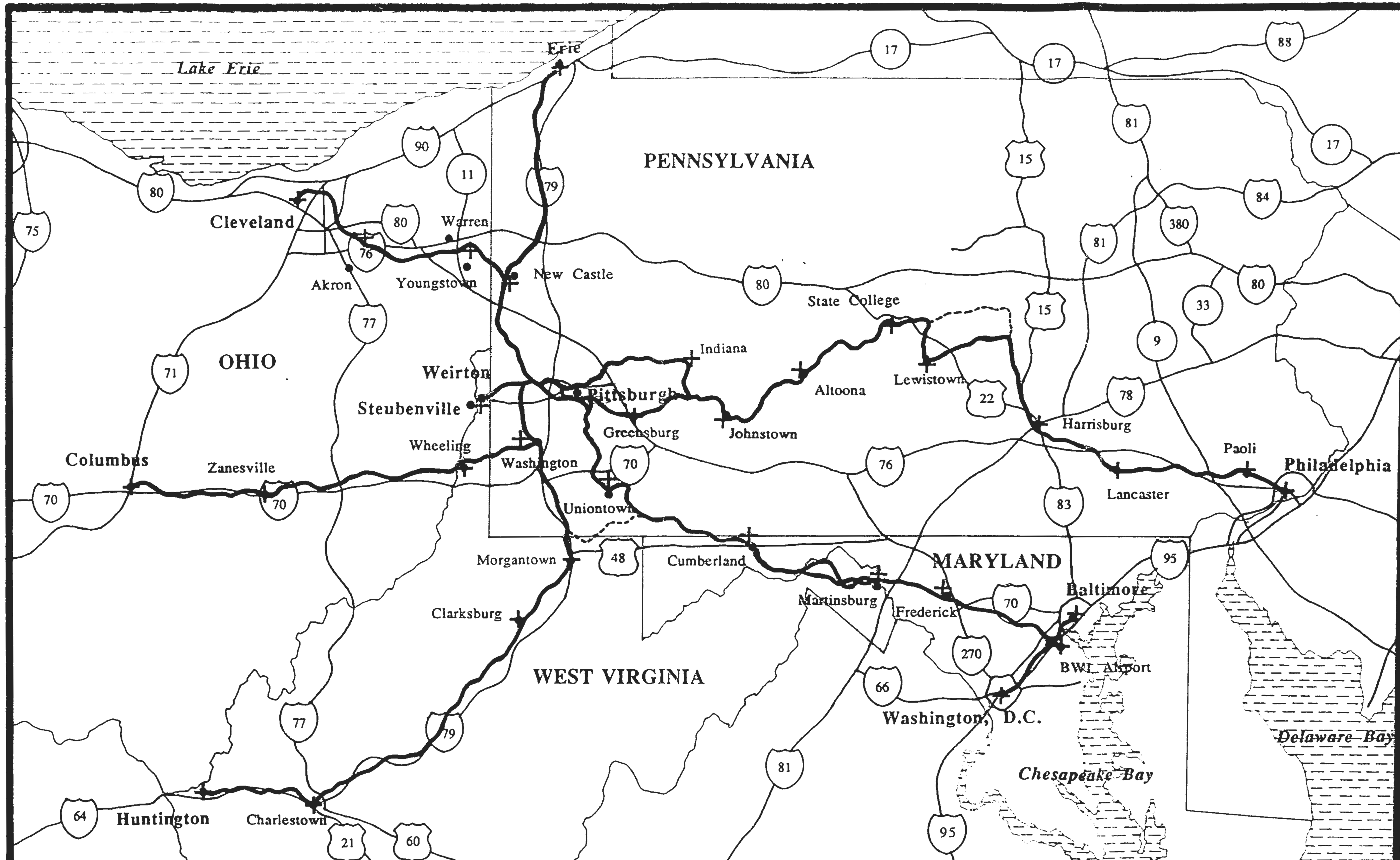
6.1.3.1 Manufacturing Economic Impact

A major economic benefit to the region will be through job creation for manufacturing the systems. The following is a brief description of the technology related to its manufacture and economic impact on the region. With a potential market of more than $200 billion for High Speed MAGLEV Systems in the U.S. and the realization that a majority of this market could be served by the Pittsburgh region, it is easy to see why it makes sense to establish this region as the manufacturing center for MAGLEV systems. The technology requires material and equipment that ranges from the basic steel and heavy construction for the guideway to the high technology aerospace and electronics for the power conditioning, communications equipment and leading edge vehicle scheduling/control systems.

Supply Requirement

The elevated support system that the vehicles glide over will require approximately 5,000 tons of steel per mile of installation. The bulk of this steel is rolled plate for the guideway beams. The linear motor, which is also part of the guideway and provides the propulsion for the vehicles, requires approximately 275 tons of magnetic steel per mile of installed guideway. These requirements will result in a resurgence of the basic manufacturing industries and will provide a new opportunity for blue collar employment within the area. The high technology areas of the MAGLEV system will continue to provide job growth within the region for the engineering and other high tech talent.

It is anticipated that the demand volume will reach more than 100 miles of installation per year. If production is limited to 40 miles of installation per year (a 2010 goal), it will take more than 32 years to complete the 1300 miles of routes already defined. The potential miles of installation that have been identified to



PITTSBURGH REGIONAL SYSTEM

FIGURE 5-3

date are more in the range of 3000 miles, increasing as the systems come on line. Even when manufacturing production and installation reach 100 miles per year, it will require 30 years to build.

As MAGLEV becomes the technology of choice for HSGT in North America, the number of miles of installation per year will continue to increase. The on-going engineering mission will result in cost reductions and system improvements that will continue to reduce the cost per mile of installation. The market for this type of transportation will continue to increase and should begin to accelerate to its peak after the year 2020.

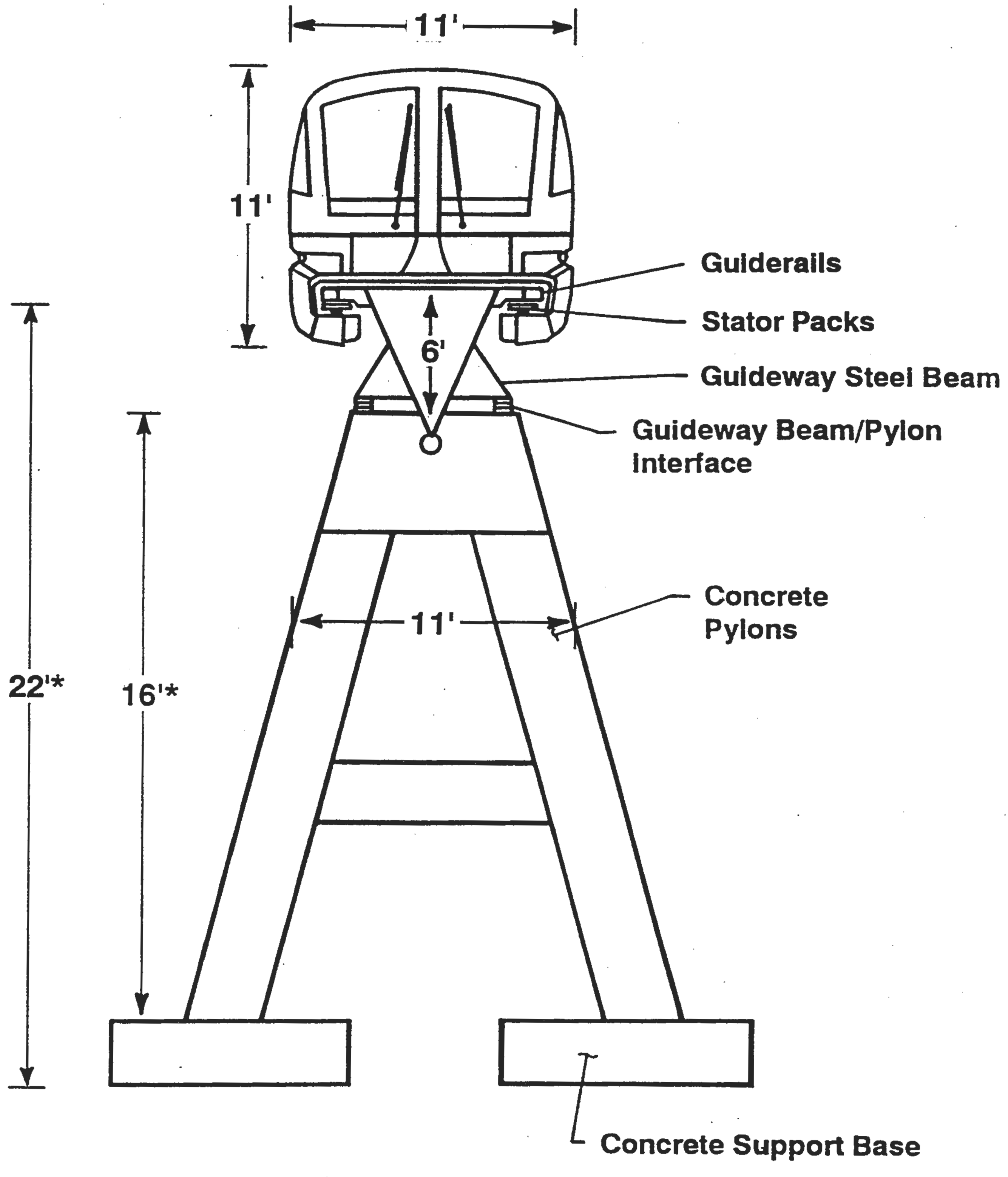
Integrated Engineering And Manufacture

Limited engineering and analysis was done to determine the expected cost of the guideway fabrication along with its attached equipment and to define how the manufactured tolerances can be met with an integrated design/manufacturing software package for the engineering and production processes. This integrated process is based on current directions in large scale construction, the availability of newer software packages and a greater understanding of how to integrate the alignment, engineering, and production processes. The integrated package provides a "network" simulation with interactive graphics that permit detail route alignments for designing the guideway geometry, propulsion equipment, and vehicle interface to the guideway within the allowed tolerances and operating envelope of the system. The alignments then produce outputs for robotic equipment that either produces the components to the required tolerances or defines the component and tolerances for suppliers. The perfection of this package will have economic benefits beyond the MAGLEV projects.

(The present electromagnetic system that has successfully been operating on the 19 mile test track in Germany will provide the foundation for the technology. The MAGLEV Inc. engineering effort will provide the technical and economic improvements to make the system applicable to the American market.)

System Description Guideway

The guideway (Figure 6-2) represents more than 60% of the system capital cost. It is an elevated structure (approximately 16 feet above the terrain) with



Dimensions are approximate

* Dimension varies per alignment

FIGURE 6-2

prefabricated steel beams set on a concrete support system. The support system is a reinforced concrete pillar fastened to a special reinforced concrete foundation that provides long term stability for the vehicle glide plane. The beams, including the guideway switches, along with the concrete structures form a continuous support system for the vehicle propulsion, lift and lateral guidance control.

The shape of the guideway is adjusted to the track alignment and gradient features required for super speed operation. Because of the requirements of the geometry, the beams are not completely identical in shape. Because of the strict tolerance conditions, this operation requires the automated production concept to achieve the accuracy, necessary for long term maintenance free operation.

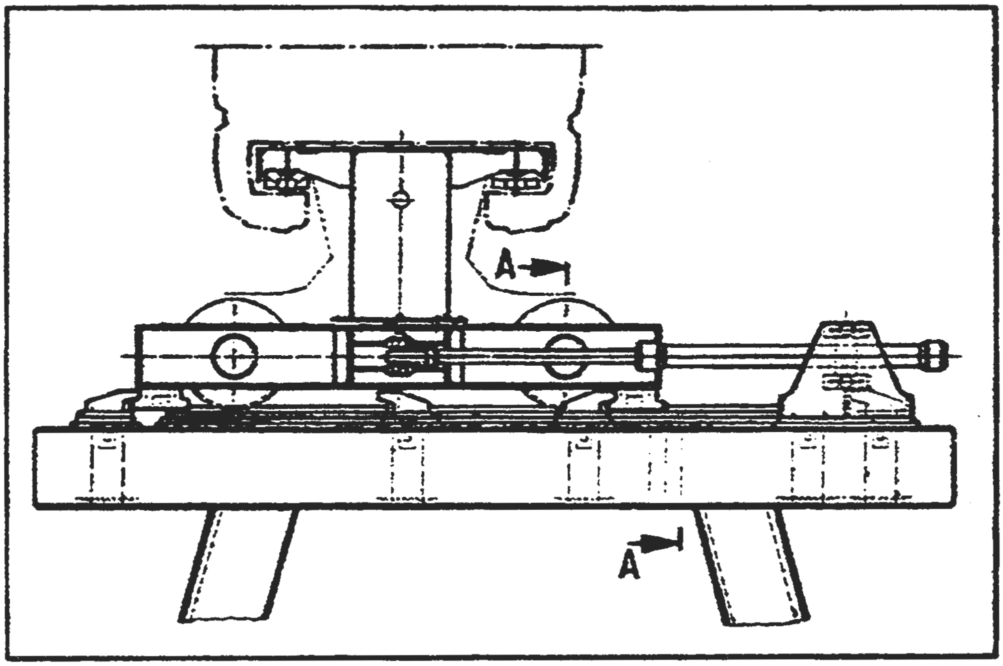
Guideway Switch

The guideway track switches are based on the box girder principle (Figure 6-3). This relatively slim box girder has been designed as a multi-span, continuous welded girder. At the individual bearing points, the girder rests on transverse support frames which sit on mobile support sub switches that use two wheels each. The attachment of the functional components such as the lateral guide rails, the emergency slide surfaces, and the stator supports are joined to the box girder as an integrated welded structure.

Propulsion

The motor consists of the stator packs, successively mounted along the guideway and the three-phase stator windings, subdivided into sections and supplied alternately by stationary converter stations with three-phase current of variable frequency and voltage. The stator packs and the associated three-phase stator winding are fixed to the underside of both sides of the track. In addition to the propulsion components, the glide plane is fitted on each side with magnetic steel rails, for the electro-magnetic guidance and lateral stability of the vehicle (Figure 6-2).

This type of drive permits the transmission of thrust and brake forces without contact and thus independence from adhesion coefficients. An iron-cored synchronous long stator motor in suspension stator design is the propulsion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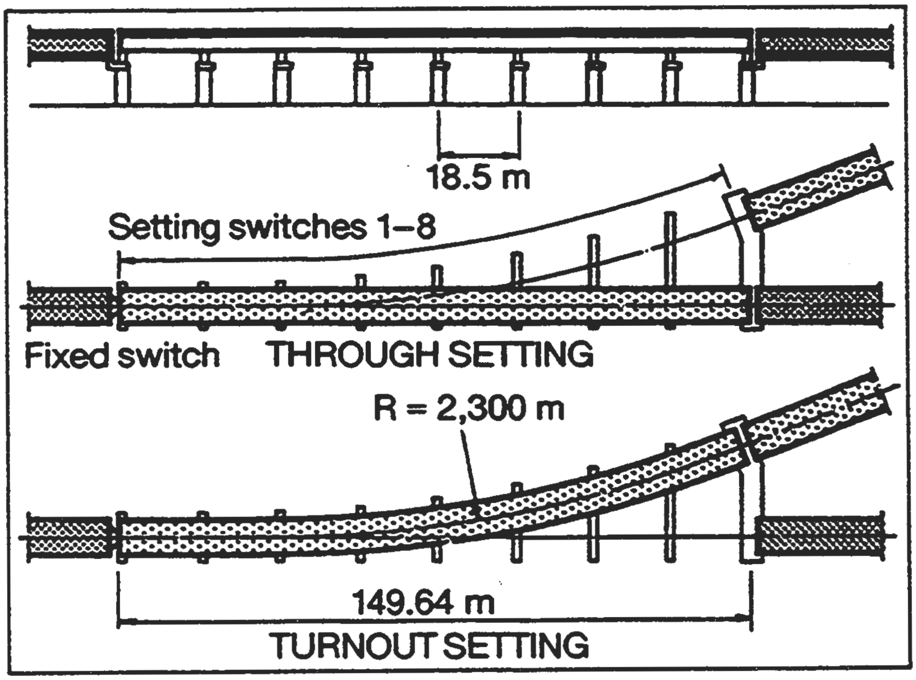

18.5 m
Setting switches 1–8
Fixed switch
THROUGH SETTING
R = 2,300 m
149.64 m
TURNOUT SETTING

FIGURE 6-3

system. The suspension magnets of the system also act as the synchronous magnets of the motor. The stator, with its three-phase traveling-field winding is attached to the guideway beam profile-piece (Figure 6-2). This winding is divided into separate feeder sections to effect vehicle speed and control.

Through variation of the length of these motor sections, the propulsion system can be adjusted to meet the demands of the alignment, of the gradients, of the acceleration and of the steady-state sections, as well as, of the headway and the length of the vehicle. The course of the sequences of stators is defined by the space curve laid in guideway alignment, and partly is composed of complex mathematical functions.

The Vehicle

The vehicle, an aerodynamic design 84 feet long (single section), 12 feet wide and 13 feet high, can accommodate up to 120 passengers. The vehicles can be coupled to make up to an eight car train. The on-board batteries and linear generators provide the power for the gap control, levitation magnets, lateral control magnets, communication and air conditioning systems. Below 62 mph, the power is supplied from on-board batteries. Above 62 mph, power is supplied from the linear generators.

Control (Signaling) System

The operations center contains the computer control system that tracks the vehicle location and commands the energizing of the guideway propulsion system from a pre-programmed vehicle speed and location profile. The control loop is closed through a digital communication system that must be a vital link.

Supply Allocation

The private sector groups that will be involved in the engineering and manufacturing of the system are as follows:

The MAGLEV Engineering Group

This supplier will be responsible for the integrated software programs that define the system to be constructed. They would be responsible for the coordination of all system supply including the coordination with the system integration group.

Civil Engineering

This firm will responsible for the subsystem supply which furnishes the following: guideway alignment, construction, concrete, concrete forms, steel rebar, wayside equipment houses and foundations, maintenance and operations buildings, passenger stations, baggage handling equipment, ticketing and passenger access equipment, and the coordination and arrangements for public utilities required for the system.

Guideway Fabrication

This supplier will be responsible for the subsystem supply for guideway steel and other materials required for guideway fabrication and guideway switch fabrication.

Stator Pack

This supplier will be responsible for the subsystem supply of the stator steel, the stator cable, the stator fastening bolts, bolt failure detection sensors and all material required to fabricate the stator for installation on the guideway. The coordination for installation of the stator packs by the guideway fabricator and coordination for installation of the cable with the civil engineering company falls under this supply.

Electrical

This supplier will be responsible for acquisition and installation of all equipment required to condition the power from the utility for demand use at the stator. This includes all cabling necessary to effect the connections.

Signal and Communication

This supplier will be responsible for engineering the control for safe operation of the vehicles over the guideway, through switches and through the passenger stations. This includes acquisition and installation of the digital communications, the wayside equipment that may be required for vehicle detection, the interface to the stator pack bolt failure detection system, the computer system(s) necessary to effect the vehicle control, passenger station closed circuit TV, vehicle passenger door control, the maintenance voice and digital communication system, all cable required to effect the connections to the equipment as well as control system.

Vehicle

This supplier will be responsible for the total vehicle. This includes the vehicle frame, the vehicle shell, the vehicle interior furnishings, the on-board batteries, the levitation system, the lateral control system, the linear generators, the on-board computers, the passenger annunciation/entertainment system, all on-board emergency systems, and all cabling required for the installation of the subsystems.

Manufacturing Supply Selection

The Manufacturing Plan requires that specifications be developed for each of the major supply items. The execution of the supply contracts transforms the design into economic benefits at the job level. In order to begin the process of selecting suppliers, bid documents will be prepared that show the detail of the item to be manufactured. This bid document will also provide a description of the required manufacturing process including quality control requirements. This process will be an ongoing one as the material is transferred and evaluated for the local supply organizations.

6.2 MARKET DEMAND

Travel demand forecasts are seen as an important element in determining the operational economic viability of High Speed Ground Transportation (HSGT) systems. Therefore, it is critical that a thorough analysis be performed in order to achieve a high degree of credibility and accuracy.

The Market Demand model that was used in this study was originally designed by Parsons Brinckerhoff/Gannett Fleming for the Pennsylvania High Speed Intercity Rail Passenger Commission. The original model was designed for a single corridor between Pittsburgh, PA, and Philadelphia, PA. This model was then expanded by COMSIS Corporation for the Regional system by gathering data for the following corridors:

Cleveland, OH - Pittsburgh, PA
Columbus, OH - Pittsburgh, PA
Erie, PA - Pittsburgh, PA
Huntington, WV - Pittsburgh, PA
Philadelphia, PA - Pittsburgh, PA
Washington, DC - Pittsburgh, PA

The results of the model are used throughout the analysis of the regional system. This further underscores the importance of the Market Demand model. The model must provide reasonable estimates of the following:

- Origin and Destination volumes: to develop operating schedules and vehicle requirements, to determine station sizes and to prioritize the system's construction schedule.
- Total passenger miles: to optimize net revenues (the difference between revenues and operating costs) in order to quantify the economic impact and environmental benefits of the system.
- Market segment demand: to highlight the differences among the five major markets (commuter, business, tourist, school and other) in order to maximize revenues by targeting each individual market segment.

In order to ensure reasonable estimates of demand, there were a variety of sensitivity tests that were performed on the major independent variables that affect mode choice. These sensitivity tests included fare structure, service frequency, run times and access/egress times.

6.2.1 OVERVIEW OF MARKET DEMAND MODEL

The model for the Market Demand evaluation was developed by Parsons Brinckerhoff/Gannett Fleming (PB/GF) for the Pennsylvania High Speed Intercity Rail Passenger Commission. The PB/GF study for Pennsylvania closely followed the Standard Guidelines for Revenue and Ridership Forecasting that was developed by the High Speed Rail Association (HSRA). The HSRA developed the market demand guidelines to provide standards calling for realistic and conservative assumptions to lend greater credibility to ridership reports.

The original area of study was for the Pittsburgh to Philadelphia line. This line is also included in the regional system for this study. PB/GF's work evaluated several travel demand forecasting equations and selected two: a trip generation/distribution equation and a multi-nomial mode choice equation. The first equation is used to estimate the total trips that are expected to be made by each of the market segments. The second equation performs the modal split and assigns trips to each of the four potential modes: auto, air, bus or MAGLEV.

Next, a comprehensive origin-destination survey was undertaken to determine who was traveling in the corridor, for what reasons and how they were traveling. Other data collected from the survey include access times to the various terminals, the amount of time spent in the terminals, the time of day when the trips took place, where the trip started and where the trip ended.

Market research surveys were also conducted to gauge the subjective criteria that are used by travelers when choosing a travel mode. The volunteer groups were tested on factors such as comfort, convenience, reliability, perceived safety security and additional amenities.

Socioeconomic data from all of the original 108 origin-destination zones for the Pittsburgh to Philadelphia corridor were collected. The data for each zone included: population, area, average per capita income, number of families, average family income, employment density, labor force size, number of hotel/motel rooms and college enrollment.

After all of the data was collected and analyzed, the model was tested and calibrated to match the existing travel patterns in the corridor at the time of the survey (1985). Calibration consisted of running the model while varying key attributes of the equations until the results closely matched the known zone to zone travel patterns for each of the five market segments: commuter, business, tourist, school and other.

Once the model was calibrated and deemed reliable for the current data, the socioeconomic data was extrapolated to the year 2000. Then, hypothetical high speed ground transportation systems were incorporated into the model for both steel wheel and MAGLEV with associated run times based on the geography of the alignments. The result is an estimate of the zone to zone travel patterns expected in the Pittsburgh to Philadelphia corridor in the year 2000.

6.2.2 EXTENSION OF MARKET DEMAND MODEL TO REGIONAL SYSTEM

COMSIS Corporation was retained by Michael Baker Jr., Inc. to forecast the demand for a regional HSGT system that had Pittsburgh as the hub. The Regional system study built upon the work that was done by PB/GF for the Pittsburgh to Philadelphia corridor. COMSIS obtained the model and data that was used in the original study from PB/GF. The PB/GF model was then translated from the mainframe computer package UTPS to COMSIS' proprietary software package MINUTP. MINUTP is a microcomputer based multimodal transportation demand forecasting model.

After converting the original model from UTPS to MINUTP, COMSIS was able to calibrate the MINUTP model to within 1% of PB/GF's results for the Pittsburgh to Philadelphia corridor. COMSIS then modified the socioeconomic data sets to include the additional areas required for the expanded system. The expanded regional system will serve travelers from the states of Pennsylvania, Ohio, West Virginia, Maryland, New Jersey, Virginia and the District of Columbia.

There are a number of assumptions used to project the transportation demand in the future. Data obtained from the 1980 Census was used for the base year socioeconomic data. The future year scenarios used growth factors obtained from various regional agencies to project future conditions for the respective regions in the study from the 1980 Census data. The future scenario was extended from the year 2000 to the year 2010 in the COMSIS implementation. It was assumed that per capita income and average family income would stay constant in real dollars from 1980 to 2010. This is equivalent to income levels keeping pace with inflation.

The transportation systems used in the model reflect levels of service for the air, auto and bus modes at the time of the original study (1985). The assumption infers that future improvements will be made to coincide with levels of congestion. Therefore, the perceived travel times should remain nearly constant. The HSGT mode will consist of a combination of the conventional rail service and the proposed MAGLEV Regional network. Income levels were held constant in 1979 dollars (from the 1980 Census data). Therefore, travel costs were also left constant at 1979 levels internal to the model. After the model is run, the internal fares used in the model are converted to 1991 dollars to generate revenue projections. This conversion is performed using the Consumer Price Index for the transportation segment from the years 1980 through December 1991. Table 6-1, Consumer Price Index Increases for Intercity Travel, shows the annual increase in intercity fares.

The model is designed to forecast total demand for five distinct market segments or trip purposes: commuter, business, tourist, school and other. Each of the five segments use unique mathematical equations utilizing the socioeconomic data that best describes the demand for travel for that segment. The following equation is the generalized form of the trip generation/distribution.

$$Tpij = a[Fi]^{b} * [Fj]^{c} * [tpij]^{d} * [Cpij]^{e}$$

Explanation:
Tpij = Total number of one way trips for purpose p from zone i to zone j.
Fi = A socioeconomic factor for zone i.
Fj = A socioeconomic factor for zone j.
t = The weighted average travel time.
C = The weighted average travel cost.
a,b,c,d and e are constants derived from regression analysis.

The trip generation/distribution model establishes estimates of travel demand between each origin zone and each destination zone in the Regional study area. The model forecasts trip production, attraction and distribution in an integrated fashion which avoids the problems of calibrating each effect separately. The equations utilized by the Regional systems travel demand model for each mode's total trip demand are displayed in Table 6-2, Initial Trip Distribution Equations. The trip generation/distribution equations use social and economic variables along with measures of travel cost and time for each of the four modes between each pair of zones in order to estimate the total number of trips for each purpose.

Table 6-3, Calibrated Trip Generation/Distribution Model Coefficients, shows the calibrated coefficients that are used in trip generation/distribution model equations. The values displayed in Table 6-3 are the result of regression analysis performed in the original PB/GF work.

The equations utilized in the model for the modal split are displayed in Table 6-4, Modal Split Model Equations. Mode choice is dependent primarily upon the relationships between travel cost and total travel time. Travel time is directly composed of access time, line haul travel time and egress time. Travel time is also indirectly influenced by the frequency of service. Traveler perceptions about different transportation alternatives also affect the mode choice. These perceptions include safety, comfort and convenience. These perceptions are addressed in the modal split model equations by the Mode Bias Coefficient calculation shown in Table 6-4.

TABLE 6-1

CONSUMER PRICE INDEX INCREASES FOR INTERCITY TRAVEL

(1980-1991)

Intercity Transportation	
1980	14.3%
1981	17.8%
1982	4.8%
1983	7.0%
1984	10.7%
1985	6.3%
1986	4.9%
1987	2.0%
1988	7.1%
1989	1.7%
1990	6.6%
1991	2.0%

Source: U.S. Department of Labor
Bureau of Labor Statistics
Consumer Price Index
Table 5 - December 1980
Table 26 - October 1991

The December 1980 CPI tables divided intercity transportation into multiple categories. The Intercity Train Fare index was deemed to be the most appropriate index to use for that year. Subsequent years use the Other Intercity Transportation index. The numbers reflect percentage increases from the previous year.

TABLE 6-2
INITIAL TRIP GENERATION/DISTRIBUTION EQUATIONS

Commuter trips: $Tc_{ij} = a[LF_i]^d [E_j]^e [t_{ij}]^b [c_{ij}]^c$

Business trips: $Tb_{ij} = a[LF_i]^d [E_j]^e [t_{ij}]^b [c_{ij}]^c$

School trips: $Ts_{ij} = a[F_i]^g [CA_j]^k [t_{ij}]^b [c_{ij}]^c$

Tourist trips: $Tt_{ij} = a[P_i]^f [I_i]^l [P_j]^i [E_j]^e [H_j]^j [t_{ij}]^b [c_{ij}]^c$

Other trips: $To_{ij} = a[P_i]^f [E_j]^e [E_j/A_j]^h [t_{ij}]^b [c_{ij}]^c$

Explanation: tk_{ij} = Home-based trips from origin zone i to destination zone j for purpose k.

t_{ij} = Weighted average travel time between zones i and j.

c_{ij} = Weighted average travel cost per person between zones i and j.

LF_i = Labor force in origin zone i.

I_i = Per capita income in origin zone i.

E_j = Employment in destination zone j.

A_j = Area of destination zone j in square miles.

F_i = Number of families in origin zone i.

Yi = Average family income in origin zone i.

P_i = Population in origin zone i.

P_j = Population in destination zone j.

CA_j = College attendance in destination zone j.

H_j = Number of hotel/motel rooms in destination zone j.

a,b,c,d,e,f,g,h,i,j,k,l and m = coefficients uniquely determined for each trip purpose by regression.

TABLE 6-3

CALIBRATED TRIP GENERATION/DISTRIBUTION MODEL COEFFICIENTS

Exponent	Variable	Commuter	Business	Tourist	School	Other
a	constant	2576	2.239	59.38	45970	4650
b	cij	1.500	0.217	0.808	0.788	1.434
c	tij	1.000	1.200	0.050	0.010	0.050
d	LFi	0.229	0.376	0	0	0
e	Ej	0.800	0.500	0.100	0	0.213
f	Pi	0	0	0.100	0	0.125
g	Fi	0	0	0	0.250	0
h	Ej/Aj	0	0	0	0	0.118
i	Pj	0	0	0.100	0	0
j	Hj	0	0	0.100	0	0
k	CAj	0	0	0	0.080	0
l	Ii	0	0	0.100	0	0
m	Yi	0	0	0	0.763	0

TABLE 6-4
MODAL SPLIT MODEL EQUATIONS

$Pc = \exp(U_c) / \text{sum}(\exp(U_i))$

Explanation:

Pc = Probability of choosing mode c, c=1...4

exp = Base of natural logarithms

sum (exp(Ui)) = Summation of exponential of all utilities

Ui = Utility or relative value of mode i

$Ui = aC_i + bYT_i + (cY) / (2Fi) + dYAi + MBi$

Explanation:

C_i = Cost of mode i, in dollars

T_i = Travel time in mode i, in hours

F_i = Frequency of mode i (average number of departures per hour)

A_i = Access of mode i (miles to common carrier terminal)

Y = Annual family income in dollars/2000 working hours per year

MB = Mode Bias Coefficient

MODE SPLIT COEFFICIENT (LEVEL OF SERVICE VARIABLES)

Constant	Commuter	Business	Tourist	School	Other
a	-0.0303	-0.0202	-0.0313	-0.0313	-0.0313
b	-0.0163	-0.0163	-0.0048	-0.0144	-0.0144
c	-0.0438	-0.0244	-0.0006	-0.0145	-0.0019
d	-0.0013	-0.0006	-0.0026	-0.0065	-0.0026

Mode Bias Coefficients

$MB = MB1 + MB2 * D^5$

Explanation: D = distance in miles

MB1

Mode	Commuter	Business	Tourist	School	Other
Air	- 6.100	- 6.495	- 3.178	- 0.400	- 5.300
Bus	-2.707	-3.031	-2.740	-0.050	-0.100
Rail	-6.283	-6.667	-3.599	-1.000	-5.576

MB2

Mode	Commuter	Business	Tourist	School	Other
Air	0.392	0.352	0.190	0.060	0.140
Bus	0.005	0.005	0.005	0.005	0.085
Rail	0.377	0.300	0.190	0.060	0.190

6.2.3 PITTSBURGH SUBURBAN SYSTEM

Ridership levels for the Pittsburgh Suburban System were estimated utilizing data obtained from the Southwestern Pennsylvania Regional Planning Commission (SPRPC). The SPRPC is the Metropolitan Planning Organization (MPO) for the Greater Pittsburgh area and includes the six-county region surrounding the city. As an MPO, the SPRPC is responsible for developing and updating a comprehensive multi-modal transportation plan for the local six county region.

The SPRPC compiles current and future estimates of total passenger trips in the six county area for their regional transportation plan. The data contains the total trips between each of 995 zones for three types of trips: home-based work, home-based other and non home-based. The trip tables supplied by SPRPC provide the same basic function for the Suburban system as the trip generation/distribution model output does for the Regional system, estimating total trip demand for the appropriate region.

In order to determine the total number of trips for the Suburban system, the Suburban stations were overlaid onto the regional maps containing the zonal locations. Next, the zones that were expected to be serviced by each of the stations were aggregated into larger "service" zones. The service zones included all zones within an estimated ten minute access time by automobile. There are a total of thirteen service zones contained within the SPRPC data and a total of six suburban station areas outside of the six county region. Of the six areas outside of the six county region, four of the stations are included in the regional system ridership numbers. Therefore, only two stops have no ridership data associated with them. These two stops are Indiana, PA, and Weirton, WV/Steubenville, OH. Since neither the Regional or the Suburban ridership models accounted for ridership at these stations, the East Line to Philadelphia ridership numbers were modified to include an estimated ridership for these two cities. The method used to estimate this ridership involved finding Philadelphia East Line cities with similar populations to the two cities in question, and modifying these riderships by the ratio of the two cities' respective populations. Table 6-5, Projected Ridership With and Without MAGLEV, reflects this modification.

After the suburban system zones were aggregated, the zones were split into either primary attraction zones or primary production zones. The primary attraction zones were determined to be the central business district of Pittsburgh, the Pittsburgh International Airport and the university and hospital area of Oakland. The three attraction zones serve two of the three basic markets of the Suburban system. The first market is the airport access rider. The hub and spoke system at Greater Pittsburgh International Airport creates demand throughout the day for access service. It is estimated that ground connection costs to the airport are approximately $1.00 per mile by taxi and $0.50 per mile for private bus service (airport limousines). The second market is the commuter market to Downtown Pittsburgh and Oakland. This market is expected to be larger than the airport access market although at a lower fare structure. The third market identified is the feeder system to the regional MAGLEV stations which cannot be addressed from this data.

The remainder of the zones are classified as production zones where the majority of the trips to these zones will originate. The production zones are primarily residential areas.

The suburban trips are defined as production-attraction pairs instead of origin-destination pairs as in the regional model. A trip "attraction" is defined as the non-home end of a trip whereas a trip "production" is the home end portion of a trip. A simple example can illustrate the difference between origin-destination and production-attraction trips. A trip from X to Y results in two origin-destination trip pairs, X-Y and Y-X. The same trip from X to Y results in two production-attraction trip pairs, X-Y and X-Y.

Information regarding the mode split for the Demonstration System was provided by COMSIS Corporation. The mode split is determined by using a simple gravity model with an average per mile fare of $0.28. The SPRPC data is an estimate of total trips for a weekday. Annual ridership numbers are converted from daily ridership numbers by multiplying the daily numbers by 260 weekdays and adding one half of the ridership per weekend day (105/2=52). The following is the standard gravity model equation used:

$$T_{ij} = P_i * \frac{A_j * F(T_{ij}) * K_{ij}}{SUM_z [A_z * F(T_{iz}) * K_{iz}]}$$

Explanation:

T = Resulting trips
P = Productions in a zone
A = Attractions in a zone
K = Adjustment factor between zones
F = Function of T
T = Time between zone pairs
i = Designation of production zone
j = Designation of attraction zone
z = Designation of all zones

6.2.4 FORECAST RESULTS

The Regional system is designed with Pittsburgh as a transportation hub with six spokes extended outward. Geographically, Pittsburgh is a logical hub as the primary connection between the Midwest and the heavily populated East coast. Suburban system stops are interspersed among the Regional system's alignments. Therefore, there are small incremental costs incurred since the majority of the system utilizes the Regional systems guideway. The six alignments, shown with their intermediate stops, are as follows:

East Line
1.) Philadelphia
Pittsburgh - Greensburg - Johnstown - Altoona - State College - Harrisburg - Lancaster - Greater Valley/Paoli - Philadelphia
Suburban stops - Homestead - Monroeville

2.) Washington, D.C.
Pittsburgh - Uniontown - Cumberland - Hagerstown - Frederick - Baltimore - Washington, D.C.
Suburban stops - McKeesport - Elizabeth

Southwest Line
3.) Columbus
Pittsburgh - Washington, PA - Wheeling - Zanesville - Columbus

4.) Huntington
Pittsburgh - Washington, PA - Morgantown - Clarksburg -Charleston - Huntington

North Line
5.) Cleveland
Pittsburgh - New Castle - Youngstown - Akron/Canton - Cleveland

6.) Erie
Pittsburgh - New Castle - Erie
Suburban stop - Aliquippa

Allegheny Line
7.) Indiana
Suburban stops - Oakland - Fox Chapel - New Kensington - Apollo/Vandergrift - Indiana

For comparison purposes, a number of runs were made varying key components in the demand equations. Runs were made varying fares, running times and frequency. The ridership model assumed that the Regional system was completely built in the future year scenario of 2010 and operated over an 18-hour daily schedule. Fares for the HSGT system were varied from $0.23 per mile to $0.65 per mile (converted to 1991 dollars). At each of the cost levels, the frequency of service was varied among 10 trains per day, 16 trains per day and 24 trains per day. At each of the cost and frequency pairs, the trains were run at 125 mph, 186 mph and 300 mph maximum speeds.

The results observed from the sensitivity runs passed basic reasonability tests for total MAGLEV trips. As fares increased, the corresponding ridership decreased. As frequency of service increased, the overall ridership increased. And, as running times decreased, the corresponding overall ridership increased.

The model was also used to estimate the anticipated future ridership for the region assuming no MAGLEV system were built. The projected weekday ridership for this "no-build" scenario is compared to the MAGLEV ridership in Table 6-5. For the MAGLEV case it was assumed that no conventional passenger rail service would exist.

Comparison of the "build" to the "no-build" MAGLEV scenario indicates that nearly three-quarters of those people riding MAGLEV are displaced automobile drivers, while the remaining quarter is almost entirely former conventional rail passengers. These results also indicate a peculiarity of the model: it projects fewer total trips with the introduction of the MAGLEV system. A possible explanation for this phenomena is that the implementation of a MAGLEV system would cause the average price of travel to rise, thereby forcing the total number of travelers down.

TABLE 6-5
PROJECTED RIDERSHIP WITH AND WITHOUT MAGLEV
(YEAR 2010)

	Projected Daily Ridership	
	With MAGLEV	Without MAGLEV
Commuter Air	2,664	2,904
Commuter Bus	9,017	9,260
Commuter Rail		4,699
Commuter MAGLEV	28,908	
Commuter Auto	2,596,812	2,639,736
Business Air	4,201	4,339
Business Bus	2,657	2,680
Business Rail		1,522
Business MAGLEV	10,302	
Business Auto	576,346	580,118
Tourist Air	871	910
Tourist Bus	1,054	1,099
Tourist Rail		4,354
Tourist MAGLEV	6,948	
Tourist Auto	292,032	301,754
School Air	89	92
School Bus	1,921	2,048
School Rail		375
School MAGLEV	1,245	
School Auto	124,690	126,672
Other Air	56	56
Other Bus	18,399	18,572
Other Rail		688
Other MAGLEV	1,590	
Other Auto	528,420	531,982
Total Air	7,882	8,303
Total Bus	33,051	33,661
Total Rail		11,640
Total MAGLEV	48,994	
Total Auto	4,118,300	4,180,262
Total	4,208,227	4,233,866

In order to understand the results, the overall ridership numbers were decomposed into their individual components. Each of the five trip purposes were assumed to have unique characteristics which would cause them to react with differing sensitivity to different factors. It was assumed that the expanded model would exhibit the same sensitivities as those observed by PB/GF in the Pennsylvania High Speed Intercity Rail Passenger Commission report. A verification check of two major factors, cost and time, showed that the expanded model did exhibit the same sensitivities as the original model. It was then assumed that the other sensitivities also exhibited the same characteristics as originally modeled.

The commuter segment accounts for the largest percentage of travelers, with a range from 55 percent to 61 percent of the total trips based upon various combinations of price, running time and frequency. Commuter trips are defined as travel occurring three or more times per week. These trips include both commuters and frequent business travelers. Since commuters often pay the cost of travel themselves, they are more sensitive to cost than time. The majority of commuter travel is expected to occur between 6:00 AM and 9:00 AM and between 4:00 PM and 7:00 PM so service schedules and rolling stock availability must be able to meet these peak demand periods.

The business segment accounts for the second largest percentage of travelers, with a range from 18 percent to 22 percent of the total trips based upon various combinations of price, running time and frequency. Business trips are defined as business related trips made once or twice per week. Business trips are less sensitive to fares than commuter trips. This may be attributed to business trips being paid for by the employer and not out of pocket by the traveler. In addition business travel is often conducted on short notice.

The tourist segment accounts for the third largest percentage of projected travelers, with a range between 12 percent and 18 percent of the total forecast trips based on combinations of fare, running time and frequency. The tourist segment is very sensitive to cost and practically indifferent to both frequency and speed.

The school segment accounts for the smallest percentage of projected travelers with roughly 3 percent of the total share of trips. As can be expected, this segment is very sensitive to fare. Frequency of service and speed of service variations have little impact on the passenger levels.

The "other" segment contains riders who don't fit into any of the four previous segments. This segment is also very small and accounts for approximately 4 percent of total trips, which is just slightly higher than the school segment. This segment is also very fare sensitive and relatively indifferent to increased speed or increased frequency of service.

The aggregate numbers for the system shows demand to be more fare sensitive than frequency of service or time sensitive for most market segments. These numbers are dominated by the commuter segment which contains approximately 58 percent of the total daily passengers.

In addition to the summarized aggregate numbers for each of the five travel segments, the MINUTP model provides zone to zone origin-destination pairs. From this information, the economic model is able to assign travelers to each of the proposed lines of the Regional system. Given that the distance between stations is known, link volumes and passenger miles were calculated for given fare structures. Lines can then be prioritized using projected revenues and operating costs to maximize net revenue. Based upon the results generated by the economic model, the net revenue maximizing fare is $0.37 (1991 dollars) per passenger mile with 24 trains daily in each direction.

A comparison of the revenue maximizing MAGLEV fares against current air fares is shown in Table 6-6.

TABLE 6-6
COMPARISON OF MAGLEV FARES TO CURRENT AIR FARES

City Pair	MAGLEV Fare *	Air Fare (Range) (Average)	
Pittsburgh - Harrisburg	$218	$230-828	$496
Pittsburgh - Philadelphia	$268	$270-918	$555
Pittsburgh - Baltimore	$185	$250-828	$505
Pittsburgh - Washington, D.C.	$208	$230-828	$496
Pittsburgh - Columbus	$140	$150-860	$477
Pittsburgh - Charleston	$158	$150-798	$455
Pittsburgh - Huntington	$193	$200-768	$456
Pittsburgh - Erie	$ 92	$170-618	$371
Pittsburgh - Cleveland	$106	$180-618	$375

Source: AEG Westinghouse Transportation Systems, Inc. travel agent July 30, 1992

All fares are for round trip travel. The minimum airfare requires 14 days advance purchase and a weekend layover. The maximum airfares are full price first class fares. There are a total of six airfares in the range between the minimum and maximum airfares. The average airfare is the weighted average of seats available in each airfare range.

* The MAGLEV fares were escalated from 1991 dollars to 1992 dollars using an escalation factor of 5% for comparison purposes.

TABLE 6-7
PHILADELPHIA LINE RIDERSHIP REPORTS
ANNUAL ORIGIN-DESTINATION REPORT

Total annual passengers: 8,406,225

ANNUAL LINK REPORT EASTBOUND

Station	Station	Annual Ridership	Annual Mileage
Weirton/Steubenville	Pittsburgh	592,613	12,984,146
Pittssburgh	Greensburg	2,127,707	64,767,402
Pittsburgh	Indiana	2,449,203	142,641,596
Greensburg	Johnstown	2,530,197	100,625,946
Indiana	Johnstown	2,530,197	76,766,186
Johnstown	Altoona	2,640,899	90,028,249
Altoona	State College	2,731,850	102,744,894
State College	Harrisburg	2,833,246	271,736,583
Harrsiburg	Lancaster	2,546,127	87,765,000
Lancaster	Paoli	2,302,144	91,072,817
Paoli	Philadelphia	1,752,169	43,506,355
	TOTAL	25,036,353	1,084,639,174

TABLE 6-7 (continued)
PHILADELPHIA LINE RIDERSHIP REPORTS
ANNUAL ORIGIN-DESTINATION REPORT

Total annual passengers: 8,406,225

ANNUAL LINK REPORT WESTBOUND

Station	Station	Annual Ridership	Annual Mileage
Philadelphia	Paoli	2,025,720	50,298,627
Paoli	Lancaster	2,393,565	94,689,431
Lancaster	Harrisburg	2,713,928	93,549,101
Harrisburg	State College	2,832,966	271,709,728
State College	Altoona	2,731,850	102,744,894
Altoona	Johnstown	2,640,899	90,028,249
Johnstown	Indiana	2,530,197	76,766,186
Johnstown	Greensburg	2,530,197	100,625,946
Indiana	Pittsburgh	2,449,203	142,641,596
Greensburg	Pittsburgh	2,127,707	64,767,402
Pittsburgh	Weirton/ Steubenville	592,613	12,984,146
	TOTAL	25,568,846	1,100,805,306

TABLE 6-8
WASHINGTON, D.C. LINE RIDERSHIP REPORTS
ANNUAL ORIGIN-DESTINATION REPORT

Origins	Pittsburgh	Uniontown	Cumbrland	Hagerstown	Frederick	Baltimore
Pittsburgh	0	53232	88648	125104	86456	326772
Uniontown	53232	0	8944	11520	7132	30448
Cumberland	88648	8944	0	28428	14440	50700
Hagerstown	125104	11520	28428	0	23340	62432
Frederick	86456	7132	14440	20844	0	68760
Baltimore	326772	30488	50700	59368	67352	0
Washington D.C.	630988	52400	100748	102528	139816	442112

Total annual passengers: 4,867,404

ANNUAL LINK REPORT EASTBOUND

Station	Station	Annual Ridership	Annual Mileage
Pittsburgh	Uniontown	1,311,200	88,401,101
Uniontown	Cumberland	1,368,412	90,999,398
Cumberland	Hagerstown	1,465,136	72,421,672
Hagerstown	Frederick	1,482,984	46,120,802
Frederick	Baltimore	1,558,592	86,517,439
Baltimore	Washington, D.C.	1,433,068	55,803,665
	Total	8,610,392	440,264,077

ANNUAL LINK REPORT WESTBOUND

Station	Station	Annual Ridership	Annual Mileage
Washington, D.C.	Baltimore	1,468,592	57,186,970
Baltimore	Frederick	1,561,120	86,657,768
Frederick	Hagerstown	1,482,824	46,115,826
Hagerstown	Cumberland	1,465,136	72,421,672
Cumberland	Uniontown	1,368,412	90,999,398
Uniontown	Pittsburgh	1,311,200	88,401,101
	Total	8,657,284	441,782,735

TABLE 6-9
HUNTINGTON LINE RIDERSHIP REPORTS

ANNUAL ORIGIN-DESTINATION REPORT

Origins	Pittsburgh	Wash PA	Morgntown	Clarksburg	Charelston	Huntington
Pittsburgh	0	100,564	66,852	142,224	193,468	141,252
Washington, PA	100,564	0	11,020	20,560	25,132	18,068
Morgantown	66,852	11,020	0	21,852	24,084	17,944
Clarksburg	142,224	20,560	22,836	0	55,328	38,356
Charleston	193,468	25,132	24,084	55,328	0	53,976
Huntington	141,252	18,068	17,944	38,356	53,976	0

Total annual passengers: 1,862,344

ANNUAL LINK REPORT SOUTHBOUND

Station	Station	Annual Ridership	Annual Mileage
Pittsburgh	Washington, PA	664,360	16,502,059
Washington, PA	Morgantown	618,576	24,990,471
Morgantown	Clarksburg	604,584	19,582,475
Clarksburg	Charleston	513,632	54,932,940
Charleston	Huntington	269,596	12,393,328
	Total	2,650,748	128,401,273

ANNUAL LINK REPORT NORTHBOUND

Station	Station	Annual Ridership	Annual Mileage
Huntington	Charleston	269,596	12,393,328
Charleston	Clarksburg	513,632	54,932,940
Clarksburg	Morgantown	605,568	19,614,347
Morgantown	Washington, PA	618,576	24,990,471
Morgantown	Pittsburgh	644,360	16,502,059
Washington, PA	Total	2,651,732	128,433,145

TABLE 6-10
COLUMBUS LINE RIDERSHIP REPORTS

ANNUAL ORIGIN-DESTINATION REPORT

Origins	Pittsburgh	Washington PA	Wheeling	Zanesville	Columbus
Pittsburgh	0	100,564	140,576	99,364	227,776
Washington PA	100,564	0	25,696	15,084	33,468
Wheeling	140,576	25,696	0	31,464	61,168
Zanesville	99,364	15,084	31,464	0	72,160
Columbus	227,776	33,468	61,168	72,160	0

Total annual passengers: 1,614,640

ANNUAL LINK REPORT WESTBOUND

Station	Station	Annual Ridership	Annual Mileage
Pittsburgh	Washington, PA	568,280	14,553,651
Washington, PA	Wheeling	541,964	17,532,534
Wheeling	Zanesville	468,324	27,276,937
Zanesville	Columbus	394,572	21,283,213
	Total	1,973,140	90,746,335

ANNUAL LINK REPORT EASTBOUND

Station	Station	Annual Ridership	Annual Mileage
Columbus	Zanesville	394,572	21,283,213
Zanesville	Wheeling	468,324	37,376,937
Wheeling	Washington, PA	541,964	17,532,534
Washington, PA	Pittsburgh	568,280	14,552,651
	Total	1,973,140	90,746,335

TABLE 6-11
CLEVELAND LINE RIDERSHIP REPORTS

ANNUAL ORIGIN DESTINATION REPORT

Origins	Pittsburgh	New Castle	Youngstown	Akron	Cleveland
Pittsburgh	0	85,264	96,464	156,968	114,300
New Castle	85,264	0	27,156	38,256	28,728
Youngstown	96,464	27,156	0	56,424	44,856
Akron	156,968	38,256	56,424	0	112,396
Cleveland	114,300	28,748	44,856	112,396	0

Total annual passengers: 1,521,664

ANNUAL LINK REPORT NORTHBOUND

Station	Station	Annual Ridership	Annual Mileage
Pittsburgh	New Castle	452,996	17,929,582
New Castle	Youngstown	461,892	9,625,829
Youngstown	Akron	439,552	18,896,341
Akron	Cleveland	399,399	9,084,075
	Total	1,654,740	55,535,827

ANNUAL LINK REPORT SOUTHBOUND

Station	Station	Annual Ridership	Annual Mileage
Cleveland	Akron	300,300	9,084,075
Akron	Youngstown	439,552	18,896,341
Youngstown	New Castle	461,892	9,625,829
New Castle	Pittsburgh	452,996	17,929,582
	Total	1,654,749	55,535,827

TABLE 6-12
ERIE LINE RIDERSHIP REPORTS

ANNUAL ORIGIN-DESTINATION REPORT

Origins	Pittsburgh	New Castle	Erie
Pittsburgh	0	85,264	55,160
New Castle	85,264	0	12,412
Erie	55,160	12,412	0

Total annual passengers: 305,672

ANNUAL LINK REPORT NORTHBOUND

Station	Station	Annual Ridership	Annual Mileage
Pittsburgh	New Castle	140,424	5,557,982
New Castle	Erie	67,572	5,414,544
	Total	207,996	10,972,526

ANNUAL LINK REPORT SOUTHBOUND

Station	Station	Annual Ridership	Annual Mileage
Erie	New Castle	67,572	5,414,544
New Castle	Pittsburgh	140,424	5,557,982
	Total	207,996	10,972,526

TABLE 6-13
SUBURBAN RIDERSHIP RESULTS

	Daily MAGLEV Trips	Annual Trips	Passenger Miles (1,000,000)
Downtown to Airport	968	302,016	5.8
Airport Area to Downtown	2,413	752,856	14.5
Airport Area to Oakland	1,295	404,040	9.0
Oakland to Airport	1,016	316,992	7.1
Aliquippa to Downtown	1,274	397,488	10.7
Aliquippa to Airport	143	44,616	0.2
Aliquippa to Oakland	243	75,816	2.4
Fox Chapel to Downtown	5,417	1,690,228	19.4
Fox Chapel to Airport	2,772	864,864	25.9
Fox Chapel to Oakland	1,686	526,256	3.9
New Kensington to Downtown	1,400	436,800	10.0
New Kensington to Airport	390	121,680	5.0
New Kensington to Oakland	357	111,384	2.1
Apollo/Vandergrift to Downtown	1,361	424,632	14.4
Apollo/Vandergrift to Airport	286	89,232	4.6
Apollo/Vandergrift to Oakland	386	120,432	3.6
Homestead to Downtown	979	305,448	2.1
Homestead to Airport	216	67,392	1.7
Monroeville to Downtown	4,480	1,491,110	23.8
Monroeville to Airport	2,917	910,104	30.9
Monroeville to Oakland	2,462	768,268	12.3
Greensburg to Downtown	118	36,988	1.1
Greensburg to Airport	1,195	372,840	18.3
Greensburg to Oakland	683	213,096	6.6

TABLE 6-13 (continued)
SUBURBAN RIDERSHIP RESULTS

	Daily MAGLEV Trips	Annual Trips	Passenger Miles (1,000,000)
McKeesport to Downtown	4,991	1,557,192	2.2
McKeesport to Airport	1,024	319,488	10.2
McKeesport to Oakland	2,103	656,136	9.2
Elizabeth to Downtown	3,450	1,076,400	22.6
Elizabeth to Airport	501	156,312	6.1
Elizabeth to Oakland	901	281,112	5.9
Washington to Downtown	258	80,450	3.5
Washington to Airport	331	103,272	2.7
Washington to Oakland	422	131,664	6.6
TOTAL	**48,879**	**15,250,248**	**304.4**

Numbers come from an extrapolation from the Regional ridership numbers. These riders are the net increase from adding the additional suburban service.

6.2.5 SUMMARY AND RECOMMENDATIONS

The preliminary forecast results predict that the Regional system will transport approximately 18,700,000 passengers if the system is completed by 2010. This estimate can be viewed as conservative for a number of reasons. The model is not incorporating effects of future congestion increases on either the highways or airways. There is no assumption of induced ridership for the system. Many studies have predicted induced ridership to attract an additional 10% to 30% of the base ridership demand.

The preliminary forecast results for the Suburban system show that it would add approximately an additional 15,000,000 commuting and airport access riders to the total system ridership. Although the Suburban system ridership is about the same magnitude as the Regional system, the miles traveled are significantly less. However, the suburban riders would be able to generate cash flow to the system prior to the completion of the entire Regional system and may ease some of the effects of future congestion on the local highways. The forecasted numbers for the

the Suburban system represent approximately 13% of the total trips between the production and attraction zones of the Suburban system.

Tables 6-7 through 6-12 display the results from the Regional system ridership demand model ranking the alignments from highest to lowest in annual passenger miles. For each of the Regional System corridors, there is an origin-destination report showing the forecasted annual ridership in one-way trips between each city pair. There are also two directional link volume reports showing the number of passengers that are forecast to traverse each link. The annual passenger count in the link volumes reports is calculated by the economic model from the origin-destination reports. Using the Philadelphia line as an example, a single passenger traveling from Pittsburgh to Altoona would be counted in the link volume for each of the following links: Pittsburgh - Greensburg, Greensburg - Johnstown and Johnstown - Altoona. The annual mileage is calculated by multiplying the annual link ridership by the length of the segment. The link volume reports are used to determine fleet requirements and generate revenue projections.

Table 6-12 shows the forecasted Suburban System annual MAGLEV trips and passenger miles between each production service area and attraction zones. The numbers reflect two one-way trips from the production zone to the attraction zone without any corresponding trips from the attraction zone to the production zone, due to the organization of the data in the SPRPC trip tables.

6.3 SYSTEM OPERATIONS

The analysis of potential operating schedules was undertaken to establish run times, to develop timetables and to determine fleet requirements for the Mid-Atlantic Regional System. The determination of fleet requirements is dependent upon proposed timetables and the corresponding ridership demand that results from different combinations of speed, fare and frequency.

6.3.1 SYSTEM RUNNING TIMES

Carnegie Mellon's Energy Management Model (EMM) was used to determine station to station running times for the regional system. The EMM has been successfully used on various rail systems in the past and simulates actual operation of the rail system closely. The EMM consists of four principal components, one of which is the Train Performance Simulator (TPS). The TPS module accepts as input vehicle parameters, wayside parameters and system operational characteristics. Vehicle parameters include items such as weight, tractive effort, efficiencies versus speed, train resistance, numbers and types of vehicles in train, auxiliary electric loads and passenger load factors.

Wayside parameters include items such as power distribution system type, voltage and right-of-way profile (grade, curve and speed restrictions as a function of location).

System operational characteristics include items such as acceleration and braking rates, maximum speed and station dwell times.

Station to station running times were developed using the TPS and are shown in Table 6-14, Train Performance Simulation. The running times include two-minute dwell times at each stop.

6.3.2 FLEET REQUIREMENTS

The Regional system will operate primarily as a hub-and-spoke system with Pittsburgh serving as the hub where the majority of vehicle transfers occur when the entire system is constructed. The economic model has assigned transferring passengers to two origin-destination pairs, origin to transfer point and transfer point to destination. Once the origin-destination pairs were determined, link volumes were analyzed for each segment in the regional system. The segment with the maximum volume on each spoke was used as the bottleneck segment and the fleet requirements were determined by minimally solving for this segment.

In addition to running times, a significant factor for determining fleet requirements is the turnaround time for a vehicle set. The turnaround time is affected by vehicle cleaning and preparation. Turnaround times for HSGT systems range from approximately fifteen minutes to one hour. The conservative figure of one hour for turnaround times are used for regional trains while the suburban system assumes a fifteen minute turnaround time.

TABLE 6-14

TRAIN PERFORMANCE SIMULATION OF TRANSRAPID MAGLEV SYSTEM

	Distance - Miles	Time - Minutes
Cleveland Air TO Akron/Canton	30.25	12.58
Akron/Canton TO Youngstown/Warren	42.99	14.66
Youngstown/Warren TO New Castle	20.84	13.73
New Castle TO Pittsburgh Airport	39.58	16.76
RUN SUMMARY	133.66	57.73
Pittsburgh Airport TO Washington, PA	25.61	12.19
Washington, PA TO Wheeling	32.35	16.91
Wheeling TO Zanesville	71.29	22.13
Zanesville TO Columbus	53.94	19.76
RUN SUMMARY	183.19	70.99
Pittsburgh Airport TO Washington, PA	25.61	12.19
Washington, PA TO Morgantown	40.40	14.46
Morgantown TO Clarksburg	32.39	12.69
Clarksburg TO Charleston	106.95	30.03
Charleston TO Huntington	45.97	23.34
RUN SUMMARY	251.31	92.71
Pittsburgh Airport TO Station Square	18.18	10.79
Station Square TO Uniontown	49.23	22.10
Uniontown TO Cumberland	66.50	24.39
Cumberland TO Martinsburg	49.43	18.13
Martinsburg TO Frederick	31.10	13.30
Frederick TO BWI	45.78	15.98
RUN SUMMARY	260.22	104.71

TABLE 6-14 (continued)
TRAIN PERFORMANCE SIMULATION OF TRANSRAPID MAGLEV SYSTEM

	Distance - Miles	Time - Minutes
Pittsburgh Airport TO Station Square	18.18	10.79
Station Square TO Greensburg	30.44	19.56
Greensburg TO Johnstown	39.77	16.59
Johnstown TO Altoona	34.09	14.08
Altoona TO State College	37.61	14.07
State College TO Harrisburg	90.44	27.57
Harrisburg TO Lancaster	34.47	13.18
Lancaster TO Great Valley/Paoli	39.56	13.95
Great Valley/Paoli TO Philadelphia	24.83	15.90
Philadelphia TO Philadelphia Airport	6.42	7.12
RUN SUMMARY	349.40	145.70
Pittsburgh Airport TO New Castle	39.58	16.76
New Castle TO Erie	80.13	24.21
RUN SUMMARY	119.71	40.97
Pittsburgh Airport TO Weirton/Steubenville	21.91	8.65
RUN SUMMARY	21.91	8.65
Pittsburgh Airport TO Indiana, PA	76.42	49.17
RUN SUMMARY	76.42	49.17

6.3.3 TRAIN SIZES

The minimum train size is two cars and the maximum train size is ten cars. The capacity of passenger vehicles is expected to range from a minimum of 40 first class seats for a cab-end vehicle to a maximum of 113 coach seats for an intermediate vehicle. An average of 96 seats is utilized for this study.

Passenger vehicles will provide room for carry-on baggage and each of the trains will also have a vehicle for containerized baggage. It is expected that one baggage vehicle will provide enough baggage capacity for up to four passenger vehicles. Vehicles can also be configured as a combination of seats and baggage containers.

The loading factor utilized for the requirements is 65%. Since over 60% of the projected travelers are either commuters or business travelers, it is expected that the demand will be clustered around the 06:00 to 09:00 and 16:00 to 19:00 peak rush hour periods. It is assumed that each of the six peak hourly periods will contain ten percent of the average daily trips. The twelve non-peak hourly periods contain the remaining forty percent of the travelers.

It was determined that the coupling and decoupling of cars in a train is to be minimized. Therefore, the train sizes for each line are not varied between different periods of the day but instead additional trains will be run during the peak periods.

Table 6-15, Schedule and Train Sizes for Mid-Atlantic Regional System, shows the proposed headways and train sizes for each line.

6.4 MID-ATLANTIC REGIONAL SYSTEM COSTS AND REVENUES

The following sections contain the cost estimates and revenue projections for the Mid-Atlantic Regional System.

6.4.1 CAPITAL COSTS

Capital costs include all non-recurring costs required for the initial construction of the regional system. The major components of the system include the guideway and guideway substructure, special constructions such as bridges, tunnels, earthworks, and drainage, erosion and sedimentation control guideway electronics and propulsion, power supply, signals and communication stations and vehicles.

TABLE 6-15
SCHEDULE AND TRAIN SIZES FOR MID-ATLANTIC REGIONAL SYSTEM

		Distance Miles	Time Minutes	Peak	Non-Peak	Total Cars
				(Trains/Hour Cars/Train)		
Pittsburgh Regional System						
Pgh Airport	TO Cleveland Air	133.66	57.73	1x3	1x3	18
Pgh Airport	TO Columbus	183.19	70.99	1x3	1x3	18
Pgh Airport	TO Huntington	251.31	92.71	1x3	1x3	24
Pgh Airport	TO BWI	260.22	104.71	2x4	1x4	48
Pgh Airport	TO Philadelphia	349.40	145.70	3x4	1x4	64
Pgh Airport	TO Erie	119.71	40.97	1x2	1x2	12
Pgh Airport	TO Weirto/Steubnville	21.91	8.65	1x2	1x2	2
Total Regional System						186
Pittsburgh Suburban System						
Pgh Airport	TO Indiana, PA	76.42	49.17	2x2	1x2	8
Pgh Airport	TO New Castle	39.58	19.11	1x2	1x2	2
Pgh Airport	TO Greensburg	48.63	35.74	2x2	1x2	8
Pgh Airport	TO Uniontown	67.42	42.45	2x2	1x2	8
Pgh Airport	TO Morgantown, WV	66.00	22.65	1x2	1x2	4
Pgh Airport	TO Wheeling, WV	57.96	25.10	1x2	1x2	4
Total Suburban Systems						34

There are a number of areas that need to be addressed when considering capital costs for a new technology and a new industry. Capital costs must include not only the cost of the components that will be required for the transportation system but also the startup costs required to engineer and manufacture the components. New manufacturing facilities may be required for guideway fabrication and vehicle assembly. Other facilities may also be needed but are not foreseen at this time.

It is estimated that each guideway fabrication facility can produce approximately eight miles of single guideway per year and that each vehicle manufacturing facility can produce approximately twelve vehicles per year. It is assumed that manufacturing capacity can be expanded linearly (i.e. doubling the plant and machinery will double the capacity) since the fabrication process can proceed independently for each guideway beam and each vehicle.

6.4.1.1 Unit Costs

The capital cost estimates for components and sub components of the MAGLEV system were developed from various sources including: AEG Westinghouse Transportation Systems, Inc., Michael Baker Jr., Inc., Carnegie Mellon University, Transrapid International, and Wheeling Pittsburgh Steel Corporation, and a local metal fabricating company.

The capital costs were examined in detail for the 19 mile demonstration system and extrapolated to the regional system by the economic model. The costs were verified by comparing them to cost estimates provided by Transrapid for the Pittsburgh Demonstration System and the Orlando project. Table 6-16 indicates that the internally generated capital unit costs compare favorably against cost estimates provided by Transrapid for the Pittsburgh Demonstration System and with the Orlando project.

The cost estimates for the Regional system reflect double guideway throughout the entire Regional system. Double guideway was chosen to maximize the operational flexibility of the Regional system. High speed switches are utilized at junction points on the Regional system where multiple lines connect. All figures are stated in 1991 dollars.

Guideway Costs

The guideway cost estimates are comprised of three major components: the guideway, the supporting piers and the substructure. There are two basic types of guideway and supporting piers identified, curved and tangent.

Elements considered for the guideway beam costs include the cost of the fabricated steel using local labor costs, rust proofing, transportation to the construction site and mounting of the beams.

TABLE 6-16
MAGLEV COST ESTIMATE COMPARISON

		Transrapid	Internal	Florida Study
A)	Guideway Structure:	$111.22m $5.66m/mi	$134.73m $6.85m/mi	$96.08m $6.43m/mi
B)	Special Construction: - Florida estimate includes land acquisition only, very little earthwork and no special structures. - An independent estimate includes considerable earthwork and structures also drainage, E&S and tunnels (not considered in others).	$35.04m	$64.38m	$20.00m
C)	Equipment/Facilities: - Transrapid's estimate was adopted. - Common item costs:	$105.94m	$105.94	$88.22m
	Longstator	$1.45m/mi		$1.19m/mi
	Lowspeed Switches	$1.37m Ea.		$1.14m Ea.
	Control Center	$21.27m Ea.		$14.25m Ea.
	Fixed Substation	$9.30m Ea.		$10.67m Ea.
	Control Substation	$1.34m Ea.		$1.12m Ea.
D)	Stations/M&O Facilities: - Common item costs:	$8.45m	$17.25m	$100.06m
	Airport Station	--	$4.30m	$37.34m
	Other Station	--	$4.30m	$45.40m
	Parking	--	$5.83m	$2.31m
	M&O Facility	$8.45m	$2.83m	$15.00m
E)	Additions-Design, Construction Management:	$30.00m	$43.35m	$37.66m
F)	Vehicles:	$21.40m (4 cars @ $5.35m Ea.)	$21.40m (4 cars @ $5.35m Ea.)	$95.40m (20 cars @ $4.67m Ea.)
	- Recovery Vehicles	--	--	$2.00m (5 cars @ $0.4m Ea.)
G)	Other:	--	$89.75m	$14.10m
	- Maintenance Facility Equipment	--	$25.00m	$9.50m
	- Baggage Handling	--	$3.00m	$2.50
	- Utility Work, Electrical Service, Check-out, Testing, Management & Operations, etc.	--	$61.75m	$2.10m
	Total:	$312.05m	$476.80m	$451.52m

NOTE: The cost estimates shown are for comparison only. The Transrapid estimate is based on an alignment of 18.33 miles, the internal estimate is based on 19.66 miles; therefore, the Transrapid estimate has been escalated by a factor of 1.073 and another 1.07 for conversion from 1989 to 1991 dollars. The Florida estimate is based on another alignment of 14.95 miles and is expressed in 1990 dollars. An independent estimate was done separately where appropriate.

The support pier estimates include items such as local labor rates, construction of on-site molds, reinforced concrete and substructure costs.

The guideway cost estimate was jointly developed by Carnegie Mellon University and a local metal fabrication firm with additional cost estimates provided by Wheeling Pittsburgh Steel Corporation. The pier cost and substructure cost estimates were provided by Michael Baker Jr., Inc. and reflect an average pier height of 20 feet.

Tangent Guideway	$1,730.00 per linear foot
Curved Guideway	$1,730.00 per linear foot
Tangent Piers	$42,500.00 each
Curved Piers	$43,500.00 each

Special Construction

The special construction estimates are provided by Michael Baker Jr., Inc. and reflect construction costs for the regional area. Items included in this category are land acquisition, drainage, erosion and sedimentation control, earthworks, bridges and tunnels. Land acquisition costs assume a width of 60 feet. The costs of bridges and tunnels are exclusive of the cost of the guideway.

Land Acquisition	
Urban core	$1,100,000 per mile
Urban	$ 480,000 per mile
Suburban	$ 220,000 per mile
Rural	$ 132,000 per mile
Drainage, Erosion and Sedimentation Control	
	$39.00 per linear foot of guideway
Earthworks	$6.00 per cu. yd of earth (fill & cut)
Bridges	
Short Span	$4,500 per linear foot of dbl. guideway
Long Span	$5,400 per linear foot of dbl. guideway
Road Overpass	$1,000,000 each
River Crossing	$7,000 per linear foot of dbl. guideway
Tunnels	$6,400 per linear foot of dbl. guideway

Equipment and Facilities

Cost estimates for guideway equipment and stationary facilities were provided by Transrapid International in December 1990 for the Pittsburgh Demonstration system and the estimates were updated to 1991 dollar figures.

Stator pack & cable winding estimates include manufacturing and transporting the cable, bending and weaving of the cable winding onto the stator pack and fastening of the stator packs onto the steel guideway beams.

Switch costs are incremental costs above and beyond the cost of the guideway for the length of the switch. Components included in the switch costs include switch drives, control devices, steering devices and components required for beam bending.

Power supply and wayside equipment estimates were aggregated and averaged for a cost estimate from Transrapid's December 1990 estimate, escalated to 1991 dollar amounts and applied for the Regional system. A comprehensive examination of each alignment was not performed to detail the power supply and substation requirements for this report.

Stator packs & cable windings	$548 per linear foot of dbl. guideway
Switches	
2-way low speed	$1,280,000 each
3-way low speed	$2,230,000 each
2-way high speed	$2,400,000 each
Power supply	$724 per linear foot of dbl. guideway
Signal/Communication	$122 per linear foot of dbl. guideway

Stations, Maintenance and Operations Facilities

Stations for the Regional system were divided into three classifications based upon expected daily ridership: small, medium and large. Small station facilities are defined as those stations that are expected to generate less than 100,000 passengers per year. Medium stations are those that are expected to generate between 100,000 and 1,000,000 passengers per year. Large stations are expected to handle more than 1,000,000 passengers annually.

The Regional system cost estimates contain off-line stations in order to maximize operational flexibility. Off-line stations consist of six low-speed switches and 7000 feet of single guideway for the siding adjacent to the mainline double guideway track. The additional guideway costs include propulsion costs, signaling costs, etc. and are reflected in their respective categories.

Large station	$10,000,000 each
Medium station	$ 6,000,000 each
Small station	$ 2,000,000 each
M&O Facility	$ 8,000,000 each
Control Center	$20,000,000 each
Guideway Mfg. Facility	$ 9,000,000 each
Vehicle Mfg. Facility	$15,000,000 each

Vehicles

The cost estimates for the vehicles were provided by Transrapid in the December 1990 estimate for the Pittsburgh Demonstration Project. This estimate was updated to 1991 dollar amounts.

Vehicle segment $5,350,000

Construction Management

Estimates for construction management and engineering was provided by Michael Baker Jr., Inc. and are representative of standard civil engineering projects.

Construction Mgmt/Engineering 10% of capital costs

6.4.1.2 System Capital Costs

The Regional system alignments were divided into a number of segments. A segment is bound on either end by regional nodes or by junction switches that divide corridors. Suburban stations can lie in the middle of Regional segments and consist of six switches, 7000 feet of siding guideway and a small station.

Utilizing the unit costs discussed above and detailed alignment data, capital cost estimates were prepared under different scenarios in order to minimize the capital costs of the Regional system. Each of the six corridors were compared for cost differentials using both 5% maximum grades and 10% maximum grades. A mountain traversing segment between Cumberland, MD, and Hagerstown, MD, was compared for the cost differential of allowing tunneling versus a tunnel-free alignment.

The only area of capital costs affected by the different maximum grade scenarios is in the special construction area. Special construction costs are approximately 11% lower for the 10% maximum grade case than for the 5% maximum grade case. Allowing 10% grades resulted in lower earthworks costs, less bridges and fewer tunnels than the 5% maximum grade case. The total cost of the 10% maximum grade case is approximately 3% lower than the total cost of the 5% maximum grade case for the Regional system.

The tunnel-free alignment between Cumberland and Hagerstown had total costs that were 23% higher than the alignment which allowed tunneling. By avoiding tunnels, there was over eight additional miles of guideway and guideway equipment required for the segment. In addition, the mountainous terrain still required extensive earthwork costs that were 16% higher per mile for the tunnel-free alignment. Final design of the Regional system will require further analysis for differing terrain when determining whether to tunnel or not. The terrain seen in the Mid-Atlantic region has many steep hills and valleys situated in close proximity. This terrain is difficult to navigate around and it appears to favor tunneling.

The capital cost estimates for the Regional system are shown in Tables 6-17 through 6-19. The case displayed allows tunneling and maximum grades of 10%. The column "Total Cost" is the sum of the other columns in Tables 6-17 through 6-19 plus the additional 10% construction management costs that are not listed on the tables. The Regional alignments often share segments of common guideway as described in Section 6 by the route alignment descriptions. The alignments are

TABLE 6-17
REGIONAL SYSTEM CAPITAL COST

STATION	Length Miles	Total Cost	Gdway Cost	Special Const	Equip Facility	Vehicle Cost	Stat Cost
Pittsburgh Airport - EJ Switch	29	886	370	98	277	32	28
EJ Switch - Baltimore/Washington	270	8877	3317	2340	2064	300	50
EJ Switch - Philadelphia	326	9248	3998	1501	2491	355	62
AVWJ Switch - AVEJ Switch	67	1913	831	327	502	73	6
Pittsburgh Airport - NJ Switch	40	1308	493	336	321	32	6
NJ Switch - Cleveland Airport	99	2389	1215	112	759	64	22
NJ Switch - Erie	80	1866	974	95	600	21	6
Pittsburgh Airport - S/WJ Switch	24	749	299	130	203	43	6
S/WJ Switch - Huntington	228	8456	2777	3070	1717	107	16
S/WJ Switch - Columbus	158	4381	1928	771	1195	75	14
S/WJ Switch - Steubenville/Weirton	21	657	263	141	180	11	2
Total System	1342	40730	16466	8921	10310	1113	218

Note: All cost figures are stated in millions of 1991 dollars.

TABLE 6-18
PITTSBURGH SUBURBAN SYSTEM INCREMENTAL COSTS

STATION	Length (miles)	Total Cost	Guideway Cost	Vehicle Cost	Station Cost
Pittsburgh Airport - EJ Switch	29	22.6	18.5	0	2
EJ switch - Uniontown	39	80.4	37.1	32	4
EJ Switch - Greensburg	19	57.8	18.5	32	2
Pittsburgh Airport - New Castle	40	34.7	18.5	11	2
Pittsburgh Airport - Morgantown	66	23.1	0.0	21	0
Pittsburgh Airport - Wheeling	56	23.1	0.0	21	0
AVWJ Switch - AVEJ Switch	67	136.7	73.3	43	8
Total Suburban System	316	378.4	165.9	160	18

All cost figures are stated in millions of 1991 dollars.

TABLE 6-19
TOTAL REGIONAL SYSTEM CAPITAL COST WITH PITTSBURGH SUBURBAN SYSTEM

STATION	Length (MI)	Total Cost	Gdway Cost	Special Const	Equip Facility	Vehicle Cost	Stat Cost
Pittsburgh Airport - EJ Switch	29	909	378	98	302	32	30
EJ Switch - Baltimore/Washington	270	8958	3333	2340	2085	332	54
EJ Switch - Philadelphia	326	9306	4006	1501	2516	387	64
AVWJ Switch - AVEJ Switch	67	2050	897	327	510	116	14
Pittsburgh Airport - NJ Switch	40	1342	501	336	332	43	8
NJ Switch - Cleveland Airport	99	2389	1215	112	759	64	22
NJ Switch - Erie	80	1866	974	95	600	21	6
Pittsburgh Airport - S/WJ Switch	24	749	299	130	203	43	6
S/WJ Switch - Huntington	228	8479	2777	3070	1717	128	16
S/WJ Switch - Columbus	158	4404	1928	771	1195	96	14
S/WJ Switch - Steubenville/Weirton	21	657	263	141	180	11	2
Total System	1342	41109	16572	8921	10399	1273	236

Note: All cost figures are stated in millions of 1991 dollars.

separated into the unique portions of the ROW's in order to avoid double counting any piece of the Regional system. The switchpoint acronyms that terminate segments on the Tables are: East Junction (EJ), North Junction (NJ), Allegheny Valley East Junction (AVEJ), Allegheny Valley West Junction (AVWJ) and South/West Junction (S/WJ).

The capital cost estimate for the Regional system is shown in Table 6-17. This estimate reflects 10% maximum grades for each of the alignments. The East Junction switch to Baltimore/Washington reflects the costs of tunneling on the segment between Cumberland and Hagerstown. This estimate does not include any costs associated with the Pittsburgh Suburban System.

The capital cost estimates for the Suburban system are displayed in Table 6-18. The Suburban system cost estimates are the incremental capital costs above and beyond the required expenditures of building the Regional system lines.

The capital cost estimates for the Regional system with the costs of the Suburban system imbedded in the appropriate Regional alignments are displayed in Table 6-19.

6.4.2 OPERATING AND MAINTENANCE COSTS

Only certain aspects of the operation of HSGT systems can be inferred from other transportation modes. Operating cost items such as station operation costs, transportation personnel costs, equipment maintenance and energy costs can be estimated with some degree of certainty due to the similarities to other transportation modes. Maintenance cost items for the guideway structure and propulsion are more difficult due to the uniqueness of the technology and the lack of operating data.

For the Mid-Atlantic Regional System estimates, two sets of O&M cost estimates were developed in order to cross-check each of the estimates. The first estimate utilizes information generated by AEG Westinghouse and Transrapid International. The second estimate is based upon the model developed by Parsons Brinckerhoff Quade & Douglas, Inc. in the Transportation Research Board (TRB) report (in pursuit of speed New Options for Intercity Passenger Transport). This model was selected to validate the internally generated O&M cost model due to the availability of the service parameters from the economic model for the Regional system.

6.4.2.1 Unit Costs

The first O&M model categorizes costs into four basic areas: transportation, energy, maintenance and administrative. AEG Westinghouse has provided local wage rates based upon a people mover system that will begin operations at Greater Pittsburgh International Airport in October 1992. The wage rate utilized includes salary, fringe benefits and overhead costs for general administrative support. The personnel requirements for revenue service are taken from estimates provided by Transrapid International in December 1990.

Transportation costs include the train crew and staff and passenger station staff. Each train will have one operator per train and one attendant per car. Annual figures include estimates to provide coverage 7 days per week. Energy costs were estimated from runs made by CMU's Energy Management Model and operating schedules of 24 daily trains in each direction over an 18-hour operating period. Energy costs are divided into two components, energy demand and energy usage. Energy demand is the total energy used over a 15-minute time period measured in kilowatts. The energy demand charge is to offset the capital costs borne by the utility to provide the peak power requirement of the system. Energy usage is the actual energy used measured in kilowatt hours.

Maintenance costs include maintenance of guideway, power distribution equipment, signals and communication, vehicles and vehicle cleaning.

Administration costs include system management, ticket agent fees and the control center operation. The values utilized are shown in Tables 6-20, Annual O&M Unit Costs and 6-21, TRB Model Annual O&M Unit Costs.

6.4.2.2 System O&M Costs

The numbers reported under the column labeled Model 1 in Table 6-22 are the result of the model developed from AEG Westinghouse and Transrapid International estimates. The O&M costs developed from the TRB model are shown under the column labeled Model 2 in Table 6-22.

The estimates from the TRB model are approximately 16% higher than those derived from internal estimates for the Regional system. As noted above, estimating costs for a new transportation mode is difficult but the O&M cost figures shown below are comparable to those found in other corridor studies. Table 6-23, Pittsburgh Suburban System Incremental O&M Costs, shows the O&M costs for each suburban line.

6.4.3 REVENUES

The revenues generated by a regional HSGT system will come from a variety of sources and may include not only passenger fares but also revenue from high priority freight and development around stations.

TABLE 6-20
ANNUAL O&M UNIT COSTS

Annual employee hours	1800 hours = 1 person-year
Average wage cost	$27.79 per hour (1991 dollars)
Transportation	
Train crew	5 people per car annually
Large station	30 people per station
Medium station	20 people per station
Small station	15 people per station
Maintenance	
Guideway/Propulsion	0.322 people per double track mile
Switch	0.1 people per switch
Vehicle cleaning	0.37 people per vehicle
Vehicle	1.00 people per vehicle
Administration	
	25% of Transportation, Maintenance and Energy

TABLE 6-21
TRB MODEL
ANNUAL O&M UNIT COSTS

Capital Cost	$	2,800	per million dollars of C.C.
Route-miles	$	24,500	per route mile
Track-miles	$	18,100	per track mile
Stations	$	1,500,000	per large station
	$	1,000,000	per medium station
	$	750,000	per small station
Seat-miles	$	7,300	per million seat miles
Seat-hours	$	3,929,900	per million seat hours
Passengers	$	599,300	per million passengers

TABLE 6-22
REGIONAL SYSTEM O&M ANNUAL COST ESTIMATES

	MODEL 1	MODEL 2
Pittsburgh Airport - EJ Switch	11	14
EJ Switch - Philadelphia	115	140
EJ Switch - Washington D.C.	93	113
AVWJ Switch - AVEJ Switch	14	16
Pittsburgh Airport - NJ Switch	12	13
NJ Switch - Cleveland Airport	31	27
NJ Switch - Erie, PA	14	18
Pittsburgh Airport - S/WJ Switch	11	11
S/WJ Switch - Huntington, WV	55	62
S/WJ Switch - Columbus, OH	36	43
Pittsburgh Airport - Weirton/Steubenville	6	6
Total Regional System	393	462

All figures reflect millions of 1991 dollars.

TABLE 6-23
PITTSBURGH SUBURBAN SYSTEM INCREMENTAL O&M COSTS

STATION	Length (miles)	O&M Costs
Pittsburgh Airport - Uniontown	67	13.4
Pittsburgh Airport - Greensburg	49	9.1
Pittsburgh Airport - New Castle	40	8.9
Pittsburgh Airport - Morgantown	66	7.6
Pittsburgh Airport - Wheeling	56	6.2
Pittsburgh Airport - Indiana	76	20.0
Total Suburban System	354	65.2

All figures reflect millions of 1991 dollars.

6.4.3.1 Transportation Revenues

Transportation revenues have been defined as those revenues that are derived from the direct operation of the transportation system. The two major components of transportation revenues that have been identified are: passenger fares and freight hauling revenue.

The estimates of passenger revenue is based upon the results from the ridership estimate contained in Section 6.2. Passenger revenue is highly sensitive to the type of service provided. The scope of the DD&D report did not include an intensive evaluation of the network approach versus the regional approach. As described in Section 6.2, the Mid-Atlantic Regional System ridership model forecasts intercity passenger trips. Intercity trips are more representative of the networked system which is only a portion of the total trips expected to be generated by the regional HSGT approach. Data was also collected from the Southwestern Pennsylvania Regional Planning Commission. This data was in the form of trip-tables for the six county metropolitan Pittsburgh area.

The origin-destination trip pairs were then broken into their individual segments for boarding reports. From this report, the revenue per segment is easily determined using the per mile fare utilized by the regional ridership model. A fare of $0.37 per mile was utilized. Table 6-24, Passenger Revenue Summary, shows the results of the passenger revenue by line.

The production-attraction trip pairs were aggregated based on the Suburban line where they are located. Based on information obtained from COMSIS Corporation, the revenue projections are based on a fare of $0.28 per mile. Table 6-25, Suburban System Revenue, shows the results of the passenger revenue by Suburban line for the stations that fall within the six county Greater Pittsburgh area. Regional stops that terminate the Suburban system outside of the SPRPC database and whose additional revenue is not reflected in the numbers in Table 6-25 are: Morgantown, Wheeling, New Castle, Weirton/Steubenville and Indiana.

TABLE 6-24
PASSENGER REVENUE SUMMARY

STATION -	STATION	Annual Passenger Mileage	Annual Passenger Revenue
Pittsburgh -	Philadelphia	1025.7	$ 379.5
Philadelphia -	Pittsburgh	1026.8	$ 379.9
Pittsburgh -	Washington, D.C.	440.3	$ 162.9
Washington D.C. -	Pittsburgh	441.8	$ 163.5
Pittsburgh -	Huntington	128.4	$ 47.5
Huntington -	Pittsburgh	128.4	$ 47.5
Pittsburgh -	Columbus	90.7	$ 33.6
Columbus -	Pittsburgh	90.7	$ 33.6
Pittsburgh -	Cleveland	55.5	$ 20.5
Cleveland -	Pittsburgh	55.5	$ 20.5
Pittsburgh -	Erie	11.0	$ 4.1
Erie -	Pittsburgh	11.0	$ 4.1
	Total	3506.0	$1297.2

Passenger miles are stated in millions.
Revenue is stated in millions of 1991 dollars.

TABLE 6-25
SUBURBAN SYSTEM REVENUE

STATION	- STATION	Annual Passenger Mileage	Annual Passenger Revenue
Pittsburgh Airport	- Elizabeth	60	$ 16.8
Pittsburgh Airport	- Greensburg	93	$ 26.0
Downtown Pittsburgh	- Aliquippa	13	$ 3.7
Downtown Pittsburgh	- Washington	13	$ 3.6
Pittsburgh Airport	- Indiana	89	$ 24.9
Total Suburban System		268	$ 75.0

Passenger mileage and revenue is expressed in millions of 1991 dollars.

6.4.3.2 High Priority Freight Revenue

Another potential transportation revenue will come from freight service. The regional MAGLEV system has the potential to integrate air freight cargo operations in ways similar to those of passenger operations by avoiding the ground congestion around regional airports. Air freight operations stress the minimization of takeoffs and landings to load or unload freight due to high costs and the loss of time experienced. The regional MAGLEV system may fill a niche in the industry by extending service to cities that might not justify air service delivery.

The MAGLEV vehicles are designed to use standard LD3 air transport containers. The LD3 containers are used for cargo and baggage in the lower-deck compartments of most passenger aircraft. The small standardized containers will facilitate quick and efficient intermodal transfers both between the ground and MAGLEV and between the MAGLEV and air modes. The HSGT system will feed the air express service for long-haul destinations and other areas not directly served by the HSGT system since the regional system will provide frequent service to the major airports.

The revenues that can be generated from high value freight are unclear at this time. Additional study is required focusing on the relationships that can be developed with the small package air-surface delivery industry (Airborne Express, Emery Worldwide, Federal Express, etc.). Given the fact that airport space is limited and expensive, it may be beneficial to create "MAGLEV cargo consolidation and distribution facilities". It may be possible to operate these distribution facilities at a lower cost than airport facilities. The HSGT system nodes would be able to act as satellite terminals thus avoiding the increasing congestion around the major airports.

6.4.3.3 Development Around Stations

Additional operating revenue may be realized throughout the life of the project as a result of the economic development around HSGT stations. Additional operating revenue can be realized by the incremental increase in ridership that may occur due to the attraction of the retail development. This increase is net ridership, riders who wouldn't normally be making trips on the transportation system. The Regional system may also be able to enter into revenue-sharing agreements with developers. Non-farebox revenue may be an important contributing funding source in public/private transportation systems although it is not a panacea for capital debt repayment.

6.4.4 ECONOMIC IMPACTS

There is a substantial base of past research linking the construction of new transportation projects with economic growth. Much of the prior research has focused on highway and transit construction. Transportation projects have shown a "multiplier" effect of approximately 2 to 4 times the original investment. Multiplier effects result from the spending and respending of the same dollar from the initial investment.

The overall benefits expected from investment in HSGT systems are diverse and include: increased efficiency of both the air and highway modes measured by reduced door-to-door travel time and travel cost, reduced pollution emissions, reduced operating costs, increased safety, increased tourism and increased business activity. Better accessibility to the labor and consumer markets of the region will also lead to increased economic development.

The demand for travel is expected to increase sharply as the U.S. economy continues to shift to more service based industries. Travel demand is also expected to increase as the U.S. population ages. The construction of HSGT systems will provide a portion of the additional infrastructure capacity that will be required to maintain industrial competitiveness into the 21st century and to maintain the mobility that the population has come to expect and demand. HSGT systems offer a way to provide the necessary infrastructure required for economic development and to enable existing industries to flourish in their present locations. New development opportunities will also become feasible as transportation costs are reduced.

While providing additional transportation capacity in the long-term, HSGT system construction will also provide a direct and measurable stimulus to the national economy by creating thousands of engineering, manufacturing and construction jobs in the short-term.

An economic forecasting model that was developed by Regional Economic Models, Inc. (REMI), and licensed and operated by the University of Pittsburgh was utilized for the analysis of the expected economic impacts from the construction and operation of the Regional MAGLEV system.

A control forecast was prepared for the national economy and the six county Greater Pittsburgh metropolitan area economy in order to contrast the impacts that a large scale construction project such as the Regional system would have on the respective economies. It was expected that the full impacts of the manufacturing and construction of the Regional system would not be entirely realized using the local model due to economic "leakage" to areas outside of the six county region. This was verified in an early run of the model. Therefore, the national REMI model was utilized for construction and manufacturing economic impacts of the Regional system. The operation and maintenance impacts of the Regional system are less likely to flow outside of the geographic region since more of the jobs are service jobs that are able to be filled by local firms. The hub and spoke layout of the Regional system will also tend to concentrate O&M personnel in the local region. Therefore, the local REMI model was utilized for the operation and maintenance economic impacts.

The capital and operating cost estimates for the Regional system were analyzed and each component categorized into a number of industry segments where money would most likely be spent. For example, industry segments that would benefit from building the guideway include fabricated metal, stone and concrete, and construction labor. The estimated dollar amount for each industry segment was then allocated to the year of expected expenditure. These were then input into the REMI model and compared against a control forecast.

A number of different construction and operating scenarios were analyzed. Construction expenditures were spread over a 30 year period. Operation and maintenance expenditures were pro-rated over the 30 year construction period and continued at 100% throughout the remainder of the time span of the model.

The scenario presented here consists of a smoothed construction schedule over 30 years of equal annual capital expenditures and linearly increasing O&M expenditures. This scenario eliminated wild fluctuations in employment and economic activity due to uneven capital expenditures and more closely follows the expected construction pattern.

The economic impacts that are outlined here result from the direct construction and operation costs of the regional MAGLEV system. The REMI model that was utilized is not currently equipped to incorporate induced effects from a new transportation mode such as new station development, reduced costs or increased business expansion.

6.4.4.1 Employment Benefits

The building of a regional MAGLEV system will create thousands of jobs in a variety of industries and locations. The jobs created by building the Regional system will not only occur in construction and manufacturing industries but jobs will also develop in retail and wholesale trade, insurance and finance, and potentially in tourism related industries.

The Transrapid MAGLEV system uses a highly automated manufacturing process for guideway manufacturing and field installation. The computerized nature of the manufacturing process is expected to require a skilled work force. A large portion of the employment gains will accrue to the region where manufacturing of the guideway beams and associated guideway equipment occurs. Employment gains will also spread throughout the entire region as the guideway and piers are erected on-site, at stations and special constructions that occur throughout the region.

For every $1 billion (1991) spent on MAGLEV manufacturing and construction, the REMI model forecasts that over 16,500 jobs will be created, to equal one person-year of employment. Of these jobs, it is estimated that approximately 7100 of these jobs will be a direct result of the manufacturing and construction of the MAGLEV system. The primary industry sectors that are directly affected from building the system are manufacturing, construction, transportation and mining. Due to the highly automated nature of the manufacturing process for the guideway and guideway equipment, the bulk of the direct jobs will accrue in the manufacturing area. It is estimated that the largest percentage (approximately 34% of the total jobs), over 5500 jobs per $1 billion, would occur in the manufacturing segment. The construction and transportation segments are expected to account for the majority of the remaining 1600 direct jobs created by the construction of the Transrapid MAGLEV systems.

The jobs that are indirectly created by the construction of the system are: finance, insurance and real estate; retail trade; wholesale trade; services; and agriculture. The service sector accounts for the largest percentage of the indirect jobs with approximately 5400 jobs per $1 billion (approximately 33% of the total jobs). The service sector will include some jobs directly resulting from the construction of the MAGLEV systems, primarily in engineering and consulting services for the design and management of the system.

The manufacturing and construction of the Regional and Suburban systems are expected to create over 675,000 jobs over the 30 year construction lifetime. On average, over 22,500 jobs for each of the 30 years of construction of the system will be created by building the Regional and Suburban systems.

For every $1 million spent on operation and maintenance, the model forecasts that there will be approximately 28 jobs created. When fully constructed, the Regional and Suburban systems would directly generate 5300 jobs in the operation and maintenance of the system. Over 6600 additional annual jobs will indirectly be created by the O&M expenditures of the Regional system. Unlike the construction impacts of the systems, the O&M impacts will continue indefinitely which will cause the nearly 12,500 jobs created to be permanent job increases.

6.4.4.2 Economic Development

Public investment creates economic development when the total benefits derived from the investment exceeds the cost of the investment. Investment in construction projects produce substantial short-term economic impacts throughout the construction phase. Impacts resulting from operating and maintenance of the MAGLEV system will extend indefinitely since the expenditures recur annually.

The economic development impacts are reported by the REMI model in many different ways. The most appropriate in this context are net increase in real disposable income (after-tax) and GNP total output. All figures are reported in 1991 dollars.

A dollar of direct expenditure for the construction and manufacturing of the system will generate approximately two dollars of total expenditures. The Mid-Atlantic Regional MAGLEV System is estimated to generate over $78 billion in direct economic benefits from the manufacturing and construction of the system. Over $20 billion will be realized by employees in wages and salaries. Taxes paid to the various levels of government will increase by over $4 billion. Building the system will result in an increase in real disposable income of over $10.4 billion for the people located within the region.

A dollar of direct expenditure for operation and maintenance is estimated to generate approximately three dollars of total expenditures in the economy. While the levels of expenditure during operation are significantly lower than during the construction phase, they are essentially permanent expenditures. The Regional MAGLEV System is estimated to generate over $1.2 billion of economic development per year from operations when in full revenue service and as much as $14.5 billion during the construction period as segments of the system go into operation. Over $750 million will annually be realized in wages and salaries and various levels of government will realize approximately $143 million in taxes annually based on current estimated levels of service and ridership.

6.4.4.3 Nodal Development

Although the REMI model is unable to forecast the effects that a new transportation system may induce, it is expected that the economic development that can occur at and around HSGT stations can be substantial if properly planned. Joint development of stations with retail centers can provide ongoing non-farebox revenue for the operation and maintenance of the HSGT system and help defray the capital cost of the system. It will be important to include developers early in the planning stages to maximize the potential returns for both the retail developer and the HSGT system developer. Joint development of stations may also lead to increased ridership on the system since the station complex can be designed as a regional attraction.

Transportation modes have historically preceded office and retail development. Transportation systems were built to serve the population but were not concerned with developing the area around the transportation centers. After the transportation was established, though, retail and office developments have occurred by capitalizing on the increased mobility of the populace. The transportation nodes create value for developers. Therefore, since the transportation system creates value, proper system design can capture some of the value of the stations through joint development.

Economic development around HSGT stations offers the possibility of reducing the initial capital cost requirements. The infrastructure required to access the station area can be better designed by incorporating the stations with retail and office development at the beginning of the project instead of altering the infrastructure after the system is in place. Additionally, the cost of the stations may be reduced if the station area is viewed as an amenity of the complex and incorporated into the developers costs instead of into the HSGT builder's costs.

Building HSGT systems will require substantial input from both the public and private sectors. Public participation will allow growth to be managed in ways to protect the quality of life of local constituents. The land use policies developed by the public agencies can ease the bureaucratic entanglements that private developers often encounter and may reduce the cost of the land required to build the HSGT system. The transportation agency is usually better suited to deal with local governments than the developer which can reduce the administrative barriers and streamline the development process.

The potential of joint developments is great but it will require innovative changes to current practices. It will be important for developers, public officials and HSGT operators to work together early in the planning stages in order to maximize the total benefits that can be realized for everyone involved.

6.4.4.4 Manufacturing Economic Benefits

In addition to the direct economic impact resulting from the actual fabrication of the MAGLEV system, other manufacturing economic benefits can occur by locating plants near stations and advancing manufacturing techniques.

Industries that produce high value freight or services where hauling time is critical will experience competitive advantages and reduced costs from a HSGT system. Industries that currently rely on air cargo express service could be drawn to areas of close proximity to HSGT stations. Small, high-technology manufacturing industries highly utilize express air service. These industries include computers and computer equipment, electronic components, aerospace equipment and parts, and semiconductors. For these industries, HSGT systems will complement and supplement the air cargo express service.

Important advances in automated manufacturing techniques are likely as companies gain experience building the MAGLEV systems and attempt to reduce costs. Innovative manufacturing techniques developed by one industry are often transferable to other industries. These advanced techniques would then increase overall industrial competitiveness of the U.S. manufacturing sector. Examples of this include the automation of the automobile and aircraft manufacturing plants which have benefited all manufacturing industries.

6.5 SUMMARY AND CONCLUSIONS

Building and operating a regional high speed MAGLEV system will have a tremendous socioeconomic impact on the region. These benefits include improved mobility, travel cost and time savings, reduced pollution emissions, reduced reliance on foreign oil, increased employment and economic growth and development.

The construction of the Regional and Suburban systems are expected to create over 675,000 jobs over the construction lifetime. The operation of the system is expected to create almost 12,500 permanent jobs. Economic growth and development is expected to increase by at least $78 billion from the construction of the systems and $14.5 billion dollars from operation and maintenance with an additional $1.2 billion of benefits accruing annually from the operation and maintenance of the system.

The Regional MAGLEV System is expected to generate enough farebox revenue to cover operating and maintenance costs and also be able to contribute toward the repayment of capital.

Table 6-26 summarizes the estimated costs and revenues by line. Table 6-28 shows the total Regional system capital cost with the Suburban system.

Using a simplified cash flow model which ignores the effects of inflation and a cost of capital of 7% compounded annually, Table 6-27, Regional System Capital Requirements By Time, shows the amount of 1991 dollars that can be repaid if the system was built over 30 years starting 1996 with a maximum 30 year payback of non-public capital funds from passenger revenue. The income derived from freight, stations and value capture would only increase the potential of payback on investment.

The assumptions include a three year lag between when the capital funds are required to build a portion of the system and when that portion of the system is ready for operation. It is also assumed that capital funds are required at the beginning of the time period and interest accrues at the end of the year. All capital costs, operating costs and passenger revenues are pro-rated over the construction life of the system. There are no assumptions of additional induced riders over time.

This rough analysis shows that approximately 20% of the capital costs can be repaid from farebox revenues and thus could be derived from non-public sources. The percentages of non-public financing would differ for each of the phases of the project since some lines are more profitable from operation than others. Private capital investment is most appropriate for the purchase of vehicles, O&M facilities and station development.

The ridership analysis is a preliminary estimate that was undertaken with a limited amount of study funds. There are a number of areas that have been identified that

TABLE 6-26

SUMMARY OF COSTS AND REVENUES

	Capital Cost	ANNUAL O&M Cost	ANNUAL Passenger Revenue
Pittsburgh Airport - EJ Switch	886	11	N/A
EJ Switch - Philadelphia	9033	115	522
EJ Switch - Washington D.C.	9173	93	326
Pittsburgh Airport - S/WJ Switch	1308	11	N/A
S/WJ Switch - Huntington, WV	2389	55	95
S/WJ Switch - Columbus, OH	1866	36	67
Pittsburgh Airport - NJ Switch	749	12	N/A
NJ Switch - Cleveland Airport	8456	31	41
NJ Switch - Erie, PA	4381	14	8
Pittsburgh Airport - Weirton/Steubenville	657	6	N/A
Mid-Atlantic Regional System	38898	383	1059
Pittsburgh Suburban System	2182	65	75
Total Regional and Suburban System	41080	448	1134

All figures are millions of 1991 dollars.

TABLE 6-27
REGIONAL SYSTEM CAPITAL REQUIREMENTS BY TIME
7% Interest Rate
30 Years to Construct Regional System
Non-Public Capital at 19.5 Percent of Total Capital Investment

Time Period	Period Capital Extended	Period Revenue	Period O & M	Net Revenue	Total Capital	Non-Public Capital
1996	1291	0	0	0	1291	263
1997	1291	0	0	0	2583	543
1998	1291	0	0	0	3874	844
1999	1291	35	13	23	5166	1143
2000	1291	71	26	45	6457	1441
2001	1291	106	38	68	7748	1737
2002	1291	141	51	90	9040	2031
2003	1291	177	64	113	10331	2323
2004	1291	212	77	135	11623	2613
2005	1291	247	90	158	12914	2901
2006	1291	283	102	180	14206	3186
2007	1291	318	115	203	15497	3469
2008	1291	353	128	225	16788	3749
2009	1291	389	141	248	18080	4027
2010	1291	424	154	270	19371	4301
2011	1291	459	167	293	20663	4572
2012	1291	494	179	315	21954	4839
2013	1291	530	192	338	23245	5103
2014	1291	565	205	360	24537	5363
2015	1291	600	218	383	25828	5618
2016	1291	636	231	405	27120	5868
2017	1291	671	243	428	28411	6114
2018	1291	706	256	450	29702	6354
2019	1291	742	269	473	30994	6589
2020	1291	777	282	495	32285	6818
2021	1291	812	295	518	33577	7040
2022	1291	848	307	540	34868	7255
2023	1291	883	320	563	36159	7462
2024	1291	918	333	585	37451	7662
2025	1291	954	346	608	38742	7853
2026	0	1060	384	675	38742	7727
2027	0	1060	384	675	38742	7593
2028	0	1060	384	675	38742	7449

TABLE 6-27 (continued)
REGIONAL SYSTEM CAPITAL REQUIREMENTS BY TIME
7% Interest Rate
30 Years to Construct Regional System
Non-Public Capital at 19.5 Percent of Total Capital Investment

Time Period	Period Capital Extended	Period Revenue	Period O & M	Net Revenue	Total Capital	Non-Public Capital
2029	0	1060	384	675	38742	7295
2030	0	1060	384	675	38742	7130
2031	0	1060	384	675	38742	6954
2032	0	1060	384	675	38742	6765
2033	0	1060	384	675	38742	6563
2034	0	1060	384	675	38742	6348
2035	0	1060	384	675	38742	6117
2036	0	1060	384	675	38742	5869
2037	0	1060	384	675	38742	5605
2038	0	1060	384	675	38742	5322
2039	0	1060	384	675	38742	5019
2040	0	1060	384	675	38742	4695
2041	0	1060	384	675	38742	4348
2042	0	1060	384	675	38742	3977
2043	0	1060	384	675	38742	3580
2044	0	1060	384	675	38742	3156
2045	0	1060	384	675	38742	2701
2046	0	1060	384	675	38742	2215
2047	0	1060	384	675	38742	1695
2048	0	1060	384	675	38742	1138
2049	0	1060	384	675	38742	542
2050	0	1060	384	675	38742	* -95
2051	0	1060	384	675	38742	-777

* Break-even point for non-public capital investment at 7 percent.

TABLE 6-28
TOTAL REGIONAL SYSTEM CAPITAL COST
WITH PITTSBURGH SUBURBAN SYSTEM

STATION	LENGTH (MI)	TOTAL COST	GDWAY COST	SPECL CONST	EQUIP FACIL	VEH COST	STAT COST
Pittsburgh Airport -EJ switch	29	909	378	98	302	32	30
EJ switch - Baltimore/Washington	270	8958	3333	2340	2085	332	54
EJ switch-Philadelphia	326	9306	4006	1501	2516	387	64
AVWJ Switch - AVEJ Switch	67	2050	897	327	510	116	14
Pittsburgh Airport -NJ Switch	40	1342	501	336	332	43	8
NJ Switch - Cleveland Airport	99	2389	1215	112	759	64	22
NJ Switch - Erie	80	1866	974	95	600	21	6
Pittsburgh Airport - S/WJ Switch	24	749	299	130	203	43	6
S/WJ Switch - Huntington	228	8479	2777	3070	1717	128	16
S/WJ Switch - Columbus	158	4404	1928	771	1195	96	14
S/WJ Switch - Steubenville./Weirton	21	657	263	141	180	11	2
Total System	1336	40924	16448	8903	10383	1273	226

require additional analysis in a subsequent phase that may cause the forecasted ridership to change.

First, the network concept is only partially applicable for a regional transportation system. The results generated by this model are probably understating the expected demand because it only estimates inter-city travel. It does not integrate the MAGLEV system into the regional airport hubs such as Pittsburgh's new Midfield Terminal. The network approach acts primarily as a direct competitor to the air system while the regional approach integrates the highway mode to complement the air system in the metropolitan area. In addition, the model is unable to integrate positive effects that the Suburban system may have on the Regional System.

The regional model utilized survey data from a single corridor, socioeconomic data from 1980, and service levels from 1985. A finance-quality ridership study with an up-to-date survey covering each intercity corridor and the suburban areas that a regional MAGLEV system would serve should be performed using current census data and up-to-date service levels and fares.

Current models treat MAGLEV systems as if it had the same characteristics as existing passenger rail. Modern MAGLEV systems will be more similar to air travel than to rail travel in speed, comfort, and passenger amenities while retaining the multiple locations of rail stations. Future models should incorporate the features of these new systems that will complement both the highway and air modes.

This report has attempted to identify potential sources of revenue but at this preliminary stage of analysis it is difficult to precisely quantify the amounts and timing of revenue flows. The ridership analysis was performed utilizing available models and data and a thorough finance-quality study should be undertaken immediately. This model should incorporate a comparison of the network approach versus the regional approach in order to determine the optimum building strategy.

There is a lag between the time that capital is required for the project and the time that the system is in operation and generating revenues. In order to minimize the lag between construction and operation, the systems should be built such that passenger revenues are realized as soon as possible. This will require a phased construction approach that will maximize revenues early in the project.

Based on the current ridership study, the preferred construction method would build the Eastern lines first, followed by the South/Western lines. The Northern lines would either be deferred into the future when manufacturing costs may be reduced or the terminus cities may need to be extended to larger population centers such as Buffalo, NY, Detroit, MI, and Chicago, IL. Passenger revenue studies show that running into major population centers increases the revenue projections for the entire line thus making the line more financially viable.

The feasibility of a regional MAGLEV system will depend upon the verification of the construction and operating costs of a demonstration system. It is expected that capital costs will be reduced as more experience is gained through manufacturing and construction of MAGLEV systems. Therefore, it is imperative that MAGLEV demonstration systems be built as soon as possible in order to gather the information required to operate large-scale systems.

7.0 PITTSBURGH DEMONSTRATION SYSTEM

7.1 OVERVIEW

The first phase of the Regional system will be a Demonstration Line between Pittsburgh International Airport (PIA) and Downtown Pittsburgh. There are several purposes for developing this line:

- Verify the safety and reliability of MAGLEV,
- Verify the capital and operating costs,
- Verify the system's performance characteristics,
- Verify the environmental impacts,
- Define, set up and test manufacturing and construction methods,
- Increase the visibility of MAGLEV,
- Promote public acceptance for this new transportation mode,
- Establish the primary link of the Regional System.

This section describes the investigation into the feasibility of constructing the Pittsburgh MAGLEV Demonstration System. The study focused on several elements.

- Collecting available information and data,
- Performing preliminary transportation planning analysis including ridership forecasts,
- Preparing preliminary schematics (horizontal and vertical alignment development),
- Developing capital and operation costs estimates,
- Evaluating corridors for potential environmental impacts,
- Comparing costs and benefits of alternative alignments to form the basis for the future selection of a preferred alignment.

7.1.1 OVERVIEW OF STUDY

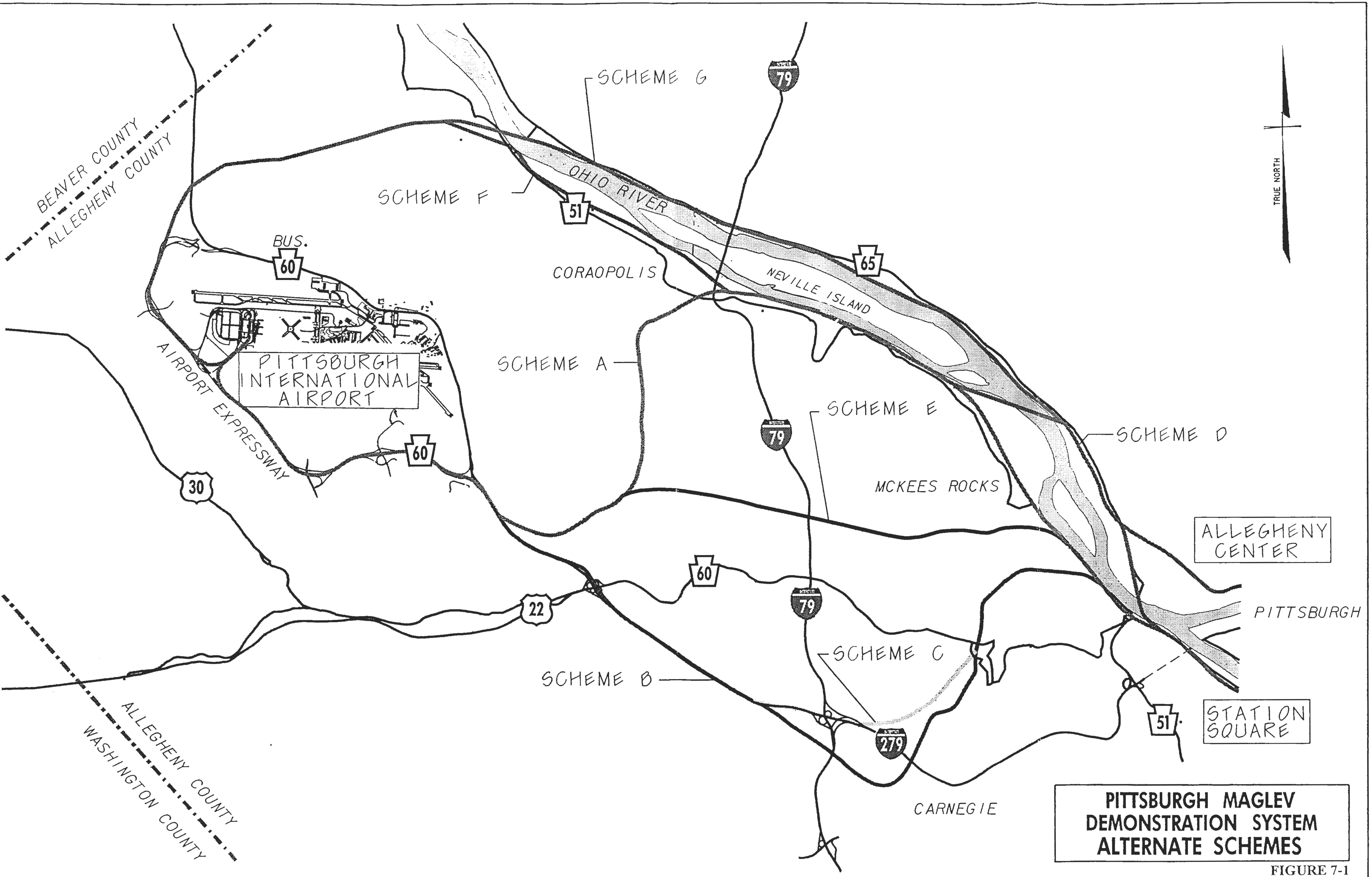
As part of the Preliminary Feasibility Study, five conceptual corridors for the Pittsburgh MAGLEV Demonstration System were developed. All corridors begin at the Pittsburgh International Airport (PIA) and terminate in downtown Pittsburgh (see Figure 7-1, Preliminary MAGLEV System Corridors). Stations at the airport and downtown were selected to provide intermodal connections with the air system and the regional mass transit system.

The Preliminary Feasibility Study recommended that Corridors A, D and E be carried over into the DD & D Study for further evaluation. Corridors B and C were dismissed from further consideration because of a lack of available right-of-way along the Airport Parkway and possible conflicts with the Port Authority of Allegheny County's proposed Airport Busway which would share the same railroad right-of-way. At the onset of this study, Corridors F and G were also recommended for further investigation. Since most of Corridor F is common to Sections of Corridors A and G, the need for further investigation was not deemed necessary.

The further analysis of Corridors A, D, E and G included the following work elements:

- Preparation of mapping,
- Evaluation and analysis of ridership data,
- Field review of the four corridors,
- Collection and analysis of existing design standards
- Development of conceptual alternatives,
- Development of 1"=200' scale schematic designs of four alternatives,
- Comparative analysis of alternatives,
- Environmental analysis of alternatives.

All alignments were originally developed at a scale of 1"=2000' scale. Potential alignments including horizontal and vertical geometry based on design criteria for a Transrapid system within Corridors A, D, E and G were developed to 1"=200' scale. Plans, profiles and typical sections were prepared for the four alternative alignments. Based on developed vertical and horizontal alignments, preliminary operational cost estimates as well as cost estimates for right-of-way acquisition and construction of each alternative alignment were prepared.



PITTSBURGH MAGLEV DEMONSTRATION SYSTEM ALTERNATE SCHEMES

FIGURE 7-1

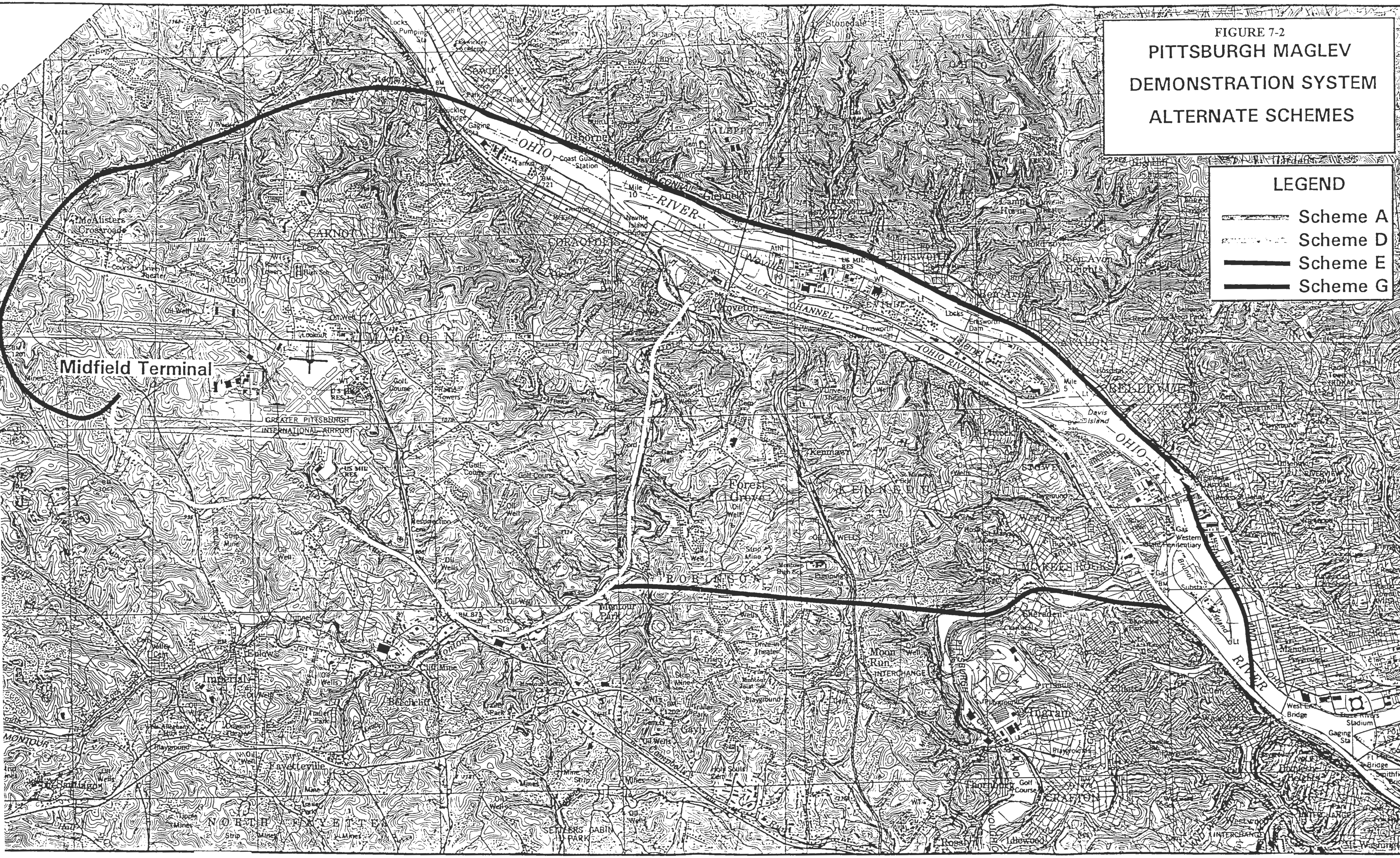


FIGURE 7-2
PITTSBURGH MAGLEV DEMONSTRATION SYSTEM ALTERNATE SCHEMES

Ridership data was collected and analyzed to determine the number of daily trips expected. Fares and parking costs were varied to determine their impact on ridership, and the subsequent impact on revenues.

An environmental constraint analysis of Corridors A, D, E and G was conducted, focusing on the following:

- Identification of environmental baseline characteristics of each corridor,
- Potential environmental impacts associated with proposed alternatives,
- Potential mitigation measures,
- Recommendations for further detailed studies,
- Identification of Federal, State and/or local permits required for construction.

7.1.2 OVERVIEW OF DEMONSTRATION SYSTEM ALTERNATIVES

All alternatives begin at PIA and terminate in Downtown Pittsburgh (see Figure 7-2 for Demonstration, Design and Development Study Alignments). All four proposed alignments begin at a station located in the long-term parking area of the Midfield Terminal above the moving walkway.

Alternatives A, E and G terminate at Station Square, allowing passengers to make connections to the light rail transit and bus systems operated by the Port Authority of Allegheny County (PAT) as well as private and public automobiles. Alternative D ends in Pittsburgh's North Side at a station near Allegheny Center, allowing riders to connect to PAT buses, automobiles and ultimately the proposed Spine Line light rail system.

A brief description of locations of alternatives is given below.

7.1.2.1 ALTERNATIVE A

Alternative A exits PIA by crossing over the Airport Terminal entrance ramps to Route 60. Traveling southeast, the alignment parallels Route 60 along its north side toward the junction of Route 60 and Business Route 60. The alignment then crosses over the Airport Parkway and proceeds along the north side of the Airport Parkway to the abandoned Montour Railroad right-of-way. Through this section, the alignment crosses over the abandoned railroad at several locations, heading northeast through Moon and Robinson Townships. Alternative A makes an approximately 90 degree turn near Coraopolis, crossing over Route 51 and under Interstate 79, entering the CSX Railroad right-of-way along the south side of the Ohio River. The alignment follows the CSX Railroad past the Emsworth Locks and Dam, through the railroad yard in McKees Rocks, and into the City of Pittsburgh. Alternative A continues along the CSX Railroad right-of-way, paralleling the north side of Carson Street, crossing under the West End and Fort Pitt Bridges. The alignment then crosses over Carson Street, following the Conrail right-of-way under the Monongahela Incline to a station adjacent to the existing PAT Station at the intersection of Carson and Smithfield Streets.

7.1.2.2 ALTERNATIVE D

Alternative D follows the same alignment as Alternative A to a point just west of the railroad yard in McKees Rocks. At this point, Alternative D continues east along the P&LE Railroad right-of-way and crosses the Ohio River, approximately 3/4 of a mile northwest of the McKees Rocks Bridge. Alternative D then parallels the north side of the Ohio River, following Conrail railroad right-of-way to the north of the Alcosan Treatment Plant in the City of Pittsburgh, under Route 65 and through West Park. The alignment then leaves the Conrail Corridor, for a short distance, near Merchant Street because the Conrail alignment curvature is too sharp for the MAGLEV vehicle to traverse. Alternative D terminates at a station on Conrail Railroad right-of-way just south of the shopping mall at Allegheny Center.

7.1.2.3 ALTERNATIVE E

Alternative E also follows the same alignment as Alternative A to a point just south of Hookstown Grade Road where Alternative E continues east, crossing under the intersection of Clever Road and Silver Lane and tunneling under Longview Road. The alignment then proceeds south of the Montour High School, crossing over Interstate 79 and under Robb Street, McKees Rocks Road and Longview Road, before crossing Chartiers Creek and entering the City of

Pittsburgh. Alternative E then crosses Chartiers Creek twice more near the Sheridan Park Apartments, passes over Stadium Drive and turns south along the Conrail right-of-way, south of Carson Street. Alternative E continues under the Duquesne Incline and the Fort Pitt Bridge, following the Alternative A alignment to a station adjacent to the PAT station at Station Square.

Between Hookstown Grade Road and the Ohio River, the alignment corridor could be developed as part of a multimodal transportation corridor which would also include an airport alternative highway as recommended by the Southwestern Pennsylvania Regional Planning Commission in the Airport Corridor Multi-Modal Transportation Study (1989).

7.1.2.4 ALTERNATIVE G

Alternative G follows the Alternative A alignment a short distance before turning west out of PIA and follows the north side of Route 60. Crossing under the Flaugherty Run Interchange and over Business Route 60, the alignment proceeds northeast along the same general alignment as Flaugherty Run Road, tunneling under Shafer Road and Westbury Drive before crossing over Route 51 and the Ohio River. Along the northern side of the Ohio River, Alternative G crosses under the Sewickley Bridge, and follows the Conrail right-of-way, south of the Ohio River Boulevard, under Interstate 79, and past the Emsworth Locks and Dam and the Alcosan Treatment Plant into the City of Pittsburgh. Alternative G then crosses the Ohio River near Franklin Street and follows the Alternative A alignment to a station at Station Square.

7.2 ENVIRONMENTAL CONSTRAINT ANALYSIS

An environmental constraint analysis of Corridors A, D, E and G was conducted focusing on the following:

- Collection of all available secondary resources including mapping of the study area,
- Identification of environmental baseline characteristics of each corridor,
- Development of environmental constraint mapping,

- Determination of potential environmental impacts associated with proposed alternatives,
- Evaluation of potential mitigation measures,
- Recommendations for further detailed studies,
- Identification of Federal, State and/or local permits required for construction.

The investigation considered a number of environmental issues related to construction of transportation facilities including:

Land Use and Displacements	Traffic and Other Considerations
Energy Requirements	Air Quality
Cultural Resources	Aesthetics
Water Quality	Floodplains
Terrestrial Environment	Geotechnical Considerations
Safety and Security	Pedestrians and Bicyclists
Noise and Vibration	Section 4(f) Resources
Navigable Waterways	Wetlands
Threatened and Endangered Species	Construction Impacts

7.2.1 LAND USE AND DISPLACEMENTS

The U. S. Department of Commerce Standard Zoning Enabling Act (1924) established zoning as a power by which local governmental officials can guide development of their communities. Zoning controls development in a community by directing new growth into areas conducive to development while protecting existing property owners by requiring that development allow for adequate light, air and privacy for individuals living and working within the community.

Zoning is the division of a municipality (or other governmental unit) into districts usually based on land use characteristics (residential, commercial and industrial) as well as the density of development. Zoning characteristics vary widely from community to community as do zoning ordinances governing a wide variety of site development characteristics such as building height, set back distances, acreage of open land, aesthetics of structure, size of parking areas, etc.

The alignments being considered for the MAGLEV Demonstration System traverse through eight townships, nine boroughs, and the City of Pittsburgh as shown on Table 7-1, Municipalities By Alternative.

TABLE 7-1
MUNICIPALITIES BY ALTERNATIVE

Alternative	Municipalities
A	Findlay Township
	Moon Township
	North Fayette Township
	Robinson Township
	Kennedy Township
	Stowe Township
	McKees Rocks Borough
	City of Pittsburgh
D	Findlay Township
	Moon Township
	North Fayette Township
	Robinson Township
	Kennedy Township
	Stowe Township
	Bellevue Borough
	City of Pittsburgh
E	Findlay Township
	Moon Township
	North Fayette Township
	Robinson Township
	Kennedy Township
	McKees Rocks Borough
	City of Pittsburgh
G	Findlay Township
	Moon Township
	Sewickley Borough
	Osborne Borough
	Haysville Borough
	Glenfield Borough
	Kilbuck Township
	Emsworth Borough
	Ben Avon Borough
	Avalon Borough
	Bellevue Borough
	City of Pittsburgh

Of the communities through which the MAGLEV alternatives pass, most have zoning policies and regulations. Primary zoning classifications characterizing the study corridors are residential, commercial, light industrial, heavy industrial, limited professional, business park, light manufacturing, industrial/commercial and commercial/manufacturing.

Based on a minimum 60 foot right-of-way and an estimate of the required construction limits of each alternate, an estimate was made of how each alternative alignment (A, D, E and G) would encroach upon public and privately owned land within various zoning districts.

Alternative A would require the following right-of-way acquisitions:

- 41 acres at the Pittsburgh International Airport owned by Allegheny County
- 20 acres adjacent to Route 60 currently owned by the Pennsylvania Department of Transportation
- Private property within several municipalities as follows:
  - Moon Township - 42 acres
  - Robinson Township - 35 acres
  - North Fayette Township - 2 acres
  - Kennedy Township - 8 acres
  - City of Pittsburgh - 4 acres
- Air rights to 5,500 linear feet of the abandoned Montour Railroad right-of-way
- Air rights to 39,300 linear feet of the CSX Railroad right-of-way
- 3 Buildings

Acquisitions for Alternative D include:

- 41 acres at the Pittsburgh International Airport owned by Allegheny County
- 20 acres adjacent to Route 60 currently owned by the Pennsylvania Department of Transportation
- Private property within several municipalities as follows:
  - Moon Township - 42 acres

- Robinson Township - 35 acres
- North Fayette Township - 2 acres
- Kennedy Township - 8 acres
- City of Pittsburgh - 2 acres

- Air rights to 5,500 linear feet of the abandoned Montour Railroad right-of-way
- Air rights to 19,000 linear feet of the Conrail right-of-way
- Air rights to 18,500 linear feet of the CSX Railroad right-of-way
- 5 Buildings

Acquisition requirements for Alternative E are:

- 41 acres at the Pittsburgh International Airport owned by Allegheny County
- 20 acres adjacent to Route 60 currently owned by the Pennsylvania Department of Transportation
- Private property within several municipalities as follows:
  - Moon Township - 15 acres
  - Robinson Township - 66 acres
  - Kennedy Township - 39 acres
  - McKees Rocks Borough - 3 acres
  - City of Pittsburgh - 18 acres
- Air rights to 2,100 linear feet of the abandoned Montour Railroad right-of-way
- Air rights to 13,900 linear feet of the Conrail right-of-way
- 47 Buildings

For Alternative G, acquisition would include:

- 40 acres at the Pittsburgh International Airport owned by Allegheny County
- 9 acres adjacent to Route 60 currently owned by the Pennsylvania Department of Transportation
- Private property within several municipalities as follows:
  - Findlay Township - 16 acres
  - Moon Township - 81 acres

- Borough of Sewickley - 3 acres
- Borough of Emsworth - 5 acres
- Borough of Ben Avon - 4 acres
- City of Pittsburgh - 7 acres

- Air rights to 6,600 linear feet of the abandoned P&LE Railroad right-of-way
- Air rights to 41,700 linear feet of the Conrail right-of-way
- 23 Buildings

In addition, the "taking" of several structures would occur for each alignment. The total number of structures taken by each alignment is as follows:

- Alternative A - 2 Houses and 1 Business
- Alternative D - 2 Houses, 21 Public Buildings, 1 Mechanical Building, and 1 Business
- Alternative E - 42 Houses and 5 Businesses
- Alternative G - 15 Houses, 6 Businesses, 1 Railroad Station, and 1 Building

Table 7-2 presents a summary of the land and structure encroachments for each scheme.

Under Federal requirements, for programs which use Federal funding, no person can be displaced from their residence until decent, safe and sanitary housing is made available to them. This replacement housing must be located in areas generally not less desirable with respect to public utilities and public and commercial facilities, reasonably accessible to their places of employment, at rents or prices within their financial means.

7.2.2 TRAFFIC AND PARKING CONSIDERATIONS

No long-term traffic impacts are expected to occur with the operation of the Demonstration System. The guideway will be elevated above grade or depressed below the grade of existing roadways as dictated by topographic condition. Consequently, the system will not interfere with operations on area roadways. The number of crossings of major roadways (4-lane and 2-lane arterial roads), and minor roadways (2-lane local roads), are presented in Table 7-3, Number of

TABLE 7-2
Land and Structure Encroachments

Alt.	Community	Resid	Comm	Mixed Use	Business Park	Indus/Comm	Indus	Special Use	Public Recreation	Displaced Structures
A	Findlay	-	2.8 ac.	-	1.9 ac.	-	42.5 ac.	-	-	
	Moon	1.4 ac.	14.1 ac.	-	2.9 ac.	-	23.7 ac.	-	-	
	Robinson	-	0.7 ac.	-	-	-	34.6 ac.	-	-	2 Houses
	Kennedy	-	-	-	-	-	8.2 ac.	-	-	
	N. Fayette	-	-	-	-	-	1.7 ac.	-	-	
	Pittsburgh	-	-	-	-	-	3.6 ac.	0.5 ac.	-	1 Business
	Total	1.4 ac.	17.6 ac.	-	4.8 ac.	-	114.3 ac.	0.5 ac.	-	
D	Findlay	-	2.8 ac.	-	1.9 ac.	-	42.5 ac.	-	-	
	Moon	1.4 ac.	14.1 ac.	-	2.9 ac.	-	23.7 ac.	-	-	
	Robinson	-	0.7 ac.	-	-	-	34.6 ac.	-	-	2 Houses
	Kennedy	-	-	-	-	-	8.2 ac.	-	-	
	N. Fayette	-	-	-	-	-	1.7 ac.	-	-	
	Pittsburgh	0.6 ac.	0.7 ac.	-	-	-	-	0.7 ac.	-	1 Park and Recreation Bldg. 1 Plant Mechanical Bldg. 1 Business
	Total	2.0 ac.	18.3 ac.	-	4.8 ac.	-	110.7 ac.	0.7 ac.	-	
E	Findlay	-	2.8 ac.	-	1.9 ac.	-	42.5 ac.	-	-	
	Moon	0.5 ac.	14.1 ac.	-	2.9 ac.	-	-	-	-	
	Robinson	55.7	-	-	-	-	13.5 ac.	-	3.6 ac.	14 Houses
	Kennedy	13.0	-	-	-	-	26.2 ac.	-	-	5 Businesses
	N. Fayette	-	-	-	-	-	1.7 ac.	-	-	5 Houses
	Pittsburgh	-	-	-	-	-	5.0 ac.	-	-	
	McKees Rock	6.2	1.2 ac.	-	-	-	3.0 ac.	6.9 ac.	-	
										23 Houses

	Total	75.4 ac.	18.1 ac.	-	4.8 ac.	-	91.9 ac.	6.9 ac.	3.6 ac.	
G	Findlay Twp.	-	15.1 ac.	15.8 ac.	6.0 ac.	-	43.2 ac.	-.	-	3 Businesses
	Moon Twp.	17.8 ac.	-	-	-	48.5 ac.	-	-	-	6 Houses
										2 Businesses
	Sewickley	2.6 ac.	-	-	-	-	-	-	-	3 Houses
										1 Business
										1 Railroad Station
	Emsworth	-	-	-	-	-	-	4.6 ac.	-	
	Ben Avon	-	-	-	-	-	3.5 ac.	-	-	
	Glenfield	-	-	-	-	-	-	-	-	6 Houses
	Pittsburgh	-	-	-	-	-	6.9 ac.	0.5 ac.	-	1 Building
	Total	20.4 ac.	15.1 ac.	15.8 ac.	6.0 ac.	48.5 ac.	53.6 ac.	5.1 ac.	-	

Roadway Crossings. The required roadway crossings for each alternative are presented in Table 7-4, Roadway Crossings. Temporary traffic impacts resulting from roadway crossings may occur during construction of bridges and overpasses for the MAGLEV System.

TABLE 7-3
NUMBER OF ROADWAY CROSSINGS

Alternative	Major Roadway	Minor Roadway
A	11	11
D	11	17
E	10	18
G	6	10

Adequate parking areas for the MAGLEV terminal associated with Alternatives A, E and G would be provided by constructing additional parking facilities in close proximity to the terminal. Sufficient parking for the Alternative D terminal in downtown Pittsburgh can not be provided within close proximity due to the limited space available within the densely developed area. Based on the results of the ridership study, up to 1000 passengers per day would access the station by auto at each end. A study done by Baker of Park-n-Ride lots along PAT's Light Rail System indicates that approximately 25% of auto access represents riders being dropped off. Assuming a similar percentage for MAGLEV indicates parking would be required for the remaining 75%, or approximately 750 cars at each terminal.

7.2.3 ENERGY REQUIREMENTS

As with any other transportation system that supports increased passengers per mile, MAGLEV has the potential to be more energy efficient than the private automobile.

Using information supplied by the Florida High Speed Rail Commission Study and ridership estimates for the Pittsburgh Demonstration System as summarized in Section 7.5, daily energy consumption would be approximately 50 percent less than if the riders traveled by automobiles. Because private automobile is the

TABLE 7-4
ROADWAY CROSSINGS

Alternative	Major Roadways	Minor Roadways
A	Ramp WS-C	Ramp P-9 (PIA)
	Airport Parkway (Route 60)	Ramp P-10 (PIA)
	Montour Run Road (3)	Ramp RS (PIA)
	Carson Street (Route 51)	Enlow Road
	State Avenue	McClaren Road
	Interstate 79	Scott Road
	NB Rt. 60 to PIA entrance	Montour Park Road
	SB Rt. 60 to PIA entrance	Beaver Grade Road
	NB Rt. 60 to NB Business Rt. 60	Petrie Road
	SB Business Rt. 60 to NB Rt. 60	Village Drive
	SB Rt. 60 to NB Business Rt. 60	Station Street
D	NB Rt. 60 to PIA Entrance	Ramp P-9 (PIA)
	SB Rt. 60 to PIA Entrance	Ramp P-10 (PIA)
	NB Rt. 60 to NB Business Rt. 60	Ramp RS (PIA)
	SB Business Rt. 60 to NB Rt. 60	Enlow Road
	SB Rt. 60 to NB Business Rt. 60	McClaren Road
	SB Rt. 60 to NB Business Rt. 60	Scott Road
	Airport Parkway (Route 60)	Montour Park Road
	Montour Run Road (3)	Beaver Grade Road
	State Avenue	Petrie Road
	Interstate 79	Village Drive
	Ohio River Boulevard	Station Street
		Eckert Street
		Columbus Avenue
		Brighton Road
		Ridge Avenue
		Merchant Street
		Federal Street

TABLE 7-4 (continued)
ROADWAY CROSSINGS

Alternative	Major Roadways	Minor Roadways
E	NB Rt. 60 to PIA Entrance	Ramp P-9 (PIA)
	SB Rt. 60 to PIA Entrance	Ramp P-10 (PIA)
	NB Rt. 60 to NB Business Rt. 60	Ramp RS (PIA)
	SB Business Rt. 60 to NB Rt. 60	Enlow Road
	SB Rt. 60 to NB Business Rt. 60	McClaren Road
	SB Rt. 60 to NB Business Rt. 60	Scott Road
	Airport Parkway (Route 60)	Montour Park Road (2)
	Montour Run Road (2)	Beaver Grade Road
	Interstate 79	Silver Lane
	Route 60	Phillips Lane
		Clever Lane
		Aiken Road
		Robb Street
		McKees Rocks Road
		Longview Road
		Creek Road
		Stadium Drive
		Glen Mar Street
G	PIA exit to SB Rt. 60	Ramp P-9 (PIA)
	PIA exit to SB Rt. 60	Ramp P-10 (PIA)
	Moon Clinton Rd. Entrance to SB Rt. 60	Ramp RS (PIA)
	NB Rt. 60 exit to Moon Clinton Rd.	Hookstown Grade Road
	Beaver Valley Expressway (Route 60)	Flaugherty Run Road
	Carson Street	Brodhead Road
		Shafer Road
		Westbury Road
		Narrows Run Road
		Center Avenue

TABLE 7-5
ENERGY CONSUMPTION ESTIMATES
MAGLEV AND PRIVATE AUTOMOBILE

	DAILY CONSUMPTION	ANNUAL CONSUMPTION
Automobiles	3.82×10^8 Btus	13.95×10^{10} Btus
Alternative A	1.87×10^8 Btus	6.83×10^{10} Btus
Alternative D	1.81×10^8 Btus	6.62×10^{10} Btus
Alternative E	1.54×10^8 Btus	5.61×10^{10} Btus
Alternative G	1.93×10^8 Btus	7.05×10^{10} Btus

primary source of transportation between downtown Pittsburgh and the Airport, all MAGLEV passengers were assumed to be diverted from private transportation.

MAGLEV: 1570 Btus/passenger/mile
168 passengers/one-way trip (2-car train at 70% capacity)
36 one-way trips per day

Automobile: 3025 Btus/passenger/mile
1.2 passengers per one-way trip
3160 trips per day

It should also be noted that these statistics do not reflect the increasing traffic congestion on the major routes between downtown Pittsburgh and the Pittsburgh International Airport and the resulting increase in energy consumption of the private automobile.

7.2.4 AIR QUALITY

The United States Environmental Protection Agency (USEPA) has promulgated standards known as the National Ambient Air Quality Standards (NAAQS) for seven primary pollutants - carbon monoxide, hydrocarbons, nitrogen oxides, ozone, particulate matter, sulfur oxides and lead. Table 7-6, Ambient Air Quality

TABLE 7-6
AMBIENT AIR QUALITY STANDARDS
APRIL, 1991

POLLUTANT	STANDARD	AVERAGING PERIOD	NATIONAL (a)
Sulfur Dioxide	Primary	12-Month Arith. Mean	80 ug/m^3 (.03 ppm)
	Primary	24-Hour Average (b)	365 ug/m^3 (.14 ppm)
	Secondary	12-Month Arith. Mean	---
	Secondary	24-Hour Average	---
	Secondary	3-Hour Average (b)	1300 ug/m^3 (0.5 ppm)
Total Suspended Particulates	Primary	12-Month Geom. Mean	---
	Primary	24-Hour Average	---
	Secondary	12-Month Geom. Mean (c)	---
	Secondary	24-Hour Average	---
Inhalable Particulates (PM10)	Prim. & Sec.	Annual Arith. Mean	50 ug/m^3
	Prim. & Sec.	24-Hour Average	150 ug/m^3
Carbon Monoxide	Prim & Sec.	8-Hour Average	9 ppm (10 mg/m^3)
	Prim. & Sec.	1-Hour Average	35 ppm (40 mg/m^3)
Ozone	Primary	Max. Daily 1-Hr. Avg. (d)	.12 ppm (235 ug/m^3)
	Secondary	1-Hour Average	.12 ppm (235 ug/m^3)
Nitrogen Dioxide	Prim. & Sec.	12-Month Arith. Mean	.053 ppm (100 ug/m^3)
Lead	Prim. & Sec.	3-Month Average	---
		Quarterly Mean	1.5 ug/m^3

a) National short-term standards are not to be exceeded more than once in a calendar year.
b) National standards are block averages rather than moving averages.
c) Intended as a guideline for achieving short-term standard.
d) Maximum daily 1-hour average: averaged over a three year period the expected number of days above the standard must be less than or equal to one.

Standards, summarizes the NAAQS for these pollutants. Pollutant concentrations for the City of Pittsburgh are provided in Table 7-7, Existing Air Quality Characteristics.

In accordance with the classifications defined in the 1990 Clean Air Act Amendment, the downtown Central Business District and other high traffic density areas (Parkway West corridor) are classified as being moderate non-attainment areas for carbon monoxide. The rest of Allegheny County is considered to be in attainment for this pollutant. The region is also considered to be a moderate non-attainment area for ozone. Because a significant percentage of these pollutants or their precursors as in the case of ozone, are generated by vehicular emissions, the Clean Air Act Amendments of 1991 stipulate that the Metropolitan Planning Organization (MPO) complete a baseline vehicular emissions inventory by November 1992 and develop reasonable transportation alternatives that will bring the area into compliance with air quality regulations.

Based on the ridership assumptions for the Pittsburgh Demonstration System, it is estimated that between 3,050 and 3,900 passengers will use the system daily. If the proposed ridership is diverted to private automobile, which is the primary travel mode currently between downtown Pittsburgh and PIA, between 2,540 and 3,250 trips would be made. Therefore, the system can result in a reduction of 825 tons per year of carbon monoxide, 70.6 tons per year of hydrocarbons and 98 tons per year of nitrous oxides. This analysis assumes an average speed of 40 miles per hour over a distance of 20 miles.

Furthermore, unlike each automobile and bus included in the vehicle mix, which are for all practical purposes individual pollution sources, MAGLEV will be powered by one central source. Controlling pollutants from a single source can be more efficiently and cost-effectively controlled at the source in comparison to controlling emissions from thousands of vehicles.

7.2.5 CULTURAL RESOURCES

Archaeological and historical resources are protected under Section 106 of the National Historical Preservation Act of 1966 (amended in 1980), regulations of

TABLE 7-7

Existing Air Quality Characteristics - Allegheny County

Monitoring Station	SO2	CO		O3	NOx	PM10		TSP		Pb
	Annual ave.	8-hr max.	1-HR max.	Max. daily 1-hr ave.	Max. daily 1-hr ave.	Annual arith. mean	Daily Max.	12-mos geom. mean	24-hr. ave.	3-mos. ave
Downtown (Gateway Center)	--	8.1 ppm	11.3 ppm	--	--	--	--	--	--	--
Pittsburgh (Flag Plaza)	0.12 ppm	N/A	N/A	--	0.031 ppm	33 ug/m^3	85 ug/m^3	48 ug/m^3	122 ug/m^3	0.04 ug/m^3
Pittsburgh (Point)	--	6.7 ppm	9.7 ppm	--	--	--	--	--	--	--
Lawrenceville	--	--	--	0.111 ppm	--	--	--	--	--	--
GPIA	--	--	--	--	--	--	--	59 ug/m^3	171 ug/m^3	--
Moon Twp.	--	--	--	--	--	28 ug/m^3	76 ug/m^3	--	--	--

the Advisory Council of Historical Preservation (36 CFR Part 800) and Section 4(f) of the Department of Transportation Act of 1966.

The following agencies have been consulted concerning the presence of archaeological and historical sites within the study area:

Pennsylvania Historic and Museum Commission
Pittsburgh History and Landmarks Foundation
Carnegie Museum of Natural History

A review of the National Register of Historic Places shows there are 26 sites on the National Register that are listed within close proximity to the four alternatives. These sites are listed below.

Thornburg Historic District
Carnegie Library
Oliver High School
Manchester Historic District
Davis Island Lock and Dam
McKees Rocks Bridge
West End Bridge
Langley High School
Fifth Ward School
Hoene-Werle House
Allegheny High School
Carnegie Library
Old Allegheny Rows
Mexican War Streets
Allegheny West Historic District
Snyder House
Deutschtown Historic District
Osterling Studio
House at 200 West North Avenue
Henderson-Metz House
Latimer High School
Eberhardt & Ober Brewery

Duquesne Incline
Monongahela Incline
Station Square
Smithfield Street Bridge

The majority of these sites are located on Pittsburgh's North Side, making Alternative D more likely to impact historic places.

This listing does not include sites of local significance. Numerous sites within western Allegheny County have been proposed for designation as a historic resource.

A review of the Pennsylvania Archaeological Site Survey files at the State museum in Harrisburg and the Carnegie Museum of Natural History shows that there are several recorded prehistoric and historic archaeological sites located within or near the study corridors. Table 7-8 indicates the number of known (recorded) archaeological sites located along the proposed alternatives.

TABLE 7-8
KNOWN ARCHAEOLOGICAL SITES

Alternative	No. of Known Sites
Alternative A	4
Alternative B	2
Alternative E	8
Alternative G	2

Various recent projects (e.g. PPG Place, the Gateway Center Light Rail Transit Station, Eighth Street; Crawford - Roberts Redevelopment Project) have uncovered artifact filled wells and privies as close as 12 to 18 feet below existing street levels. During construction of the East Street Valley Expressway, well-preserved remains of an entire Pennsylvania Canal Lock and an undocumented Historic period graveyard containing numerous internments were excavated.

Alternative E and G are located within close proximity to the McKees Rocks Mound and McKees Rocks Village which contained artifacts associated with Early to Middle Woodland Native American settlements.

During investigations conducted for the Airport Expressway, a 400 square meter site was discovered within the right-of-way on a terrace overlooking an unnamed tributary to Montour Run.

The study corridors for the four alignments were analyzed for the presence and/or potential presence of other unrecorded historic and archaeological resources. Initially, each corridor was considered to have at least a low probability for containing archaeological and historical resources. Areas of medium and high probability were then determined by topography, waterbodies and known settlements.

The probability of identifying cultural resources increases from low to medium and high as the alignment approaches the more important streams such as Chartiers Creek, Montour Run and the Ohio River. High probability areas also occur at and near the confluence of tributary streams to the Ohio River, at stream/river fords and where trails cross streams. Medium to high probability areas for prehistoric resources are also identified on bluffs overlooking streams (and particularly to the Ohio River), on high Pleistocene terraces along fourth and fifth order streams and on upland saddles and benches, particularly those associated with fourth and fifth order tributary drainage divides.

Each 2000 foot wide corridor was divided into areas of low, medium and high probability of containing cultural resources. Table 7-9 shows the approximate acreage by probability type for each alternative corridor. The table shows that Alternative G has the highest probability of impacting archaeological resources.

The potential for locating unrecorded cultural resources is high in the Pittsburgh area. Since 1982, archaeological research in Pittsburgh has demonstrated that extensive subsurface cultural remains are frequently preserved in urban context, even in areas that have undergone several cycles of construction. Several recent projects in the Pittsburgh area have uncovered artifact filled wells and privies twelve to eighteen feet below present street grade.

The railroad along the north side of the Ohio River appears to be located along low (terminal Pleistocene/Holocene) river terraces. These low terraces have high potential for preserving deep alluvial deposits representing the last 10,000 years. These deposits can contain archaeological deposits buried beneath subsequent alluvium, often at considerable depth. In areas where railroad construction cut terraces to establish grade, possible existing sites may have been destroyed. In other areas, archaeological sites may be preserved beneath railroad lines, particularly beneath those lines that are on the lower Holocene-age terraces. The higher (Late Pleistocene) terraces also have high potential for preserving cultural resources, albeit not deeply buried ones. These terraces have been above the river floodplain for the last 15,000 years or so.

Another high probability area is the McKees Rocks area. Alternatives A and E come within the general vicinity of the former location of the McKees Rocks Mound and McKees Rocks Village, at the mouth of Chartiers Creek. While the area has experienced extensive construction and other disturbances, the possibility exists that other sites could be encountered.

The probability of identifying historic resources within the study corridors increases as each alternative approaches Pittsburgh. The western section of the corridors (PIA and vicinity) have the lowest probability of containing significant cultural resources. This is due to the intense strip mining activity and alteration by heavy construction projects, most recently the Midfield Terminal and Southern Expressway projects. Despite these disturbances, the potential exists that historic resources such as equipment and structures related to the coal and oil industries that operated extensively in the project area in the late 19th century and throughout the 20th century may be found in the strip mines.

Two unrecorded historic period resources were identified within the study corridor of Alternatives A, D and E: the J.S. Walker Woolen Factory on the north side of McClaren Run; and the site of the McClaren Saw and Grist Mills, located on McClaren Run south of the airport. Alternative A may impact the woolen factory location, if it is preserved. The saw and grist mills are located north of Alternative A.

TABLE 7-9
CULTURAL RESOURCES
ACREAGE OF PROBABILITY TYPE FOR OCCURRENCE OF ARCHAEOLOGICAL RESOURCES

Alternative	High Probability	Medium Probability	Low Probability
A	1134.5	1810.5	843.6
D	1059.9	1668.5	899.6
E	623.9	1817.1	850.8
G	2161.5	924.0	1483.4

The study corridor which traverses the Montour Run Valley has a moderate to high potential for affecting cultural resources. One unnamed historic Indian trail apparently crossed through the project area. This was a subsidiary trail leading northwest out of the Chartiers Creek Valley where it probably connected with the very important Catfish Path that joined Pittsburgh with Catfish, now known as Washington, Pennsylvania. The unnamed trail appears to have crossed Montour Run near what was known as Ewing's Mills at the confluence of Meeks Run and Montour Run. Alternative A passes directly through this area. In addition, the Baltimore, Pittsburgh and Chicago Railroad line that parallels the Montour Run Valley, provided a transportation route for shipping coal out of North Fayette, Moon, Robinson and Findlay Townships to the Ohio River prior to 1890.

In the North Side of Pittsburgh, Alternative D could have an impact on significant historic resources. The near North Side (Old Allegheny City) contains numerous historic districts and structures listed on the National Register of Historic Places.

There are a number of early family and church cemeteries located throughout the study area. Many of these cemeteries have been documented and mapped. In addition, there are several unrecorded abandoned family plots that may be impacted by the MAGLEV System. References to several abandoned family cemeteries have been found for Moon Township, Robinson Township, the Borough of Stowe and the Borough of McKees Rocks.

The use of subsurface piers extending down as much as twenty feet to bedrock may have an impact on subsurface archaeological resources that have been sealed below the railroad and buried in floodplains. The Bureau of Historic Preservation may require extensive deep testing at each pier location in sensitive areas such as the North Side.

Coordination with the Pennsylvania State Historical Preservation Officer indicates that Alternatives A, E and G are considered to have a high probability for archaeological resources based on available information. No sites have been discovered along Alternative D alignment, and therefore the SHPD concludes that this alternative should not have any effect on prehistoric or historic archaeological resources.

Potential mitigation strategies include:

- Documentation of prehistoric and historic cultural resources through literature research, standing structure surveys, archaeological testing and/or data recovery.
- Avoidance of significant resources through alignment adjustments and adjustments of pier placements. These strategies would be implemented during final design of the project.

Placing the right-of-way within existing railroad, highway or utility corridors provides the greatest minimization of impacting cultural resources. Although, if the original depth of the disturbance was superficial, the piers could effect deeply buried resources. Wherever fluvial or colluvial (slope) deposition exists, the possibility exists that deeply buried ancient aboriginal sites may be preserved under the surface.

7.2.6 AESTHETICS

Aesthetics is considered the science or philosophy concerned with the quality of visual experience. For a project of this type, two frames of reference should be employed in the evaluation of visual impacts. The first is concerned with the visual impact that a proposed project would have on the surrounding landscape.

In other words, what will people viewing the system see. The second part evaluates the landscape that the rider will view while traveling on the system.

With regards to the first reference, efforts should be made to design structures to be aesthetically pleasing by blending into and/or enhancing the environment within which the system would be constructed. Generally, aesthetically pleasing structures are those which are creative in design and enhanced through visual mitigation.

The first step in assessing the visual impacts of a proposed project on its surrounding environs is to assess the existing landscape and determine the potential visual impacts resulting from the project. The landscapes along each of the MAGLEV study corridors vary from beginning to end. In general, each alternative passes through natural, airport, commercial, residential and industrial development; railroad yards and railroad right-of-ways; and highway right-of-way. The terrain along each alignment varies from hills and valleys to level floodplains. The following are descriptions of the landscapes through which each scheme passes and the potential visual impacts that the MAGLEV System would have on the environs along its route.

Beginning at PIA, Alternative A traverses a highway corridor surrounded for the most part by forested land consisting of hills, valleys, streams and wetlands. East of the Resurrection Cemetery, the landscape changes to include commercial development and the Airport Parkway. This area is also surrounded by forested hills and valleys.

Between the Montour Run Interchange and Beaver Grade Road, Alternative A passes through a commercial and residential area. Northeast of Beaver Grade Road the alignment follows the Montour Valley which is undeveloped forested land of hills, valleys, streams and wetlands. North of Petrie Road the landscape changes to commercial/industrial development which continues into Robinson Township. As the alignment passes under Interstate 79, the landscape becomes a transportation corridor comprised of the CSX Railroad and the Ohio River.

Alternative A follows the CSX Railroad along the river bank at the base of an incline bordering the Ohio River. At the top of the incline (approximately 170 feet) are numerous buildings overlooking the Ohio River. Continuing along the railroad right-of-way, Alternative A passes through a residential area located to the east of the Fleming Park Bridge in Stowe Township. Exiting the residential area, the alignment traverses through the Railroad yard complex, a relatively flat and densely developed landscape. The railroad complex is abutted by industrial and residential areas to the east, and a residential area to the west. Alternative A then crosses Chartiers Creek and enters into the urban environment of the City of Pittsburgh. Alternative A continues along a transportation corridor comprised of the Railroad, the Ohio River and Pennsylvania Route 51. Alternative A terminates within an existing transportation corridor serving Conrail and PAT rail systems surrounded by commercial development.

At PIA, the MAGLEV System would blend into the setting of a modern transportation facility. The modern design of the new Airport Terminal will provide an appropriate background for the futuristic design of the MAGLEV System. As Alternative A exits the PIA, this modern transportation system would parallel Route 60. The area is currently undeveloped for the most part. However, available land in the area of PIA and Route 60 is anticipated to undergo rapid development following the opening of the new Airport Terminal and the Expressway in October 1992.

As Alternative A traverses along the Airport Parkway, the system would be approximately 30 to 50 feet over the existing grade. Land alterations would occur as small hills are removed from the right-of-way. The MAGLEV system would not be obtrusive in this area due to the existing alterations of the landscape caused by the existing highways and adjacent commercial development. Between the Montour Run Interchange and Beaver Grade Road, the alignment could impact the visual quality of this residential and commercial area. The guideway would be constructed approximately 25 to 45 feet above grade and as in other areas, small hills would be removed in the right-of-way. In the undeveloped area northeast of Beaver Grade Road, along the abandoned Montour Railroad, the MAGLEV System would be surrounded by woods and wetlands as it crosses the landscape approximately 30 feet above grade.

North of Petrie Road industrial development dominates the alignment corridor. As the alignment passes under Interstate 79, it follows an existing transportation corridor approximately 15 to 30 feet above grade. East of the Fleming Park Bridge, the system could impact the unobstructed view of the Ohio River from residences and businesses adjacent to the railroad. Also in the McKees Rocks Railroad Yard, the system would impact the view of abutting buildings as it traverses the railroad yard 10 to 25 feet above grade. In the City of Pittsburgh, the system will be another form of transportation in a corridor dominated by heavy motor vehicle traffic on Route 51 and Carson Street and the railroad traffic in the adjacent Conrail corridor.

Alternative D shares the same alignment as Alternative A from PIA to the railroad yard complex where it crosses the Ohio River. The north bank of the Ohio River is a densely developed urban landscape of the City of Pittsburgh. Alternative D traverses this landscape along the Conrail Railroad corridor only a few feet above the existing ground level. The railroad corridor is abutted by Route 65 to the northeast, beyond which is a densely developed residential area and commercial/industrial development to the southwest. East of Marshall Avenue, the railroad corridor is abutted by residential, commercial and historic areas. Alternative D terminates at Allegheny Center Mall along the railroad.

East of the Fleming Park Bridge, the system would impact the view of the Ohio River from the residences and businesses adjacent to the railroad. As Alternative D crosses the Ohio River, it will be in clear view from the river and both shores. On the north bank of the Ohio River, Alternative D would vary in elevation from 5 to 10 feet above grade as it follows the Conrail right-of-way through the urban landscape. The system may block the view of the Ohio River from several buildings. On the North Side, the system could impact the visual quality of the historic areas and parks that it passes through before it terminates at Allegheny Center on the Conrail right-of-way.

Alternative E begins at PIA and follows the same alignment as Alternative A to just east of Montour Park Road, where the alignment climbs through an undeveloped area to Phillips Lane. Between Philips Lane and Clever Road, residential and commercial development is characteristic of the landscape. East of Clever Lane to Interstate 79, the alignment passes behind Montour High School. The landscape in this area is undeveloped forested hills and valleys. East of Interstate 79, the alignment passes through and tunnels under a residential area with scattered development. Crossing Chartiers Creek into the City of Pittsburgh, the alignment passes through residential, industrial and commercial areas, and terminates in a commercial district.

Beginning at Montour Park Road, Alternative E would impact the visual quality of this residential and commercial area. The guideway will be constructed approximately 20 to 30 feet above grade and as in other areas, small hills would be removed in the right-of-way. East of Montour Park Road, several land alterations will be necessary, altering the existing visual quality of the area. In the commercial and residential areas between Philips Lane and Clever Lane, Alternative E could have visual impacts to the area. Numerous hills and several buildings would be removed from the landscape. East of Interstate 79, the land alterations could impact the visual quality of the area along the MAGLEV route. Hills would be removed, although tunnels would be constructed through two of the larger hills. As Alternative E crosses Chartiers Creek, it traverses along the side of an incline down to the bank of the Ohio River in view of residential, commercial, recreational and industrial areas. Due to the urban setting, the MAGLEV System would not affect the visual quality of the Pittsburgh environment.

Exiting the PIA, Alternative G turns west out of the airport onto the highway right-of-way adjacent to Route 60 north which traverses undeveloped, forested land consisting of hills, valley, streams and wetlands. As with Alternative A, this open land surrounding the airport and its adjacent highways is expected to undergo rapid development following the opening of the new PIA Terminal in late 1992.

North of Route 60, the landscape is low density commercial development. North of Hookstown Grade Road, the landscape of hills and valleys is scattered with residences and businesses. Undeveloped areas are covered with forests. East of Flaugherty Run Road, the alignment tunnels under the hillside to just east of Narrows Run Road. From here, the alignment traverses through a low density commercial/residential development until it crosses over Route 51, the P&LE corridor and the Ohio River. On the north bank of the Ohio River, Alternative G passes under the Sewickley Bridge and the Railroad Station, believed to be the oldest standing structure in Sewickley. Alternative G follows the Conrail right-of-way along the Ohio River through Osborne and Hayesville Boroughs with residential/industrial situated between the alignment and the river. After passing by scattered pockets of development, Alternative G enters the City of Pittsburgh, hugging the shoreline of the Ohio River to North Franklin Street where the alignment crosses the river a second time and follows the Alternative A alignment to Station Square.

North of the Airport Parkway, Alternative G would be elevated approximately 15 to 30 feet above grade. The system may affect the existing visual quality of the area for those persons living within direct view of the system. Crossing the Ohio River, the alignment would pass north of buildings along the river, including the Sewickley Railroad Station and may obstruct the view of the Ohio River. The guideway would be constructed approximately 15 to 30 feet above grade. For a short stretch just beyond River Road east, Alternative G would affect the open view of the Ohio River for travelers on Ohio River Boulevard. In the Boroughs of Ben Avon and Emsworth, Alternative G continues along the bank of the Ohio River, 20 to 40 feet above grade, but this is well below the view of the Ohio River from adjacent development. In the City of Pittsburgh, the alignment sits 20 to 30 feet above grade but is situated between the Ohio River to the south and dense industrial development to the north. As the alignment crosses the Ohio River it continues through industrial and commercial areas to its terminus.

In terms of the view from the system, all alternatives will offer a rider views of undeveloped open land, transportation related developments of various types (highway, air and river), scattered suburban and heavily urbanized land development. Traversing through the Montour Run Valley, Alternatives A and D could offer a unique view of this abandoned railroad corridor and its undeveloped environment. The most outstanding view for the rider will be the new airport and the skyline of the City of Pittsburgh. All alternatives offer the same view of the airport. Alternative G, which crosses the Ohio River just south of the West End Bridge, would offer the most panoramic view of the city in comparison with the other alternatives.

The magnitude of visual impacts is difficult to quantify and depends directly on the opinions of the viewers. In further studies, particular attention should be given to those persons who own property having a direct view of the system.

Similarly the assessment of visual impacts on historic sites (eligible for or listed on the National Register of Historic Places) would need to be carefully considered for Alternatives D and G in accordance with the guidelines established by the Bureau of Historic Preservation.

Visual impact mitigation may be necessary in areas because of the MAGLEV system's unique appearance compared to other structures, development or natural settings within the study corridors. In many areas, the guideway would stand out in the landscape due to the above grade guideway design. The following are mitigation strategies which could be used to minimize visual impacts:

- Landscaping to blend the MAGLEV System into the surrounding environment.
- Lowering the height of the MAGLEV System to the same height as surrounding development adjacent to the System.

Required Permits

No permits are required with regard to aesthetic impacts of the system. However, building codes in some municipalities may require aesthetic enhancements to structures and buildings, particularly for development within a historic district.

7.2.7 WATER QUALITY

The Commonwealth of Pennsylvania has Federally approved water quality standards. The Commonwealth's water uses and water quality criteria are identified in Chapter 93 "Water Quality Standards" of the Pennsylvania Department of Environmental Resources' Rules and Regulations. The water quality standards are a combination of water uses to be protected and the general and specific criteria that need to be maintained or attained in order to prevent or eliminate pollution (PADER, 1990). Water quality criteria are established to protect the most sensitive designated use of specific waters. Usually the most sensitive protected use is either fish and aquatic life or water supply. It is believed that when the most sensitive use is protected, all other less sensitive uses are also protected.

Protected uses for named streams, rivers and tributaries in the study area are warm water fishes (WWF) and trout stocking (TSF), shown in Table 7-10, Water Quality Characteristics of Area Streams. Warm water fishes refers to the maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat. Trout stocking refers to maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat. To insure that the water quality standards are met or attained, water quality monitoring and assessments are conducted by various agencies throughout Pennsylvania.

The monitoring and assessments have resulted in the classification of stream segments in accordance with EPA regulations as water quality or effluent limited. Water quality limited segments are those where water quality does not meet applicable water quality standards and/or is not expected to meet applicable water quality standards after the application of secondary treatment or best practicable treatment. Water quality limited segments within the project area are Flaugherty Run, Montour Run, Moon Run, Lowries Run, Ohio River and tributaries of the Ohio River. Effluent limited segments are those where water quality standards are being met or the application of secondary or best practicable treatment will result in water quality standards being met. Chartiers Creek is the only effluent limited segment within the project area.

In addition to these two classifications, stream segments have been divided into four categories which represent the ranking system used in prioritizing funding for municipal sewerage projects.

Category I - Water quality segments which have existing sewage discharges from sewage systems including treatment plants are experiencing rates of growth at or above the statewide average in the segment's drainage area. Excluded from this category are streams affected by mine drainage which are not scheduled for acid mine drainage reclamation projects.

Category II - Water quality segments with drainage areas that have rates of growth below the statewide average or segments identified as "Special Protection" streams.

TABLE 7-10
WATER QUALITY CHARACTERISTICS OF AREA STREAMS

Stream	PADER Chap. 93 Classification	Pollution Sources	Known Pollutants
Ohio River	Warm Water Fish	Abandoned Mines Industrial Municipal	Urban Runoff Metals Oil Organics Phenol cyanide Pesticides Herbicides pH
Chartiers Creek	Warm Water Fish	Abandoned Mines Industrial Municipal	pH Metals Suspended Solids
Flaugherty Run	Warm Water Fish	Municipal	Ammonia Dissolved Oxygen/BOD
Kilbuck Run	Warm Water Fish		
Lowries Run	Trout Stocked		Ammonia Dissolved Oxygen/BOD
Montour Run	Trout Stocked	On-lot Sewage Abandoned Mines Industrial Municipal	Ammonia pH Metals Suspended Solids Dissolved Oxygen/BOD
Sawmill Run	Warm Water Fish	Abandoned Mines Municipal	Metals Urban Runoff Dissolved Oxygen/BOD
Spruce Run	Warm Water Fish		
Unnamed Tributaries to the Ohio River	Warm Water Fish		

Source: Pennsylvania Department of Environmental Resources,
Chapter 93 "Water Quality Standards"
Rules and Regulations, 1992

Category III - Effluent limited segments.

Category IV - Water quality segments that are affected by acid mine drainage from abandoned coal mines.

This priority ranking system reflects the stream segment classification, the severity of existing water quality problems, population, growth potential and the need to preserve high quality waters. Flaugherty Run, Montour Run, Moon Run, Ohio River and unnamed tributaries to the Ohio River have been designated as Category I waterbodies. Lowries Run has been designated as Category II and Chartiers Creek has been designated as Category III (see Table 7-10).

The project area is located in the Ohio River sub basin, which covers 3,080 square miles. Surface waterbodies in Allegheny County have historically been subject to degradation resulting from point and non-point source pollution. The single largest cause of water quality degradation in the Ohio River sub basin is drainage from abandoned bituminous coal mining (PADER, 1988). Two other major causes of degradation are industrial wastes and municipal wastes.

Abandoned mine drainage has contributed to the degradation of the water quality in the Ohio River, Chartiers Creek, Montour Run and Moon Run. Low pH, elevated concentrations of heavy metals and turbidity/suspended solids are the main pollutants resulting from abandoned mine drainage. Waterbodies affected by abandoned mine drainage have few beneficial uses and are generally unsuitable for aquatic life. The toxic properties of heavy metals and acid, coupled with the smothering effects of iron precipitates, render mine acid waterbodies biological wastelands (PADER, 1988). Both Montour Run and Chartiers Creek are scheduled for abandoned mine reclamation projects.

Industrial wastes from point sources add to the poor water quality in the Ohio River, Montour Run and Chartiers Creek. The industrial pollutants are associated with specific discharges but the primary categories of these pollutants are heavy metals, phenol, cyanide, other organics, pH and dissolved solids (PADER, 1988).

Municipal wastes such as raw and inadequately treated sewage add to the degradation of the Ohio River, Chartiers Creek, Flaugherty Run and Montour

Run. The major problems associated with municipal pollutants are reduced oxygen levels caused by the discharge of oxygen demanding materials and increased nutrient levels due to the discharges (PADER, 1988).

Non-point sources of pollution have affected several waterbodies in the study area, mainly the Ohio River, Chartiers Creek, Montour Run and Moon Run. Non-point sources include erosion and salutation, impervious area runoff, on-lot sewage and acid mine drainage. The pollutants resulting from these sources are pH, heavy metals, turbidity/suspended solids, pesticides, herbicides, dissolved oxygen and BOD.

Toxic pollutants caused by point and non-point sources also contribute to the poor water quality of the waterbodies within the study area. Segments of the Ohio River, Moon Run and Montour Run have been reported as being impacted by the following toxic pollutants: pesticides; herbicides; and other organics.

Alternatives A, D, E and G would span several waterbodies within the study area see Table 7-11, Stream Crossings. This proposed design will not have any effect on the water quality of the rivers and streams that it crosses. No Federal, State or local water quality permits are required for the MAGLEV System.

7.2.8 FLOODPLAINS

Consideration of floodplain impacts for the MAGLEV Demonstration System is required under the following acts:

- U.S. Watershed Protection Act and Floodplain Protection Act (1954)
- National Flood Insurance Act (amended 1973)
- Executive Order 11988
- U.S. Department of Transportation Order 5650.2 - Floodplain Management and Protection (1979)
- Pennsylvania Floodplain Management Act (1978)
- Pennsylvania Stormwater Management Act (1978)
- Pennsylvania Dam, Safety and Encroachment Act (1978)

TABLE 7-11
STREAM CROSSINGS

Stream	Alternative			
	A	D	E	G
Ohio River	-	1	-	2
Four Unnamed Tributaries to the Ohio River	3	3	1	-
Chartiers Creek	1	-	3	-
Davis Run	-	-	-	1
East Fork of Enlow Run	1	1	1	-
Unnamed Tributary to East Fork of Enlow Run	1	1	1	-
Flaugherty Run	-	-	-	2
Hays Run	-	-	-	1
Jacks Run	-	-	-	1
Kilbuck Run	-	-	-	1
Lowries Run	-	-	-	1
McClarens Run	3	3	3	-
Four Unnamed Tributaries to McClarens Run	4	4	4	-
Montour Run	15	15	5	-
Unnamed Tributaries to Montour Run	1	1	-	-
Moon Run	1	1	1	-
Narrows Run	-	-	-	3
Raredon Run	-	-	-	1
Three Unnamed Tributaries to Raredon Run	-	-	-	3
Sawmill Run	1	-	1	1
Spruce Run	-	-	-	1
Toms Run	-	-	-	1
West Fork of Enlow Run	-	-	-	1
Four Unnamed Tributaries to West Fork of Enlow Run	5	5	5	-
Total Number of Stream Crossings	36	35	25	20

Floodplains serve as a natural means of flood control by absorbing and retaining water during periods of excessive precipitation and runoff. Floodplains are divided into two distinct zones, a floodway and a floodway fringe. The floodway includes the stream channel and adjacent floodplain area that serves to pass the deeper, faster moving flood waters. The floodway fringe borders the floodway and represents the extent of inundation which can be expected from a flood. Floodplains have been identified and mapped by the Federal Emergency Management Agency (FEMA) under the National Flood Insurance Program (NFIP, 1968). The FEMA maps depict areas inundated by the 100-year flood which is a level of flooding that is expected to be reached or exceeded once in 100 years. This flood has a one percent chance of occurring in any given year. The 100-year flood has been adopted by the Federal Insurance Agency (FIA) as the base flood for purposes of floodplain management measures.

Encroachments on floodplains reduce the flood-carrying capacity of the area, increase flood heights of streams and increase flood hazards in adjacent areas. For these reasons, the NFIP requires that state and local governments adopt floodplain management programs which regulate construction and development within floodplains. State and local regulations may be more, but not less stringent than Federal requirements established by FEMA. In general, FEMA requires construction and development in floodplains to meet the following criteria:

- All new construction or substantial improvements shall be designed and adequately anchored to prevent floatation, collapse or lateral movement of the structure.
- All new construction or substantial improvements shall be constructed with material resistant to flood damage.
- All new construction or substantial improvements shall be constructed by methods and practices that minimize flood damages.
- All residential and nonresidential development must be elevated or flood-proofed to or above the base flood elevation.
- All new construction or substantial improvements shall be constructed with electrical, heating, ventilation and plumbing equipment and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during flooding.

- New construction and substantial improvements and other developments within the regulatory floodway are prohibited unless it is demonstrated that the proposed encroachment would not result in any increase in flood levels within the community during flooding.

The Pennsylvania Floodplain Management Act (1978) requires that municipalities having flood prone areas participate in the NFIP and adopt floodplain management regulations. Municipal floodplain regulations are usually found in zoning ordinances, subdivision and land development ordinances, or building codes. It is the responsibility of the local community to enforce the NFIP regulations through locally enacted ordinances.

The Pennsylvania Department of Environmental Resources (PADER) regulates construction and development in floodways under the Dam, Safety and Encroachment Act (1978). Under the act, the regulations stipulate that any activity considered to be a water obstruction or encroachment within any floodway requires a permit from the PADER. For streams that do not have FEMA mapped floodways, the PADER's jurisdiction extends 50-feet landward from the top of the bank on both sides of the stream. Additionally, PADER has jurisdiction over development activities of governmental and quasi-public entities occurring within any portion of an identified floodplain area.

The Chapter 105 regulations under the Dam, Safety and Encroachment Act require specific design criteria for bridges impacting floodways:

- The structure shall pass flood flows without loss of stability.
- The structure may not materially alter the natural regimen of the stream.
- The structure may not increase velocity or direct flow which results in erosion of stream bed and banks.
- Multiple span bridges shall be avoided to the maximum practicable extent.
- Crossings of less than 15-feet shall be by one span, except where conditions make it impractical to effect the crossing without multiple spans.
- Bridge piers shall be kept to a minimum in number and cross-sectional area and shall be designed to offer the least obstruction to the passage of water and ice, consistent with safety.

- Bridge piers in channels subject to unstable or super critical flow shall be designed to prevent the creation of excessive backwater and waves downstream of the pier.

Using FEMA mapping, the acreage of floodplain in each corridor was calculated. Table 7-12, Floodplains shows the results. Alternative A has the highest probability of floodplain encroachment, while Alternative G has the lowest.

The guideway support piers would potentially impact floodplains and floodways along the MAGLEV route. Piers placed in these areas would be subject to floodwater damage caused by water pressure, scouring and undermining, battering and buoyancy. Damage would also occur from forces created by ground water exerting pressure on the foundation causing the structures to float upward or collapse.

Placing piers in floodplains may result in increased flood damage to surrounding areas. Pier encroachment may cause floodwater levels and velocity to increase. Piers may also collect floating debris during flood events, thus restricting floodwater flow and creating excessive backwater. In addition, piers may increase wave action downstream during flooding.

TABLE 7-12
FLOODPLAINS (ACRES)
(WITHIN 2000' CORRIDOR)

Alternative	Floodplain (Acres)
A	402.1 Acres
D	394.6 Acres
E	285.3 Acres
G	201.0 Acres

Placing of piers to avoid floodplain and floodway encroachment is the preferred mitigation to prevent flood damage to the MAGLEV System and to surrounding areas. This will be considered during final design of the project. In areas where floodplain avoidance is not feasible, supporting piers must be designed and constructed to prevent or minimize flood damage. The piers must be properly reinforced and adequately anchored to a foundation that extends to a sufficient depth to resist scour and lateral forces.

Required Permits:

Local: Municipal permits required for floodplain encroachments.

State: Water Obstruction and Encroachment Permit - Issued by the PADER under the Dams, Safety and Encroachment Act.

Federal: Department of the Army Section 404 Permit - Issued by the Corps under the Clean Water Act.

7.2.9 TERRESTRIAL ENVIRONMENT

Climate, soils and man's intervention determine the types of plants that will inhabit an area. The MAGLEV study area is covered by a mosaic of assorted plant communities ranging from agricultural land to mature forests. The forest type in the study area is classified as an Appalachian Oak Forest. This forest community is composed of many different species of oaks, mixed with chestnut, hemlock and pines. In addition, other hardwood species including maples, hickories and beech contribute to this forest type.

Agricultural land includes cropland, pastures, orchards, nurseries, livestock farms and riding stables. Land that is vegetated predominantly with grasses, forbs or shrubs is classified as rangeland. Rangeland is typically abandoned cropland or pasture land that is undergoing successional stages into forest land. Wetlands are classified according to the dominant vegetation and described as forested, scrub-shrub or emergent. Common plant species found within each cover type in the study area are listed in Table 7-13.

The various plant community types; rangelands, forests, and wetlands, within the study area provide habitat for a large number of wildlife species. Birds, reptiles, amphibians and mammals are included in the wildlife community. Within the

TABLE 7-13
COMMON PLANT SPECIES FOUND WITHIN THE MAGLEV STUDY AREA

	Appalachian Oak Forest	
Major Trees	**Understory and Shrubs**	**Herbaceous Plants**
American Basswood	Blackberry	Asters
American Beech	Buck thorn	Black Snakeroot
American Sycamore	Eastern Redbud	Common Cinquefoil
Black Cherry	Flowering Dogwood	False Solomon's Seal
Black Locust	Honeysuckle	Golden rod
Black Oak	Hophornbeam	Mayapple
Bitternut Hickory	Maple leaf Viburnum	Solomon's Seal
Chestnut Oak	Northern Arrowwood	Spotted Wintergreen
Eastern Hemlock	Red Osier Dogwood	Trillium
Eastern White Pine	Sassafras	Violet
Gray Birch	Spice Bush	
Mocker nut Hickory	Striped Maple	
Paper Birch	Witch Hazel	
Pignut Hickory		
Red Maple		
Red Oak		
Sugar Maple		
Silver Maple		
Tulip tree		
Yellow Birch		

TABLE 7-13 (continued)
COMMON PLANT SPECIES FOUND WITHIN THE MAGLEV STUDY AREA

	WETLANDS	
Major Trees	**Understory and Shrubs**	**Herbaceous Plants**
American Elm	Buttonbush	Arrow Arum
American Sycamore	Common Elderberry	Asters
Black Willow	Speckled Alder	Bulrushes
Eastern Cottonwood	Red Osier Dogwood	Cattail
Green Ash	Silky Dogwood	Deer-tongue Grass
Pin Oak	Viburnum	Goldenrod
Red Maple	Witch Hazel	Jewel Weed
Silver Maple	Witherod	Joe-Pye Weed
Slippery Elm		Reed Canary Grass
		Rushes
		Sedges
		Sensitive Fern
		Skunk Cabbage
		Sweetflag

RANGELANDS	
Saplings and Shrubs	**Herbaceous Plants**
Bigtooth Aspen	Aster
Blackberry	Chicory
Black Cherry	Common Lamb's Quarters
Chokecherry	Common Milkweed
Eastern Red Cedar	Common Mullein
Hawthorn	Common Ragweed
Multiflora Rose	Crab Grass
Pin Cherry	Dogbane
Raspberry	Golden rod
Slippery Elm	Poison Ivy
Sumac	Pokeweed
Quaking Aspen	Thistle
	Yarrow

Source: Kricher, John C. A Field Guide to Eastern Forests, 1988.

land cover types identified in the study corridors, the Pennsylvania Game Commission has identified approximately 20 species of amphibians, 17 reptiles, 150 birds and 36 mammals. Reptiles and amphibians can be easily observed in the spring and summer. Birds are present at any time of the year, but are most diverse and abundant during the spring, summer and fall, when migration and breeding take place. Mammals that inhabit the study area range in size from tiny rodents to larger animals such as white-tailed deer. Most species are nocturnal and are thus rarely observed.

In areas where the MAGLEV system would be constructed across agricultural land and rangeland, the impacts to these vegetative communities and the wildlife inhabitants would be minimal. The impacts would occur during the construction phase of the MAGLEV System. The design of the Demonstration System should include re-vegetation plans to spur re-establishment of indigenous plant communities. After construction, the existing contours would be re-established and all disturbed areas seeded with grasses. Ultimately, through succession and surrounding seed sources, indigenous plant communities would re-vegetate the right-of-way.

In areas where the alternatives would cross scrub-shrub and forested plant communities, the construction and operation could permanently impact these habitat areas. All vegetation within the construction area would be removed. After construction, disturbed areas would be seeded with grasses. As with the herbaceous vegetative communities, succession and surrounding seed sources would re-vegetate the right-of-way with indigenous plant species. Vegetation within the right-of-way would need to be restricted to a certain height to prevent interference with operation of the MAGLEV System. Maintenance of the right-of-way in scrub-shrub and forested areas would be necessary to remove trees and shrubs that exceed the height limit. The removal of tree and scrub-shrub habitat would reduce habitat available to the resident wildlife thereby resulting in habitat displacement. The wildlife in the area would be displaced to other areas with available habitat.

The elevated design of the MAGLEV System would limit impacts to wildlife movement patterns. Wildlife would be able to resume normal movement patterns throughout the right-of-way once construction has been completed.

The next phase of study should involve identification of dominant species of vegetation and the wildlife populations supported by the vegetation existing within the undeveloped areas. A quantifiable analysis of impacts should be conducted utilizing the Habitat Evaluation Procedure (HEP) to determine impacts on wildlife populations.

One mitigation measure which may be employed to the extent practicable is to limit the construction of the system in natural areas to the late summer and fall. This construction scheduling will prevent interference with the breeding season and over wintering of the wildlife inhabitants. Another mitigating measure is to leave undisturbed cavity and nest trees near the edges of the right-of-way if the construction and operation of the MAGLEV System is not affected. Finally, reconstruction of the destroyed habitat, possibly including off-site habitat improvements, will be necessary in order to minimize impacts to wildlife.

7.2.10 GEOTECHNICAL CONSIDERATIONS

A preliminary geotechnical evaluation has been conducted to identify obvious areas within the study corridors that have geotechnical/geological features which may affect the constructibility of any of the proposed alternatives. The evaluation is based solely on available reference materials and preliminary plans.

Bedrock along the study corridors consists of cyclical sequences of relatively flat-lying beds of sedimentary bedrock of the Pennsylvania System. Rock units consist of interbedded sandstone, shale, thin limestone and coal seams.

Located through the study area are beds of soft "redbed" clay stones and shale which are notorious for being landslide prone and for weathering into unstable masses. Redbeds are typically soft, reddish brown and gray stone/clay shale units which are easy to excavate but weather rapidly when exposed. Where they outcrop on natural slopes, redbeds are usually deeply weathered and frequently covered with deep slide-prone soils of marginal stability. Soils developed from redbeds are usually clayey silts or silty clays. Often these fine-grained soils have characteristics making them marginally suitable for embankment material.

When redbeds occur in structure foundation sites, they typically have a low bearing capacity when compared to other bedrock types.

Historically, there have been many recorded landslides in western Allegheny County resulting from construction in obscure landslides or landslide prone areas. The U.S. Geological Survey (USGS) has identified areas prone to landslides based on evaluations of rock types, stratigraphy and structure, soil characteristics and steepness of slopes. The USGS Map of Susceptibility to Landsliding, Allegheny County, Pennsylvania (1975) indicates the following areas as containing landslides or being susceptible to landslides:

- Within the corridor containing Alternative E, east and west of Interstate 79.
- In Findlay Township, north of Route 60.
- Within the Airport Interchange of Route 60 at the beginning of Alternative G.

Potential problems associated with landslides and landslide susceptible areas include:

- Stability of embankments founded on landslides,
- Stability of cut slopes,
- Safety problems related to rock falls from cuts or steep natural slopes adjacent to the MAGLEV system,
- Need for additional right-of-way in order to construct stable cut slopes or for embankment stabilization.

Approximately 27 percent (28,400 linear feet) of Alternative A traverses areas identified as being susceptible to landsliding or as containing recent and prehistoric landslides. This includes areas located along Cliff Mine Road and the Airport Parkway (Route 60), the Montour Run Valley and the hillside along the Ohio River between Interstate 79 and the Fleming Park Bridge. Large prehistoric landslides are especially numerous along Montour Run downstream from Beaver Grade Road.

Approximately 26 percent (26,300 linear feet) of Alternative D will traverse landslide prone areas. Major critical areas include the area along Cliff Mine Road, the Airport Parkway and the Montour Run Valley.

Thirty-three percent of Alternative E would be constructed through landslide prone areas along Cliff Mine Road, the Airport Parkway, Montour Run, Interstate 79, Chartiers Creek and the slopes of the Ohio River. Numerous rock falls and landslides have been identified upslope from the proposed alignment where it runs parallel to the Ohio River.

Nearly four miles (20,800 linear feet) of Alternative G traverses areas where recent and prehistoric landslides have been recorded or identified as being susceptible to landslides. Approximately 67 percent of this total is located in the Flaugherty Run Valley.

The entire study area is contained within the Ohio River Drainage Basin. Soil deposits in the floodplain consist of glacial outwash overlain by recent alluvium. Typically, the glacial deposits consist of gravel, sand and clay whereas recent alluvium may be finer grained material. The average maximum thickness of the glacial deposits is about 60 feet, thinning along the valley walls. Major portions of Alternatives A, D and G are located within the Ohio River floodplain.

Major tributaries to the Ohio River, such as Chartiers Creek, Montour Run and Flaugherty Run, also flow on floodplains mantled with alluvial soils of variable depth and composition. The thickness of alluvial soil deposits along these streams ranges from 0 to 60 feet where they flow into the Ohio River.

Potential concerns relating to construction in floodplains and deep foundation soils include:

- Differential settlement beneath structures and embankments,
- Embankment stability,
- Wetlands.

Over eleven miles (approximately 60 percent) of Alternative A traverse areas of potentially deep soils possibly requiring deep foundations for piers or special treatment of the embankments to prevent slides or differential settlement. The longest section is the Ohio River where floodplain soils and valley fill predominate. The second major section is on the floodplains of Montour and McClaren Runs.

About 59 percent of Alternative D will cross areas potentially overlaid by deep foundation soils. The majority of the area is situated along the Ohio River floodplain (33,920 linear feet). The remainder (25,400 linear feet) includes the floodplains of Montour and McClaren Runs.

Relatively deep foundation soils underlie approximately 34 percent (34,700 linear feet) of the Alternative E alignment. Critical areas are found along the floodplains of McClaren Run, Montour Run, Chartiers Creek and the Ohio River.

Sixty-six percent of Alternative G (70,870 linear feet) would be constructed on the Ohio River floodplain where deep alluvial and valley fill deposits predominate.

The Pittsburgh coal seam, which can be up to 12 feet thick within the study area, has been mined on hilltops along portions of all schemes. Approximately 6 percent of the total length of all alignments has been mined. The USGS Map of Coal-Mining Features, Allegheny County, Pennsylvania (1976) identifies three major areas affected by mining within the MAGLEV study corridors:

- Within the Alternative E corridor, east and west of I-79
- In Findlay Township, north of Route 60
- Within the Airport Interchange of Route 60 at the beginning of Alternative G.

Two basic types of mining concerns will be encountered during the construction of the demonstration system: Underground (drift) Mines and Surface (strip) Mines. Associated with the mines are various related wastes, e.g. strip mine spoil and refuse piles.

The following common concerns are related to underground mined areas:

- Surface subsidence,
- Exposure of in-place coal or mine voids,
- Potential acid mine drainage discharges,
- Disposal of coal and spoil with high coal content,
- Determination of mineral rights ownership,
- Permit requirements.

Common concerns related to surface mined areas include:

- Soft, uncompacted waste resulting in settlement,
- Potential slope instability in excavations through mine spoil,
- Potential for buried industrial and/or municipal wastes,
- Difficulties in establishing a vegetative cover on spoil,
- Potential acid mine drainage discharges,
- Disposal of coal and spoil with high coal content,
- Determination of mineral rights ownership,
- Permit requirements.

Approximately two percent (2100 linear feet) of the Alternative A alignment will be affected by surface and underground mining in the Pittsburgh coal seam. Three areas are located adjacent to the northbound side of the Airport Expressway from the McClaren Road Interchange to the proposed location of the future interchange at Enlow Road. Mine seals and temporary mine drainage treatment facilities were required for the cut areas excavated during construction of the Airport Expressway. Between Stations 424 and 426, there was an underground mine fire reported in 1976 which is reportedly no longer burning. However, an active mine fire was investigated in 1989, approximately 1300 feet northeast of the area.

The Pittsburgh coal seam has been mined out in approximately two percent of the area traversed by Alternative D. The areas of concern are the same as those noted for Alternative A.

Approximately 14,700 linear feet (17 percent) of Alternative E traverses six areas which have been affected by stripping operations or underground mining. The first three areas are those listed under Alternative A. The fourth area is an underground mine in the vicinity of Phillips Lane, Clever Road and south of Montour High School where portions of the outcrop have been surface mined. The fifth is a stripped area between Robb Street and McKees Rocks Road, east of Longview Road and upslope from Chartiers Creek. The sixth area is a mine fire reported near Longview Road in 1976.

About 2000 feet (2 percent) of Alternative G has been mined. Two of the three mined areas are located within the Airport Interchange on Route 60 where surface mines are known to contain municipal and possibly hazardous waste. The third location is north of Moon-Clinton Road which appears to have been strip mined.

A summary of the major geotechnical constraints posed by each alternative are presented in Table 7-14. The table shows the linear feet and resulting percentage of affected alignment.

TABLE 7-14
POTENTIAL GEOLOGICAL/GEOTECHNICAL CONCERNS

Alternative	Coal Subsidence and Wastes	Landslide Susceptibility	Deep Foundation Soils
A	2,100 (2%)	28,400 (27%)	62,030 (60%)
D	2,100 (2%)	23,600 (26%)	59,320 (59%)
E	14,700 (17%)	28,165 (33%)	34,700 (34%)
G	2,000 (2%)	20,800 (19%)	70,870 (66%)

There are a number of corrective strategies that could be utilized in the construction of the Pittsburgh MAGLEV Demonstration System. Table 7-15, Corrective Strategies, summarizes common corrective strategies for the three areas of geotechnical concern. Alignment shifts and placement of piers that would avoid unstable areas can also be utilized to minimize the need for geotechnical mitigation given that problem areas are identified in the early stages of design.

A detailed reconnaissance should be made of the selected alignment to identify, in greater detail, all geotechnical features that could affect the design of the Pittsburgh MAGLEV Demonstration System. This reconnaissance should be initiated at the beginning of the next phase of study and should include:

TABLE 7-15
CORRECTIVE STRATEGIES FOR GEOLOGICAL/ GEOTECHNICAL CONCERNS

CONCERNS		COMMON CORRECTIVE STRATEGIES
GENERAL	SPECIFIC	
Coal Mines, Subsidence and Wastes	Surface Subsidence from Underground Mines	Excavation and Backfill
		Deep Structure Foundations, e.g., Caissons Bearing on Mine Floor
	Exposed Coal and Mine Openings	Grout Mine Voids
		Seal
	Uncompacted Spoil Below Grade	Excavate Spoil and Backfill w/ Suitable Material
		Deep Foundations e.g., Piles or Caissons for Structures
	Stability of Cuts Through Mine Spoil	Flattened Cut Slopes
		Retaining Walls
	Buried Industrial and Municipal Waste	Excavate and Dispose of Offsite
	Establishing Vegetation on Spoil	Blanket With Soil, Seed and Mulch
	Acid Mine Drainage	Temporary or Permanent Treatment
	Disposal of Coal and Spoil	Coal Becomes Property of Contractor or Mineral Rights Owner
		Dispose of Soil With High Coal Content in Waste Areas
		Use Spoil in Embankments
	Determination of Mineral Rights Ownership	Thorough Investigation During Final Design
	Permit Requirements	Meet Early in Design With DER

TABLE 7-15 (continued)
CORRECTIVE STRATEGIES FOR GEOLOGICAL/ GEOTECHNICAL CONCERNS

CONCERNS		COMMON CORRECTIVE STRATEGIES
GENERAL	SPECIFIC	
Landslides and Landslide Susceptible Areas	Stability of Embankments and Cuts	Embankment Foundation Benches
		Retaining Walls
		Subsurface Drainage
		Buttresses
		Flattened Cut and Embankment Slopes
		Select Embankment Materials, e.g., Rock and Reinforcing Grids
	Rockfall	Cut Benches
		Flattened Cut Slopes
		Rock Retaining Devices, e.g., Fences, Wire Mesh, Rock Bolts
	Additional Right-of-Way	Acquire as Needed
Deep Foundation Soils	Differential Settlement	Embankment Foundations, e.g., End-Bearing Piles, Caissons to Bedrock, for Structures
		Undercut and/or Surcharge Embankment Foundation Areas
	Embankment Stability	Embankment Foundation Benches
		Retaining Walls
		Subsurface Drainage
		Flattened Embankment Slopes
		Undercut Foundation Areas
		Select Embankment Materials e.g., Rock and Reinforcing Grids
	Possible Wetlands	Span or Replace

- In-depth search of available published and unpublished references, as well as an interpretation of aerial photography,
- Discussions and meetings with appropriate DER offices to obtain site-specific information relating to abandoned mining operations, acid mine drainage treatment and permitting requirements,
- Geotechnical field reconnaissance to locate landslide areas, mine features and other miscellaneous problems associated with the preferred corridor,
- Conduct subsurface sampling and laboratory analysis.

7.2.11 SAFETY AND SECURITY

Due to the high speed of the MAGLEV System, safety to the public will be maintained by elevating the entire demonstration line. This will prevent people, vehicles and animals from getting on the guideway and endangering themselves and the system riders. Access to the system will be available only at the two stations. The Airport station will be located at the moving sidewalk as it enters the daily parking lot. This area is a well lit, safe area vigorously patrolled by Allegheny County Police. Downtown, the station will be at either Station Square or Allegheny Center. These locations are both active commercial areas which are well lit and well served by the City of Pittsburgh Police, and likely to have MAGLEV station attendants on duty during operating hours. The safety of the Transrapid System for riders is discussed in Section 3 of this report.

7.2.12 PEDESTRIANS AND BICYCLISTS

Pedestrian and bicyclist access to the MAGLEV system will be accommodated at Station Square or Allegheny Center. At the PIA station, pedestrian access originating from within the airport will be readily accommodated by in-place systems. Bicyclist access does not currently exist because all access roads are currently designed and signed for motor vehicles only.

The MAGLEV system will be protected from potential conflicts with bicyclist and pedestrians by being elevated. In fact, the elevated design of the system makes it ideal for sharing right-of-ways with exclusive pedestrian and bicycle facilities, which would run beneath the guideway at grade. The section of Alternates A and D which would run along the abandoned Montour Run Railroad would be such a shared right-of-way facility. This railroad line is currently being developed for pedestrians and bicyclists as part of the Montour Trail.

7.2.13 NOISE AND VIBRATION

A detailed and rigorous discussion of the physical mechanisms involved in transportation noise generation and propagation may be found in many standard texts; however, only a few basic points will be made, to better facilitate understanding of the text to follow.

There are 3 factors to be considered when quantifying transportation noise levels:

1.) Magnitude
2.) Frequency
3.) Time-variance

Magnitude relates to the sound pressure displacement created by the acoustic energy of a source. This displacement may be quantified directly in pressure units such as pascal's (one newton per square meter), or in practice, through the use of a logarithmic ratio, Sound Pressure Level (SPL) mathematically expressed:

$$SPL = 10 \text{ Log } (p/p_o)^2 \text{ in decibels (dB)}$$

where:
- p is the rms sound pressure of a given sound, and
- p_0 is the reference sound pressure, 0.00002 pascals.

The nature of the human hearing mechanism is such that it responds differently to acoustic energy in different frequency ranges. Thus, it is necessary to apply a weighting factor to sound pressure levels, in order to simulate adequately human response to noise. This is best accomplished using the "A weighting curve", which attenuates sounds in the lower frequency ranges (below 1000 cycles per second, or hertz).

The unit for quantifying noise impacts is A weighted decibels, or dBA. This unit, however, is limited in its usefulness since it is instantaneous in nature, and it does not address the time-varying characteristics of noise. To examine the <u>hourly</u>

contributions involved statistical values such as L_x (the sound level exceeded x percent of the time in the hour), or energy equivalent levels, $L_{eq,\ m}$athematically expressed are used.

where:
- $\log_{10}$ is the base 10 logarithm
- t_2 and t_1 are the beginning and end points of the time period (0 and 60 minutes) is the equation of sound pressure as a function of time.

Qualitatively stated, L_{eq} is the equivalent steady noise level which contains the same noise (acoustic) energy as the time-varying noise level during the same hour. L_{eq}, then, is an energy summation integration, which does not rely on statistical distribution assumptions. Therefore, L_{eq} is a much more reliable predictive parameter than the statistical parameters L_x.

A second noise descriptor that is commonly used for impact assessment is the day-night average sound level (l_{dn}) which reflects noise levels for a 24-hour period. It is equivalent in terms of sound energy to the level of a continuous A-weighted sound level with 10 dBA added to nighttime levels. Daytime is defined as the period from 7:00 AM to 10:00 PM; nighttime is the period from 10:00 PM to 7:00 AM. The Federal Aviation Administration and the Department of Housing and Urban Development use a day-night criteria level of 65 dBA for impact assessment on residential land use. The Environmental Protection Agency's day-night criteria level is 55 dBA for residential land use.

Noise levels generated by the MAGLEV system are a function of speed, length of train, number of operations and distance between the source (MAGLEV train) and receptor. Available noise data on the operation of the Transrapid MAGLEV system indicates that there are two primary components to noise levels generated by the system: aerodynamic noise (noise generated by the airflow around the vehicle, which is the primary noise source at speeds greater than 150 miles per hour) and mechanical noise (associated with generators, fans and other system components).

Noise studies conducted for the Transrapid system are summarized in Table 7-16, Noise Levels, which provides the L_{max} for a two-car train at a distance of 82 feet from the guideway. Conclusions drawn from available information on the

Transrapid MAGLEV system demonstrate that noise impacts may extend out to distances of 500 feet from the MAGLEV guideway.

For this study, the number of potential receptor sites located within 500 feet of the proposed alignment were determined. Since the top speed of the Demonstration System will range from 208 (Alternative E) to 280 (Alternative G) mph, and will be reached for only a few minutes, the highest noise levels will range from 89 to 95 dBA (Table 7-16). Most of the trip will be at speeds of less than 200 mph, resulting in noise levels below 88 dBA. Figure 7-3 shows these noise levels corresponding to an urban street, for brief, infrequent periods.

In the next study phase, detailed information on the number of cars per train, number of operations for a 24-hour period, system-generated noise levels for various guideway heights, distances from guideway, varying speeds, as well as, data characterizing the noise environment of the areas immediately surrounding the system will be needed to assess accurately the noise impacts of the Demonstration System.

TABLE 7-16
NOISE LEVELS
(82 FEET FROM GUIDEWAY)

SPEED (mph)	L_{max} (dBA)
93	75
125	75
155	83
186	87
205	89
250	93
280	95

7.2.14 SECTION 4(f)/6(f) RESOURCES

Section 4(f) of the Department of Transportation Act of 1966 (DOT Act) established a National policy that special efforts be made to preserve publicly owned parks, recreational areas, wildlife and waterfowl refuges and significant

Common Sounds
Basic Theory: Common Sounds in Decibels (dB)

Some common, easily recognized sounds are listed below in order of increasing sound intensity levels in decibels. The sound levels shown for occupied rooms are typical general activity levels only and do *not* represent criteria for design.

Examples

Near jet engine

Threshold of pain

Threshold of feeling—hard rock band

Accelerating motorcycle at a few feet away (Note: 50 ft from motorcycle equals noise at about 2000 ft from a 4-engine jet aircraft.)

Loud auto horn at 10 ft away

Noisy urban street

Noisy factory

School cafeteria w/untreated surfaces

Stenographic room

Near freeway auto traffic

Average office

Soft radio music in apartment

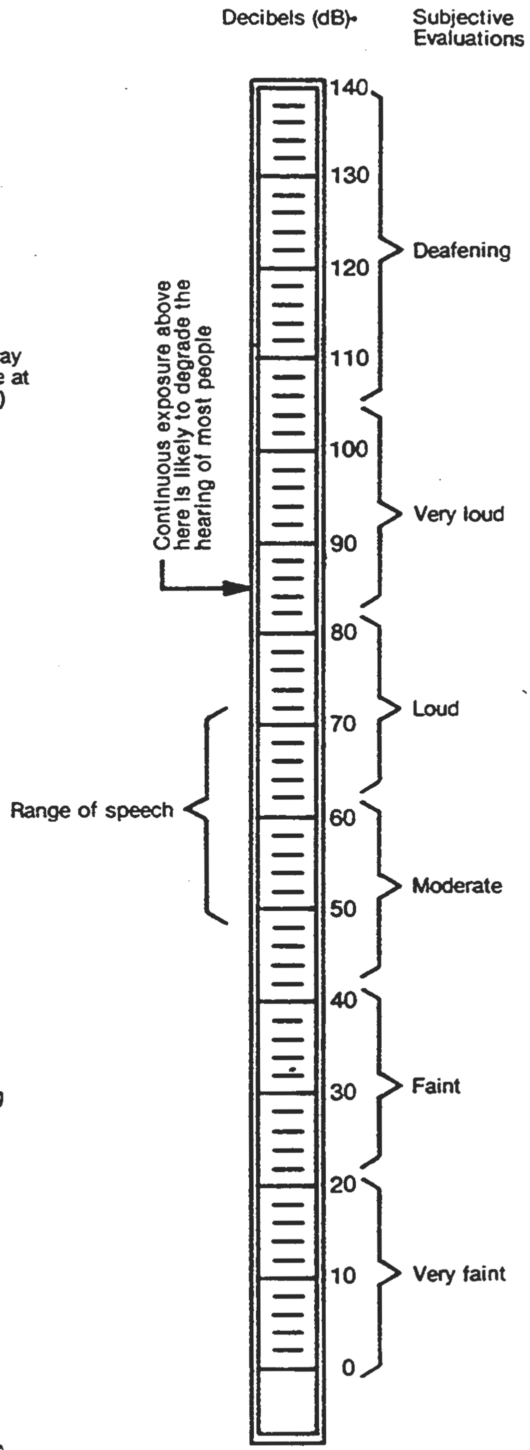
Average residence without stereo playing

Average whisper

Rustle of leaves in wind

Human breathing

Threshold of audibility



*dB are "average" values as measured on the A-scale of a sound-level meter
(From *Concepts in Architectural Acoustics:* M. David Egan, McGraw Hill, 1972.)

FIGURE 7-3

Figure 7-3

historic sites. The requirements of the statute listed below apply to all transportation plans and programs supported by Federal funding.

Special efforts shall be made to preserve sites that are significant to the general public, including:

- Publicly-owned parks and recreational areas opened to the entire public,
- Publicly-owned wildlife and waterfowl refuges,
- Historic sites which are on or eligible for the Historic Register of Historic Places and historic sites of local significance,
- Archaeological sites on or eligible for inclusion on the National Register and which warrant preservation in place, including sites discovered during construction,
- Publicly-owned waters of designated Wild and Scenic Rivers,
- Sections of publicly-owned fairgrounds that are opened to the public for recreational purposes other than annual fairs and commercial purposes.

Transportation plans and programs shall include measures to maintain or enhance the natural beauty of lands crossed by transportation activities or facilities.

The Secretary of Transportation may approve a transportation program or project requiring the use of publicly owned land of a public park, recreation area or wildlife and waterfowl refuges, or land of a historic site only if there is no prudent and feasible alternative to using that land; and the program or project includes all possible planning to minimize harm to such areas resulting from the use.

The following lands are not protected by Section 4(f):

- Privately owned parks, recreational areas, and wildlife and waterfowl refuges, even if they are opened to the public.
- Publicly-owned parks and recreational areas where visitation is limited to select groups and not the entire public.
- Archaeological sites when it is determined that the resource is important primarily because of what can be learned by data recovery and has minimal value for preservation in place.
- National historic trails.

The Pennsylvania Scenic Rivers Act (1972) established the State Scenic Rivers System and the Pennsylvania Scenic Rivers Program to protect rivers having outstanding aesthetic and recreational values. Under the state program, there are five classifications of waterways: wild, scenic, pastoral, recreational and modified recreational. Nominated waterways are classified by priority group. Rivers nominated as Priority 1 waterways exhibit outstanding aesthetic, natural, cultural, and/or recreational values and are considered to be of statewide, and in some instances national significance. Priority 2 and Priority 3 waterways are characterized by some of the previously listed values, but not to the degree required to merit statewide recognition.

Within the project study area, the Ohio River, from the junction of the Monongahela and Allegheny Rivers to the West Virginia/Ohio border, has been nominated for inclusion in the State Scenic Rivers Program as a Priority 3 waterway. Classified as a modified recreational waterway, the river has been recognized for its ability to maintain recreational use as well as provide for residential, commercial and industrial utilization.

Two of the proposed MAGLEV alignments (D and G) would require the construction of bridge crossings over the Ohio River. Under the Scenic Rivers Act, shorelines associated with modified recreational waterways may be extensively developed as long as the development does not inhibit public use. Because the Ohio River has not legally been adopted into the Scenic Rivers Program, construction of a river crossing for the MAGLEV System would not be subject to review under the Pennsylvania Scenic Rivers Program.

For any further design studies, it is recommended that coordination be continued with the Pennsylvania Department of Environmental Resources Scenic Rivers Program with respect to the Ohio River's status in the State Scenic Rivers Program and the U.S. Department of Interior, National Park Service with respect to the National Wild and Scenic River System under which Pittsburgh's three rivers may be eligible for listing for their recreational significance.

When a proposed transportation project directly or indirectly impacts land protected by Section 4(f), the proposed project must follow the requirements of the statute. Direct impacts of 4(f) land include using all or sections of protected areas for transportation projects. Indirect impacts, otherwise known as "constructive uses", are proximity impacts such as visual intrusion, noise and access, which substantially impair the function of a park, recreation area or refuge, or the historic integrity of a historic site. When the use or constructive use of 4(f) land is proposed, a Section 4(f) evaluation is required for the project. Since it is the intent of the 4(f) statute and the policy of the DOT to avoid public parks, recreational areas, refuges and historic sites, the evaluation must demonstrate that there is no feasible and prudent alternative to the use of the 4(f) land. The contents of the document must include: project purpose; project need; project alternatives that avoid or minimized impacts to the 4(f) land; and mitigation. To justify the use or constructive use of 4(f) land, it must be demonstrated that each design and location alternative would involve exorbitant costs or would present unique problems or community disruption of great magnitude. Mitigating measures include design modifications, replacement of land and facilities, or monetary compensation which could be used to enhance the remaining land.

The Section 4(f) process involves close coordination with the agency owning or administering the land, the Department of the Interior, the Department of Housing and Urban Development, the U.S. Department of Agriculture and the state. After the 4(f) evaluation and review is complete, the sponsoring agency will make the final decision as to the use or constructive use of the Section 4(f) land.

7.2.15 NAVIGABLE WATERWAYS

Navigable waterways are defined as those waterways that are subject to tidal influences and inland waterways that are used for or could be used for substantial interstate or foreign commerce. One waterway within the study area, the Ohio River, meets the latter criteria and is listed as a navigable waterway by the U.S. Coast Guard.

The Ohio River provides direct access for the shipment of commodities over an extensive inland navigation system with connections to the Great Lakes system and the Gulf Intercoastal Waterway system. Commodities transported within the Pennsylvania section of the Ohio River include coal, coke, sand, gravel, petroleum products and iron and steel goods. In addition to commercial transportation, Pittsburgh's three rivers are home to one of the largest inland recreational boating industries in the country.

Two of the proposed MAGLEV alignments (D and G) would require the construction of bridge crossings over the Ohio River. The bridge spans for each alignment crossing are:

- Alternative D - 2,100 feet
- Alternative G - 1,800 feet and 2,330 feet

Any crossings of the Ohio River must meet design requirements established by the U.S. Coast Guard (USCG) in regard to the placement of bridge abutments, horizontal clearance and vertical clearance over navigation channels. Horizontal clearance is a function of the channel pier locations and is determined by the USCG after a site inspection. The minimum vertical clearance over the Ohio River in an ideal location is 55-feet above the 2 percent flowline or 69 feet above normal pool, whichever is greater.

The Army Corps of Engineers (ACOE) does not have specific design requirements for bridges over navigable waters. The ACOE does provide comment to the USCG on bridge construction permit applications.

Potential impacts which may occur due to bridge crossing construction are:

- Alteration of navigation patterns due to the presence of barges and cranes necessary for construction and the location of guideway support piers.
- Water quality impacts due to the placement of fill material in rivers.

Mitigation for navigable water crossings include a bridge design that does not obstruct navigation along the Ohio River and environmentally sensitive construction methods. To insure that new structures do not adversely impact navigation and the environment, several agencies regulate activities in navigable waters of the Commonwealth.

The Rivers and Harbors Act (Section 10, 1899) prohibits the obstruction or alteration of navigable waterways without a permit from the ACOE. The Clean

Water Act (Section 404, amended 1987) prohibits the discharge of dredge or fill material into waters of the United States without a permit from the ACOE. Under Section 401 of the Clean Water Act, any project that is Federally licensed or permitted requires a Water Quality Certification if the proposed project has the potential to result in negative impacts to surface water or wetlands during construction and/or operation.

The General Bridge Act (1946) requires a USCG Bridge Permit, prior to construction, documenting the locations and plans for bridges spanning navigable waterways to be submitted for approval by the Commandant, United States Coast Guard.

The Pennsylvania Department of Environmental Resources (PADER) administers the state program under the Dam, Safety and Encroachment Act (amended 1991). Under this act, a Water Obstruction and Encroachment Permit and a Submerged Lands License Agreement will be required for this project. Activities that will affect a watercourse, wetland, 100-year floodway or waterbody must obtain a Water Obstruction and Encroachment Permit. Projects involving submerged lands of navigable waters in the Commonwealth require a license agreement from PADER.

Required Permits

Federal:

USCG Bridge Permit - General Bridge Act
Section 401 Water Quality Certification - Clean Water Act
Section 404 Permit - Clean Water Act
Section 10 Permit - Rivers and Harbors Act

State:

Water Obstruction and Encroachment Permit - Dam, Safety and Encroachment Act
Submerged Lands License Agreement - Dam, Safety and Encroachment Act

7.2.16 WETLANDS

Wetlands are a unique by-product of the relationship that exists between vegetation, hydrology and soil. Wetlands possess three essential characteristics: hydrophytic vegetation, hydric soils and hydrology. Hydrology is the driving force that creates all wetlands. The formation of wetlands is based on permanent or periodic inundation, or soil saturation to the surface. The presence of water for several days during the growing season typically creates anaerobic conditions in the soil which affects the types of plant (hydrophytes) species that can grow and the types of soils (hydric) that can develop. Wetlands generally include swamps, bogs, marshes and other similar areas.

In the identification of a wetland, positive indicators of the presence of hydrophytes, hydric soils and hydrology must be present. In the Federal Manual for Identifying and Delineating Jurisdictional Wetlands characteristics and technical criteria for the three wetland parameters are detailed. The wetland characteristics and technical criteria are mandatory and must be met for an area to be identified as a wetland.

Hydrophytic plant species are adapted to growth and reproduction in water or on a substrate that is at least periodically deficient of oxygen as a result of excess water content. The U.S. Fish and Wildlife Service has developed a classification system that rates plants according to their estimated probability of occurring in a wetland. Those species that are dependent on wetlands are termed "obligate" while those that can not tolerate wetland conditions are termed "upland". Between the obligate and upland classifications are a range of "facultative" plants which occur in, but are not dependent on, wetland conditions.

The Federal Manual contains specific criteria that determines hydrophytic plant communities based on the percentage of dominant plant species from all strata that are obligate and/or facultative species. In general, when more than fifty (50) percent of the dominant plant species in an area have an indicator status of obligate, facultative wetland or facultative, the plant community is considered to be hydrophytic and satisfies the wetland vegetation criteria.

The driving force behind the formation of a wetland is hydrology. Wetland hydrology includes all characteristics of areas that are periodically inundated or have soils saturated to the surface at some time during the growing season. Wetland hydrology can be supplied by surface water and/or ground water. The hydrology causes the development of hydric soils and creates the conditions required to support hydrophytic vegetation. Indicators of wetland hydrology may be obtained from recorded data such as stream gage records and aerial photography. Field indicators include ponding, flooding, high water table, oxidized root channels, water marks, drift lines, water stained leaves, surface scoured areas, drainage patterns, saturated soils and morphological plant adaptations.

Hydric soils are soils that are saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions in the upper part, the A horizon (U.S.D.A. Soil Conservation Service, 1987). The following types of soils are considered hydric:

- Most organic soils such as peat and mucks.
- Soils that are influenced by groundwater as follows:
  - -- Somewhat poorly drained soils where the water table is within 6 inches of the soil surface for more than 7 days during the growing season.
  - -- Poorly or very poorly drained soils with high permeability (greater than 6-inches per hour), where the water table is within 12-inches of the soil surface during the growing season.
  - -- Poorly or very poorly drained soils with low permeability (less than 6 inches per hour) where the water table is within 18-inches of the soil surface during the growing season.
- Soils that are ponded for greater than 7 days during the growing season.
- Soils that are frequently flooded for greater than 7 days during the growing season.

The wetlands identified within the study corridors are those that have been identified by previous studies. These wetlands include National Wetland Inventory wetlands mapped by the U.S. Fish and Wildlife Service, and wetlands identified by the Southern Expressway and Greater Pittsburgh International Airport environmental studies. For each alternative, the acreage of the documented wetlands within each 2000 foot corridor have been calculated (see Table 7-17, Wetlands). Figure 7-4 illustrates how wetlands were identified in these 2000 foot corridors.

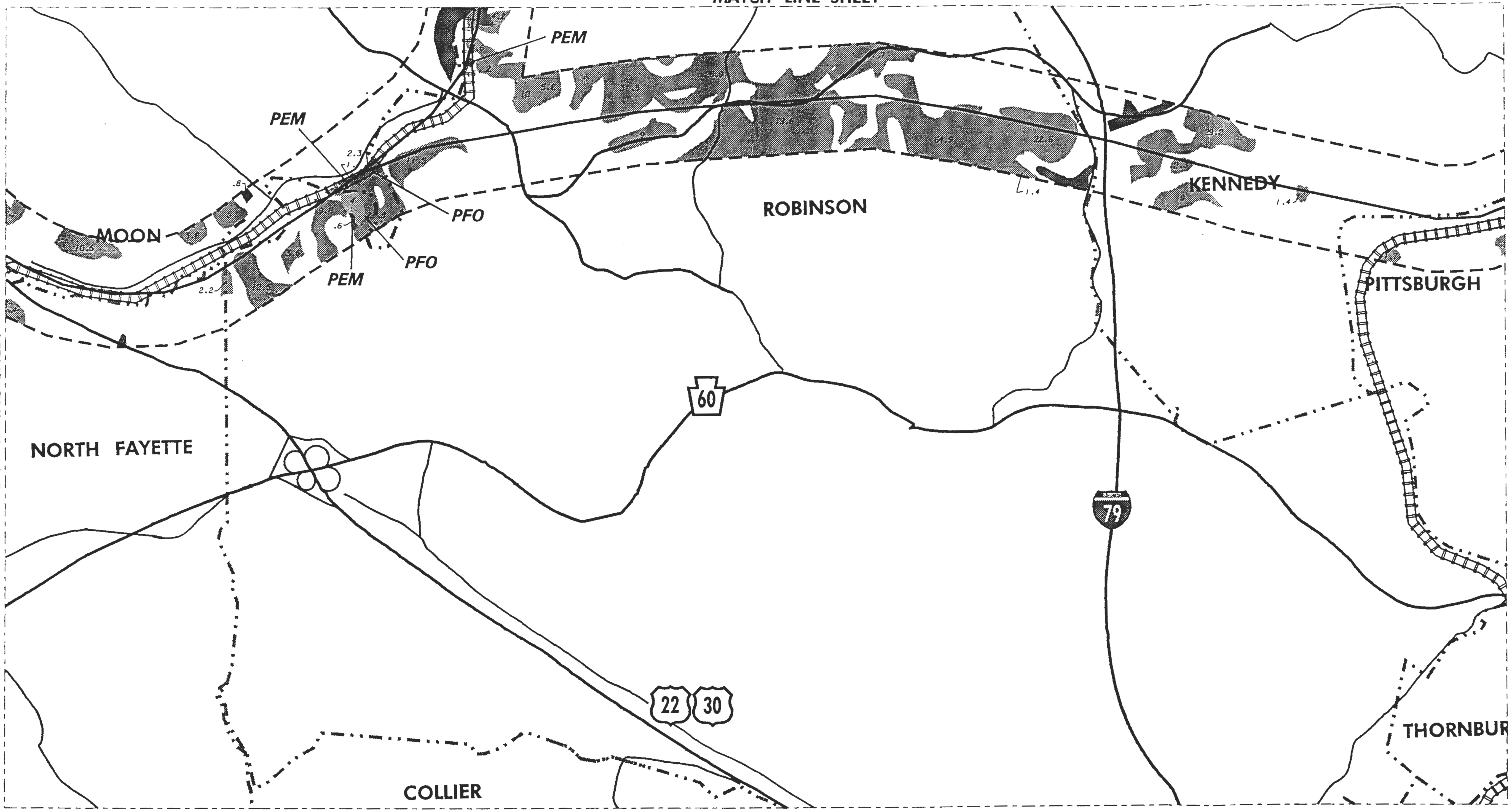
The table shows that the Alternative E Corridor contains the most acreage, with Alternative G containing the least.

The previously identified wetlands have not been field verified for this study. The acreage calculations are only estimates based on existing documentation. In the event of field verification of wetlands along each alignment, additional wetlands will most likely be identified that have not been previously documented for other environmental studies.

TABLE 7-17
WETLANDS (ACRES)

Alternative	NWI Wetlands	Hydric Soils	Soils with Hydric Indicators	Wetlands & Hydric Soils	Wetlands & Soils with Inclusions	Totals
A	12.5	123.6	849.3	6.6	6.6	998.6
D	14.3	123.6	844.9	6.6	6.6	996.0
E	5.4	75.4	970.5	5	13.3	1069.6
G	2.4	98.1	516.6	7.8	2.0	626.9

Wetlands that are located within the alignment corridors pose specific constraints to the development of the MAGLEV System. Wetlands are protected by both State and Federal governments. Anyone proposing to dredge, fill or alter in any way a wetland in the Commonwealth of Pennsylvania must meet certain State and Federal requirements. The Pennsylvania Dam, Safety and Encroachment Act of 1978, authorizes and requires regulation of activities in Pennsylvania wetlands. Under this Act, the Pennsylvania Department of Environmental Resources (PADER) is given authority to regulate and require permits for any activity in any waters and wetlands of the Commonwealth.



LEGEND

- *Wetlands*
- *Hydric Soils*
- *Soils With Hydric Inclusions*
- *Wetlands & Hydric Soils*
- *Wetlands & Soils With Hydric Inclusions*

Figure 7-4

MAGLEV

Wetlands & Hydric Soils

sht. 7 of 8

2000 1000 0 2000

Federal wetlands regulations are found in Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Section 10 prohibits the obstruction or alteration of navigable waters of the United States without a permit from the U.S. Army Corps of Engineers (Corps). Section 404 prohibits the disposal of dredged or fill materials into waters of the United States without a permit from the Corps. Waters of the United States include wetlands. The Corps construes Section 404 as regulating not only the disposal of dredge or fill materials, but also the placement of material as for development purposes and the construction of structures in wetlands.

Federal and State laws and regulations require that permits for activities in wetlands must be obtained prior to the commencement of any alteration or activity. Application for proposed projects in Pennsylvania are made to both the PADER and the Corps under a joint permit application process. The PADER and the Corps review the applications under separate regulations and issue separate permits. Permitting will require, at a minimum, filing of municipal and county notification of permit application; and preparation of a ACOE/PADER Joint Permit Application, which includes detailed plans of encroachments, evidence of notification, an Environmental Assessment demonstrating that the proposed alternative (and hence impact) is the most prudent and practicable alternative available in fulfilling the intended purpose of the project and an Erosion and Sedimentation Control Plan that has been approved be the Allegheny County Conservation District.

The ideal mitigation strategy for wetland impacts is total avoidance of wetland areas. If at all feasible, the sections of the MAGLEV System that will impact wetlands should be designed to avoid the existing wetlands. In the case of an elevated system such as MAGLEV, the impact on the wetlands will be from pier placement. During final design, alignment adjustments and pier placement decisions should be make to avoid or minimize wetland impacts. Wetland areas destroyed by construction would have to be replaced. In general, permitting agencies require that wetland replacement occur on-site, be at least as large as the wetland area destroyed and replace or recapture all lost functions and values of the impacted wetland.

Required Permits

The MAGLEV System will require two permits, one State and one Federal, for any wetland encroachments resulting from construction:

Federal
Department of the Army Section 404 Permit - Issued by the Corps under the Clean Water Act.

State
Water Obstruction and Encroachment Permit - Issued by the PADER under the Dams, Safety and Encroachment Act.

7.2.17 THREATENED AND ENDANGERED SPECIES

Species of flora and fauna listed as threatened, endangered and special concern by Federal and State agencies have been identified within Allegheny County. The U.S. Fish and Wildlife Service, the Pennsylvania Game Commission, the Pennsylvania Fish Commission and the Pennsylvania Natural Diversity Inventory (PNDI) were contacted for information regarding the presence of these species within the study area.

According to the Pennsylvania Fish Commission, none of the fishes, amphibians or reptiles listed as endangered or threatened are known to occur at or in the immediate vicinity of the study corridors. The U.S. Fish and Wildlife Service stated that except for occasional transient species, no federally listed threatened or endangered species are known to exist in the project area. Transient wildlife species identified by the U. S. Fish and Wildlife Service are the bald eagle (*Haliaeetus leucocephalus*); American peregrine falcon (*Falco peregrinus anatum*); Arctic falcon (*Falco peregrinus tundrius*); Indiana bat (*Myotis sodalis*); and Eastern cougar (*Felis concolor cougar*). The Eastern cougar is believed to be extinct in Pennsylvania.

The Pennsylvania Game Commission issued a list of endangered, threatened and special concern species for Allegheny County (see Table 7-18). This list also

TABLE 7-18
PA FISH AND WILDLIFE DATABASE
ENDANGERED, THREATENED AND SPECIAL CONCERN SPECIES LIST
ALLEGHENY COUNTY

Common Name	Scientific Name	Status
Bald Eagle	*Haliaeetus leucocephalus*	Fed/PA Endangered
Peregrine Falcon	*Falco peregrinus tundris*	Fed/PA Endangered
Rough Bullhead	*Plethobasus striatus*	Fed Endangered
Rough Pigtoe	*Pleurobema plenum*	Fed Endangered
Ohio Orbshell	*Lampsilis abrupta*	Fed Endangered
Massasauga	*Sistrurus catenatus*	PA Endangered
Midland Smooth Soft-shell	*Trionyx muticus*	PA Endangered
Short-eared Owl	*Asio flammeus*	PA Endangered
Black Tern	*Chlidonias niger*	PA Endangered
American Bittern	*Botaurus lentiginosus*	PA Threatened
Great Egret	*Casmerodius albus egretta*	PA Threatened
Yellow-Bellied Flycatcher	*Empidonax flaviventris*	PA Threatened
Upland Sandpiper	*Batramia longicauda*	PA Threatened
Eastern Bluebird	*Sialia sialis*	Special Concern
Northern Bobwhite	*Colinus virginianus*	Special Concern
Northern Harrier	*Circus*	Special Concern
Cooper's Hawk	*Accipiter cooperii*	Special Concern
Red-Shouldered Hawk	*Buteo lineatus*	Special Concern
Purple Martin	*Progne subis*	Special Concern
Common Barn Owl	*Tyto alba*	Special Concern
Grasshopper Sparrow	*Ammodramus savannarum*	Special Concern
Henslow's Sparrow	*Ammodramus henslowii*	Special Concern
Vesper Sparrow	*Pooecetes gramineus*	Special Concern
Red-Headed Woodpecker	*Melanerpes erythrocephalus*	Special Concern
Keen's Myotis	*Myotis keenii*	Special Concern

Source: Pennsylvania Game Commission
Pennsylvania Fish and Wildlife Database, September 1990

includes birds which may accidentally occur but do not nest or rear young in Allegheny County.

The Pennsylvania Game Commission has determined that the Peregrine Falcon (Falco Peregrinus), a federal and state-listed endangered species, has been observed nesting in the Pittsburgh area. While Peregrine Falcons historically nest on cliffs overlooking the river, falcons found in the area demonstrate a liking for nesting sites on man-made structures. Further studies will be required to determine if any nesting sites of the Peregrine Falcon are located within close proximity to the preferred alignment(s).

The Pennsylvania Natural Diversity Inventory (PNDI) stated that there are no known occurrences of species of special concern within any of the study corridors other than historic records of several plant species, shown in Table 7-19. The historic records taken from herbarium specimens on file at the Carnegie Museum of Natural History identify the status of all but one species to be Tentatively Undetermined (TU). TU indicates that botanists have reported that the populations are declining but more information is needed to determine their status in Pennsylvania. A single species has been identified as rare. The historic records list the following plant species for each corridor.

These sitings have not been recently confirmed. Given the age of the historic records and the known use of the areas where the species were located, PNDI concluded that they do not anticipate any impact on species of special concern by the MAGLEV system.

The presence of endangered, threatened and special concern species within Allegheny County will not cause any constraints to the development of the MAGLEV System. There are no known communities of wildlife species located within the study corridors. Based on PNDI's review, the MAGLEV system will not affect plant species listed as threatened, endangered and special concern within the study corridors.

TABLE 7-19
PADER, BUREAU OF FORESTRY
SPECIAL CONCERN SPECIES LIST

Alternative.	Common Name	Scientific Name	Recorded Date	Pennsylvania
A	Pipevine	*Aristolochia macrophylla*	1900	TU
	Heartleaf Meehania	*Meehania cordata*	1941	TU
	Passion Flower	*Passiflora lutea*	1898	TU
D	Pipevine	*Aristolochia macrophylla*	1886	TU
G	Puttyroot Orchid	*Aplectrum hyemale*	1887	Rare
	Four-flowered Loosestrife	*Lysimachia quadiflora*	1887	TU
	Pipevine	*Aristolochia macrophylla*	1886	TU
	Rock Skullcap	*Scutellaria saxatilis*	1901	TU
	Winter Duckweed	*Lemna turionifera*	1947	TU

Source: Pennsylvania Department of Environmental Resources
Bureau of Forestry. Pennsylvania Natural Diversity Inventory, 1991

7.2.18 CONSTRUCTION IMPACTS

Construction activities for any of the proposed MAGLEV schemes will have several impacts affecting the residents of the immediate project area and those traveling in the vicinity. Potential construction-related impacts would include:

- Temporary degradation of air,
- Construction noise impacts,
- Water quality degradation,
- Erosion control,
- Maintenance and protection of traffic,
- Safety issues,
- Stockpiling and disposal of construction material,
- Location and reclamation of waste and borrow areas.

Air quality impacts during the construction of MAGLEV would be temporary and would primarily be the result of open burning, emissions from diesel-powered construction equipment and dust from excavations, embankments, stock piles and haul roads. All burning would be done in accordance with all applicable laws, ordinances and regulations, and would be subject to the regulations of the Pennsylvania Department of Environmental Resources and the Allegheny County Health Department. Airborne particles from excavations, embankments, stock-piles and haul roads would be controlled through the use of watering or other dust palliatives.

Noise and vibration impacts would primarily be from heavy equipment movement and certain construction activities. The Highway Construction Noise Model (HICNOM) could be used to determine where noise abatement measures would be needed. Noise abatement could include placing temporary noise barriers and limiting construction activity to certain hours. Commercially available noise abatement, silencing and muffling equipment and procedures will be used, whenever practical, to ensure minimal disruption. Safety provisions, such as hearing protection for construction workers, will be provided. During such operations as pile driving, drilling, etc., severe vibrations may be encountered. The contractor shall monitor the vibration levels of structures in the vicinity of the construction to avoid the possibility of structural damage. Vibration assessments of structures and buildings located within close proximity to the selected alignment should be conducted prior to construction. This generally involves an inspection of the structure and photo recordation for the purpose of documenting/refuting any claims of structural damage due to construction. Nearby residences and businesses should also receive notification of construction schedules prior to the start of construction.

Water quality impacts resulting from erosion and sedimentation as well as pollutants such as chemicals, fuels, lubricants, bituminous, raw sewage and other harmful waste will be strictly controlled. The contractor will exercise every reasonable precaution necessary during construction to prevent pollution of rivers, streams or impoundments. All construction discharge will be adequately filtered prior to the release into waters and will meet the requirements of the Pennsylvania Department of Environmental Resources. During spawning seasons, discharges and construction activities in spawning areas of waters will be restricted so as not to disturb or inhibit aquatic species which are indigenous to the waters. In the event the contractor dumps, discharges or spills any contaminate which may affect water quality, he/she would immediately notify all appropriate local, State and Federal agencies and would take immediate action to control and remove the contaminate.

The maintenance of traffic, construction sequencing and detouring will be planned and scheduled so as to minimize any adverse impacts to the traveling public. Signs will be used and local newspapers notified to provide ample notice of detours, closings and other construction-related activities in order to plan for travel routes and time delays in advance. Traffic congestion and delays will be controlled where many construction operations are in progress at the same time. The contractor will use the devices and procedures described in the Commonwealth of Pennsylvania Department of Transportation's Specifications 1990, Section 901, in addition to standard practices, to assure safe passage of traffic. Access to residences and businesses will be maintained, to the extent possible, through construction scheduling and sequencing and through the use of temporary driveways.

During the course of construction, the contractor will comply with all Federal, State and local laws governing safety, health and sanitation. All reasonable safety considerations and safeguards necessary to protect the life and health of employees on the job, the safety of the public and the protection of property in connection with the construction will be taken.

The construction of MAGLEV will require the excavation of unsuitable material, placement of embankments and the use of materials such as aggregates, bituminous and portland cement concrete. The stockpiling and disposal of the construction and excavation materials may be visually displeasing to some of the residents along the construction corridor. However, this is a temporary condition and should pose no permanent problems with the use of the required temporary erosion control features. The contractor will be responsible for his/her methods of placing the necessary features of erosion control on haul roads, borrow and other material pits, areas used for the disposal of waste materials and other pollution potentials associated with the construction of the project. The temporary erosion control features will consist of berms, dikes, temporary seeding, sediment traps, fiber mats, silt fences, slope drains, mulches, crushed stone and others. The removal of structures and debris, including the disconnection or interruption of any public utilities, will be in accordance with local regulatory agencies permitting this operation.

Existing conditions that will pose problems to the constructibility of MAGLEV (large cuts and fills, rockfall areas, deep-mined and strip-mined areas, stream crossings and relocation, etc.) will be handled individually during preliminary and final design. The final alignment will be placed in the most practical location to miss problem areas in addition to minimizing environmental concerns. In-depth geotechnical research, reconnaissance and core borings are used to make sound engineering judgments to solve constructibility problems as they arise.

7.3 DESIGN CRITERIA AND ANALYSIS

7.3.1 MAPPING

Four alignments were evaluated and studied at 1"=200' scale using available existing mapping obtained from three primary sources. Mapping for the new airport and relocated Route 60 was developed for the Allegheny County Department of Aviation and Pennsylvania Department of Transportation by Michael Baker Jr., Inc. using Computer Aided Design and Drafting (CADD). Mapping covering the areas selected for the four MAGLEV alignments were plotted at 1"=200' scale with 5-foot contours. These plots were photographed and negatives were spliced together to form a continuous swath that would contain the alignment. That swath was then spliced onto a master sheet containing the profile grid and border, then photographed to produce an original mylar.

Mapping for areas within the City of Pittsburgh was obtained from the City of Pittsburgh, Department of City Planning at 1"=200' scale with 5-foot contours. These maps were then photographed and the same procedure described above was followed to produce the original mylar.

The mapping for the area between Route 60 in Moon Township and the City of Pittsburgh was obtained by using the most recent versions of United States Geological Survey (USGS) 7.5 minute Quadrangle maps. The maps, which are

1"=2000' were photographically enlarged to 1"=200' scale and spliced together. The areas were then hand drafted to form a continuous swath. The same procedure was then followed to produce the original mylar.

7.3.2 DESIGN CRITERIA AND CONSTRAINTS

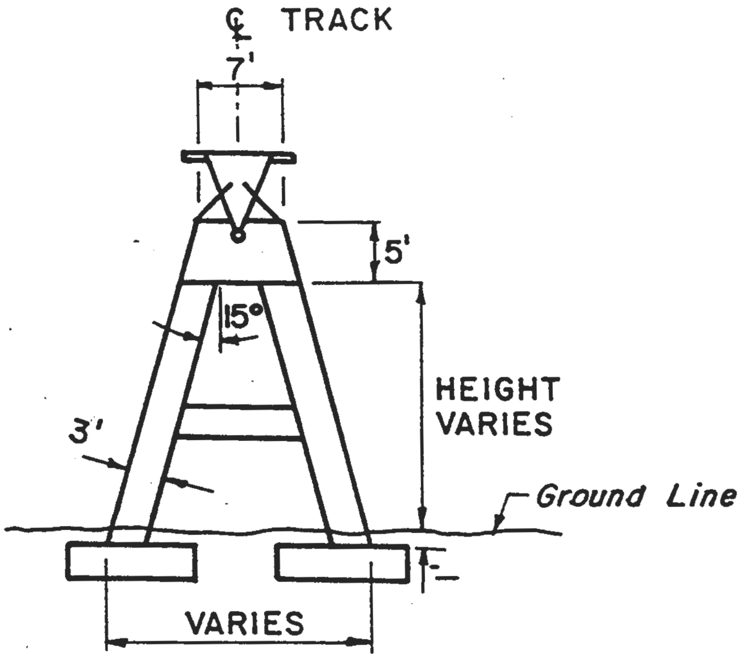
Design criteria and parameters used for the preliminary design of the horizontal and vertical alignments were obtained from Transrapid International, the German manufacturer of the system being considered for the study. These design criteria included maximum acceptable lateral acceleration, maximum acceptable vertical acceleration, maximum acceptable jerk, maximum acceptable cant (or banking of the guideway), maximum acceptable torsion, maximum acceptable gradient, minimum horizontal and vertical curvature, and spiral curve data for transition between tangent and circular track sections. Values for these criteria are listed in Section 5, which describes how they were applied to the Regional system.

7.3.3 TYPICAL GUIDEWAY SECTIONS

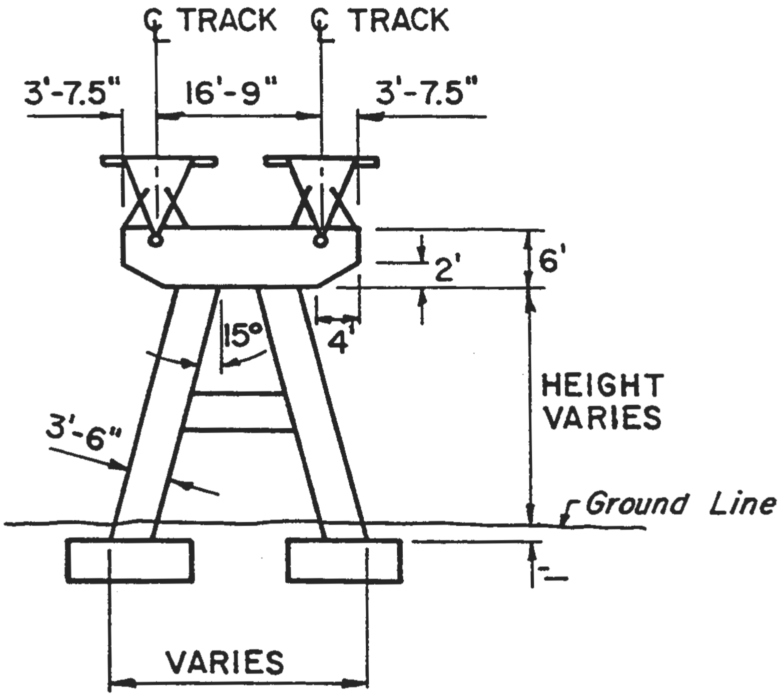
Typical sections for various construction conditions such as embankment and excavation areas for tangent and canted guideway conditions are shown in Figures 7-5 through 7-9. Conceptual concrete pier designs for single track showing spread footings and footing resting on concrete filled piles are shown, as well as an access road. Actual pier designs, footing types and access road locations will be finalized during the preliminary and final design stages.

7.4 DESIGN DESCRIPTION

Using available mapping and design criteria presented in the previous section, schematic plan and profiles for Alternatives A, D, E and G, as well as the stations, were developed. Each of the four Demonstration, Design and Development Plan Alternatives possesses elements that make it unique. These elements, described below and summarized in Table 7-20, provide many challenges in the design, construction and maintenance of a MAGLEV system and will therefore allow each alternative to be an excellent demonstration of the technology. Examples of unique elements include:



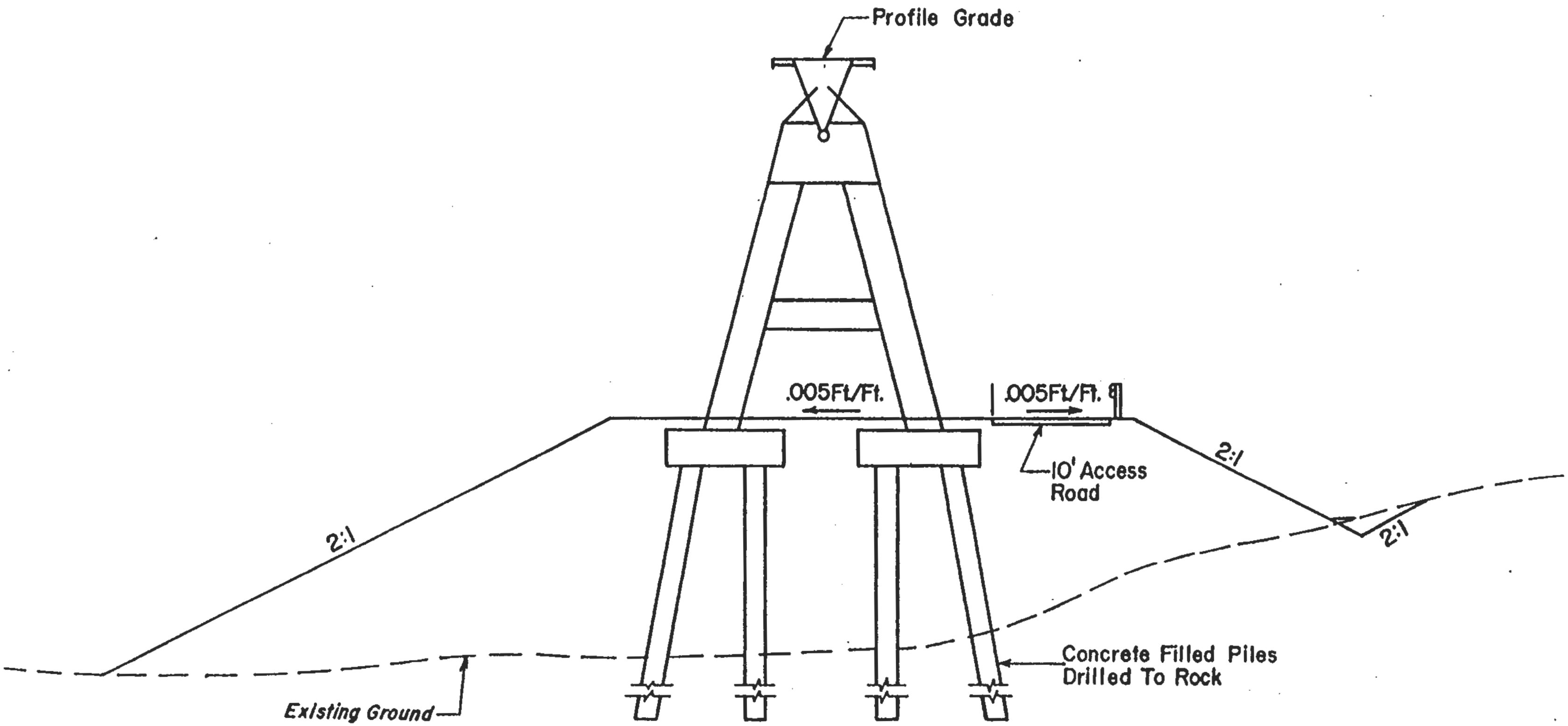
SINGLE - TRACK PIER



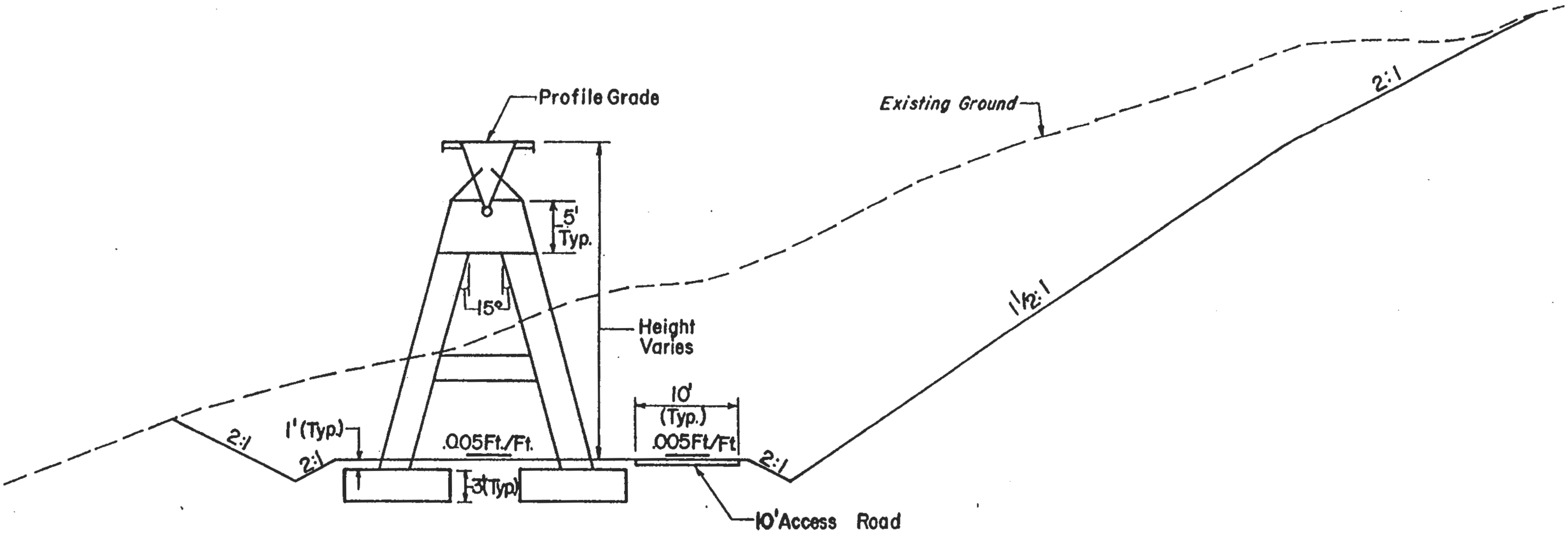
DOUBLE - TRACK PIER

SCALE: N.T.S.

FIGURE 7-5

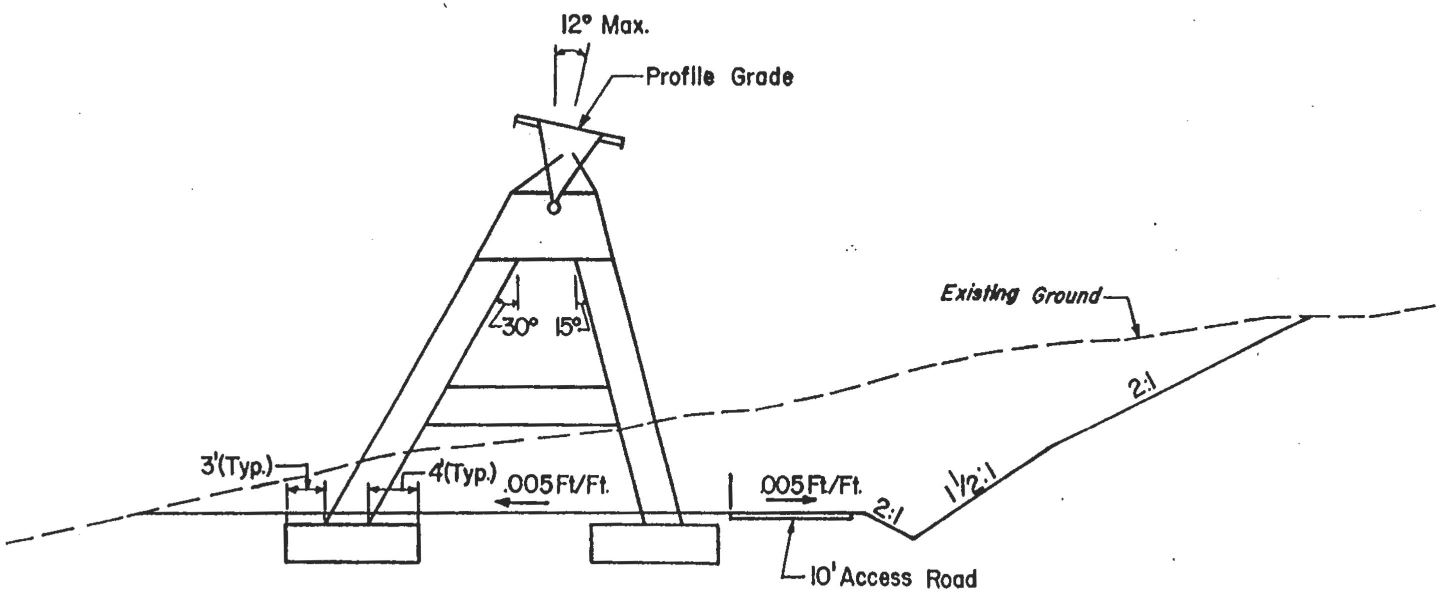


TYPICAL TANGENT SECTION
EMBANKMENT AREA

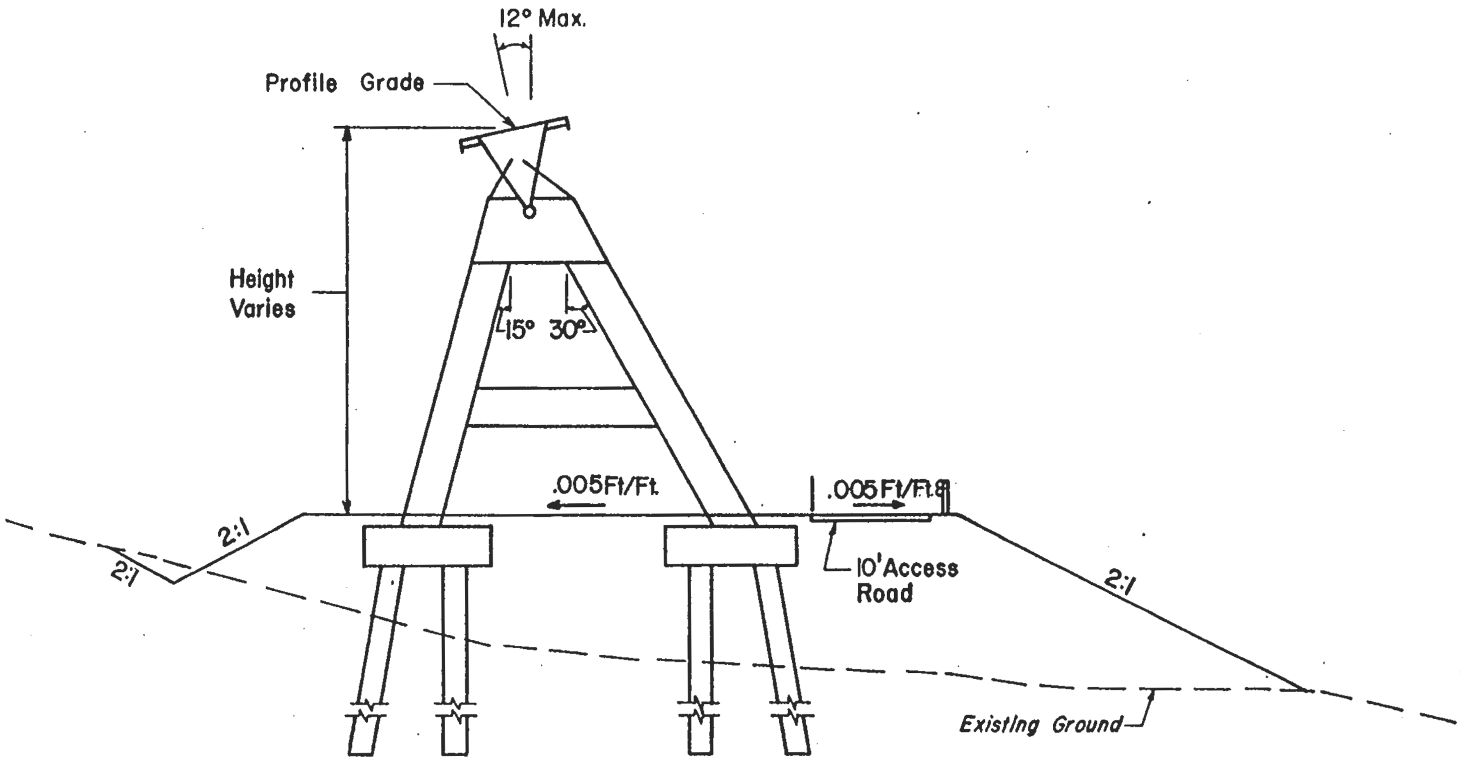


TYPICAL TANGENT SECTION
EXCAVATED AREA

FIGURE 7-7



TYPICAL CANT SECTION
EXCAVATED AREA



TYPICAL CANT SECTION
EMBANKMENT AREA

FIGURE 7-9

TABLE 7-20
Alignment Comparisons

Scheme	Length	Top Speed	Test Speed	%	Length of Vertical Alignment					Tunnels	Number of Structures	
	(miles)	(mph)	(mph)	Curved	-6 to -3.1%	-3 to -1.1%	-1 to 1%	1.1 to 3%	3.1 to 6%	(Linear Feet)	Minor - < 500 feet	Major - > 500 feet
A	19.7	225	243	72	0.5	4.6	11.9	2.7	--	960	13	0
B	19.1	224	243	79	0.5	5.7	10.0	2.7	0.2	960	10	1
C	16.2	208	225	78	2.4	3.2	6.7	2.6	1.3	680	15	0
D	20.3	282	304	75	2.0	3.3	11.6	3.4	0	5,910	2	2

- Large structures with considerable span lengths will be built within tight tolerances and must be designed to operate under various temperature conditions and vehicle loading without transmitting deflections to the guideway.
- Constructing various lengths of guideway to within tolerances to maintain rider comfort on various terrain such as embankments, excavations and ever-changing soil conditions.
- Manufacturing continuous guideway sheets to within required specifications.
- Providing direct connections with other modes of transportation such as highways, busways, light and heavy rail systems and airports provides both logistic and commercial challenges.

7.4.1 ALTERNATIVE A

Alternative A has a total length of 19.8 miles, of which approximately 69 percent, or 13.6 miles, of the guideway is curved. The horizontal curves range from the minimum allowable guideway radius of 1,640 feet to 22,920 feet with the required spiral lengths, and result in a top operating speed of 225 mph. Running without passengers, a top test speed of 243 mph is possible. Eleven (11) bridge structures will be required for this alignment, ranging in length 120 Linear Feet (L.F.). to 300 L.F. In addition to three roadway overpasses, a tunnel of approximately 960 L.F. is required, and the piers for approximately 40,000 L.F. of the guideway will require additional protection against vehicular traffic and train derailment from adjacent roadways and railroad tracks. The average pier height for Alternative A ranges from 10 feet to 30 feet.

7.4.2 ALTERNATIVE D

Alternative D has a total length of 19.1 miles, of which approximately 75 percent, or 14.2 miles, is curved guideway. The horizontal curves range from the minimum allowable radius of 1,640 feet to 22,920 feet with the necessary spiral lengths, resulting in a top operating speed of 224 mph, and a top test speed of 243 mph. Nine (9) bridge structures are expected to be required, including a major structure crossing the Ohio River near the McKees Rocks Bridge. The bridge spans range in length from 120 L.F. to 250 L.F. for minor structures, to possibly as much as 800 L.F. for the river crossing. In addition to three roadway overpasses, a tunnel of approximately 960 L.F. is required and the piers for approximately 32,000 L.F. of guideway will require additional pier protection against vehicular traffic and train derailment from adjacent roadways and train tracks. The height of piers for this scheme will range from at-grade to 45 feet.

7.4.3 ALTERNATIVE E

Alternative E has a total length of 16.4 miles, of which approximately 78 percent, or 12.8 miles, of the guideway is curved. The horizontal curves range from the minimum allowable radius of 1,640 feet to 18,330 feet with the necessary spiral lengths, resulting in a top operating speed of 208 mph and a top test speed of 225 mph. Approximately eight bridge structures will be required for this scheme with span lengths ranging from 120 L.F. to 250 L.F. Also required to operate the system would be seven roadway overpasses and a tunnel of approximately 680 L.F. The average height of the guideway will range from at-grade to approximately 45 feet in height. Additional protection to the piers from vehicular traffic and train derailment from adjacent roadways and train tracks will be required for approximately 16,600 L.F. of the guideway. Approximately 17,000 L.F. of this alignment between Hookstown Grade Road and the Ohio River could share right-of-way with SPRPC's proposed airport alternative highway, requiring design of an intermodal facility meeting criteria for both a MAGLEV system and a limited access highway.

7.4.4 ALTERNATIVE G

Alternative G has the longest length of 20.4 miles, of which approximately 70 percent, or 14.3 miles, of the guideway is curved. The horizontal curves range from the minimum allowable radius of 1,640 feet to 22,920 feet with the required spiral lengths, enabling a top operating speed of 282 mph to be reached, with a top test speed of 304 mph. Approximately four bridge structures would be required for this alignment, two of which would be major crossings over the Ohio River near the Sewickley and West End Bridges. The span lengths of the bridges range in length from approximately 200 L.F. to possibly 800 L.F. at the river crossings. Three tunnels are also required, with approximate lengths of 380, 2,600 and 2,930 L.F.. The average height of the guideway will range from at-grade to 60 feet; and additional pier protection from vehicular traffic and train derailment from adjacent roadways and train tracks will be required for approximately 20,750 L.F. of the guideway.

7.4.5 STATIONS

Two stations are proposed for the Pittsburgh Demonstration System, one at the Pittsburgh International Airport (PIA) and the second in Downtown Pittsburgh.

The station locations for all MAGLEV alignments are the same at PIA where the station is located in the long-term parking area. MAGLEV will stop directly above the moving walkway at the eastern end of the long-term parking area and enter the walkway via stairs or escalators. The long-term parking area at PIA contains approximately 6,200 parking spaces of which a portion may be set aside for MAGLEV passengers upon approval by the Allegheny County Department of Aviation. MAGLEV would interface directly with air transportation at this location and with highway transportation via Route 60.

Alternatives A, E and G will terminate at a station in an open area on the south side of Carson Street at a station located adjacent to the existing PAT station. Easy access with private automobiles is possible from Carson Street and connection to public transportation is possible at the PAT. There is sufficient room to allow for adequate passenger parking and "Kiss-N-Ride" facilities at the existing parking areas associated with Station Square. However, a designated parking area for MAGLEV passengers should be provided to ensure an adequate supply, particularly during special events. Figure 7-10 illustrates a conceptual design for a multimodal MAGLEV station as designed by Philip Kaplan of Carnegie Mellon University.

Alternative D will terminate south of the Allegheny Center on Conrail right-of-way. Allegheny Center contains approximately 2,500 parking spaces which are sometimes near capacity during events at Three Rivers Stadium and the Christmas holiday season. The proposed MAGLEV station will be located approximately 300 feet from the station area. Access by private automobile and bus is possible at this location. The Port Authority has proposed construction of a station in this area in conjunction with expansion of its light rail transit system.

The station must be located in an area which will allow the MAGLEV line to continue east as part of the Regional system. Schemes A, E & G are situated in areas where the CSX and Conrail Railroads may easily be followed out of the City toward future destinations. Scheme D, however, is on a Conrail right-of-way where the existing horizontal alignment east of the station is much too sharp for MAGLEV to continue without expensive right-of-way acquisitions or design options.

7.5 FINANCIAL CONSIDERATIONS

In order to determine a financial plan for constructing and operating the demonstration system, estimates of revenues from ridership were developed for several scenarios of fares, headways and parking costs. In addition, an estimate was developed for capital costs and annual costs of operating and maintaining (O&M) the system. These potential farebox revenues, capital and O&M costs provide the basis for a financial plan for constructing and operating the system.

7.5.1 CAPITAL COSTS

Capital costs were estimated for Alternative A, D, E and G using the unit costs described in Section 7.4. Major elements considered in the development of the capital cost estimates include:

- Guideway structures - This element includes the linear structure and piers. The number of piers for each alternative was developed based on an average placement of one pier per every 77.4 feet. This estimate is for a single guideway configuration.
- Special construction - This element includes drainage structures, earthwork, guideway bridges, roadway overpasses, tunnels, utility structures, retaining walls, pier protection and access roads.
- Electrical, control, communication equipment/facilities - This element includes switches, guideway electronics, power supply, communications and the control center.
- Stations/maintenance facilities - This element includes an airport station, a downtown area station and a maintenance facility.

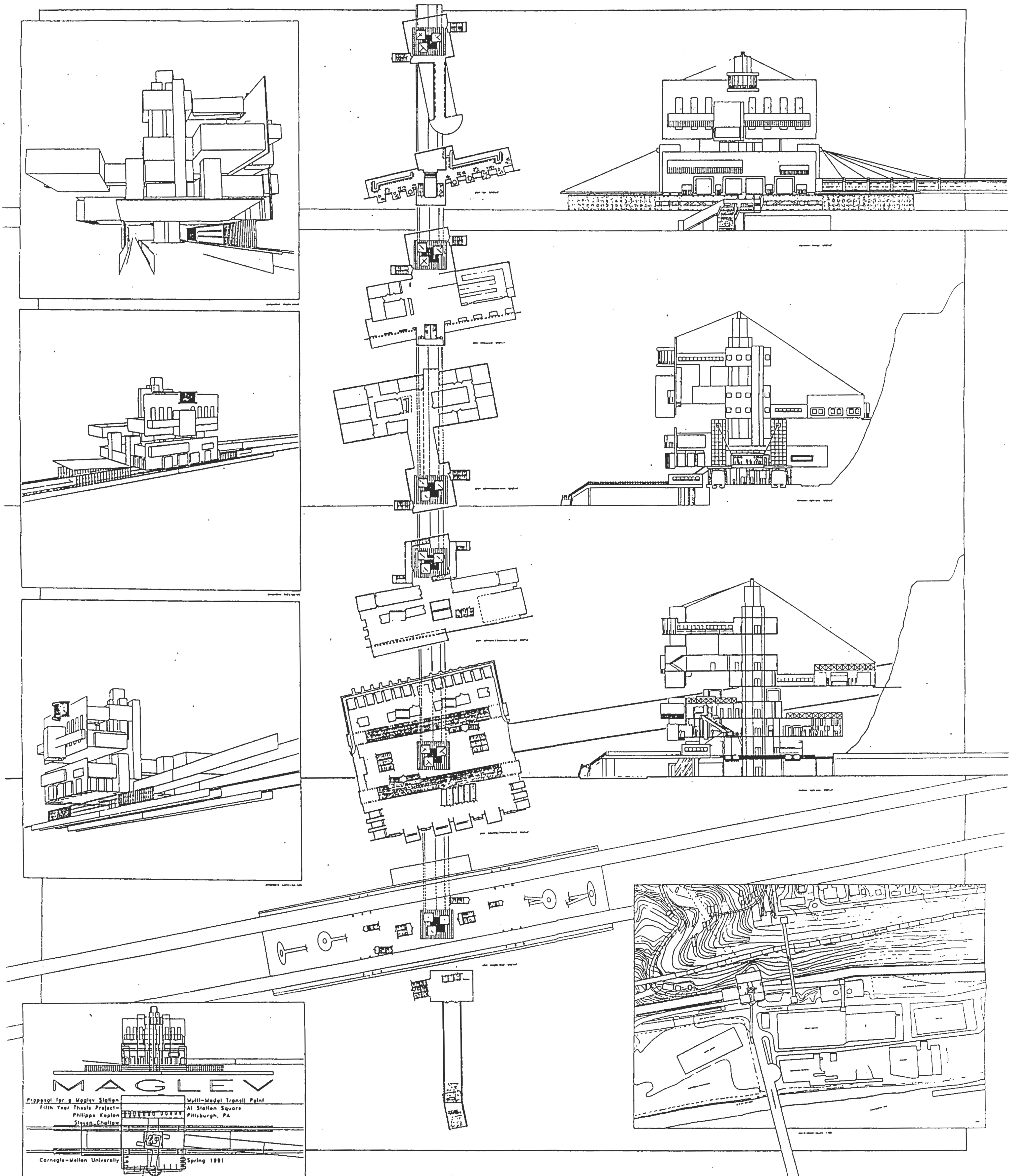

MAGLEV
Proposal for a Maglev Station
Multi-Modal Transit Point
Fifth Year Thesis Project
At Station Square
Philippe Kaplan
Pittsburgh, PA
Steven Challow
Carnegie-Mellon University
Spring 1991

FIGURE 7-10

- Vehicles - Six vehicles (two two-car trains and one spare two car train) were used in the estimation of capital costs.
- Right-of-way acquisition - This cost is based on acreage, type of land use and number and type of structure acquisitions needed for each alternative.
- Other items - This element includes maintenance equipment, specialty construction, utility work, electrical service, check-out and testing.
- Design engineering - This element includes preliminary and final design as well as other up-front services such as environmental impact studies and permitting.
- Construction Management and Inspection.

Unit costs were developed for the Demonstration System. Section 7.4 describes their development and application to the Regional system. Using the 200 scale conceptual plans and profiles developed for each alternative combined with these unit costs, the above elements were tabulated and totaled for each alternative. Table 7-21 shows the estimated costs for each of these nine elements and the estimated total costs for the four proposed alternatives, which range from $494 million (Alternative E) to $595 million (Alternative G).

7.5.2 OPERATION AND MAINTENANCE COSTS

Annual Operating and Maintenance (O&M) Costs for the Demonstration System were developed by AEG Westinghouse Inc. The costs, provided in detail in Tables 7-22, 7-23 and 7-24, include costs for a permanent operating staff, as well as subcontractor and vehicle costs. The permanent staff includes management, supervisors, engineering, technicians and clerical. Subcontractor costs include cleaning, fuel, mobile equipment and specialized maintenance items. Vehicle costs are for special equipment and vehicle maintenance costs. Table 7-22 indicates that the total costs for these items is approximately $4,250,000 annually. In addition to these costs, the other significant O&M cost will be for energy costs to run the system. System operations were modeled by Carnegie Mellon University to estimate the annual energy consumption required to run the system and the corresponding annual costs. Depending on the alignment and design speed chosen, these costs, shown on Table 7-25, Annual Energy Consumption, are

TABLE 7-21
CAPITAL COST ESTIMATES FOR THE PITTSBURGH DEMONSTRATION SYSTEM

ITEM	CAPITAL COST (in millions)			
	A	D	E	G
Guideway Structure	143.38	138.11	120.67	144.57
Special Construction	48.03	58.67	62.30	111.05
Electrical, Control, Communications	110.98	108.03	96.33	113.94
Stations/Maintenance Facilities	17.25	17.25	17.25	17.25
Vehicles	32.1	32.1	32.1	32.1
Right-of-Way	8.70	13.70	17.30	24.30
Other Items	64.50	64.50	64.50	64.50
Design Engineering	73.50	73.50	73.50	73.50
Construction Management/Inspection	10.43	10.70	10.01	13.64
TOTAL	**508.86**	**516.57**	**493.97**	**594.86**

TABLE 7-22
O & M BUDGETARY COST ESTIMATE

Description	Quantity	Cost (1992 Dollars)
O&M Staff (Productive)	78	$3,901,716
Vehicle Costs		$147,510
Subcontractor Costs		$200,000
TOTAL		$4,249,226

TABLE 7-23
O&M COSTING RATE

System Support Personnel	Quantity
Management	
Systems Manager	1
Supervision	
Operations	
Central/Ticketing/Baggage	4
Maintenance	
Vehicle/Wayside	4
Engineering	
Operations	
Central	1
Maintenance	
Vehicle	1
Wayside	1
Technicians	
Operations	
Train/Station Attendants	9
Central	5
Ticket Agents	9
Baggage Handlers	16
Maintenance	
Vehicle	14
Wayside	13
Clerical	
Secretarial	2
Storeroom Clerks	2
Total Staff	82
Productive Staff	78
Staff Monthly Costs	$ 325,143
Staff Yearly Costs	$3,901,716

NOTE: Costs based on an average labor cost of $27.79 per hour.

TABLE 7-24
O & M SUBCONTRACTOR COSTS

Item	Estimated Cost
Cleaning (including graffiti removal)	$100,000
Mobile Equipment, Maintenance Shop and Road Vehicles	$ 30,000
Fuel	$ 15,000
Fire/Smoke Alarm Maintenance	$ 5,000
Radio Maintenance	$ 15,000
Central/Office Computer Maintenance	$ 10,000
Uniform Supply and Cleaning	$ 25,000
TOTAL	**$200,000**

TABLE 7-25
ANNUAL ENERGY CONSUMPTION

Scheme	Length (miles)	Max Speed (mph)*	Acel/Decel (mph/sec)	Run Time (minutes)	Energy Usage (kWh/Run)	Annual Energy Costs	
						Energy	Demand
A	19.8	201	2/2	9.1	409	$287,000	$287,000
		225	3/3	8.8	447	$313,000	$313,000
D	19.1	201	2/2	9.2	478	$335,000	$486,000
		224	3/3	8.8	531	$372,000	$565,000
E	16.0	205	2/2	8.2	400	$280,000	$457,000
		208	3/3	7.8	427	$299,000	$512,000
G	20.4	265	2/2	8.6	576	$404,000	$627,000
		282	3/3	8.1	657	$460,000	$759,000

* Maximum speed caculated by Carnegie Mellon University and is dependent on the accel/decel rate, as well as the horizontal and vertical curvature.

estimated to range between $700,000 and $1,200,000 per year. The resulting annual total O&M costs range between $4,950,000 and $5,450,000.

7.5.3 RIDERSHIP AND REVENUE PROJECTIONS

Ridership estimates were developed for three cases of fares, parking costs and headways to examine the sensitivity of ridership to these variables. From these estimates, potential annual ridership revenue for the system was estimated.

Ridership

COMSIS Corporation was retained to develop ridership projections for the demonstration system. These projections were developed for the Year 2010, using COMSIS Corporation's proprietary MINUTP transportation modeling software described in Section 7. The basic modeling mechanism was the Southwestern Pennsylvania Regional Planning Commission's Spine Line Transit Model. This model is a recently updated model of projected Year 2010 Socioeconomic and Tripmaking characteristics throughout the region, and it is being used as the basis of ridership projections for various transit projects being planned by the Port Authority of Allegheny County.

Three cases for MAGLEV ridership were run for analysis. For each case, a sixteen-hour operating schedule was assumed for each day, consisting of two two-hour peak periods and a twelve-hour off-peak. Three trip purposes were considered in the model: Home Based Work (HBW), Home Based Other (HBO), and Non-Home Based (NHB). For the MAGLEV, a maximum operating speed of 250 miles per hour was assumed, with a maximum acceleration rate of 3 miles per hour per second. A distance of 19.5 miles was assumed for the Airport to Station Square, resulting in a run time of 8.9 minutes. Holding these assumptions constant, three cases were considered:

Case 1

Headway = 20 minutes
MAGLEV fare = $3.00, transfer to other transit = $0.25
Free Park-and-Ride Lots at both stations

Case 2

Headway = 30 minutes
MAGLEV fare = $3.00, transfers to other transit = $0.25
$5.00 Park-and-Ride Lots at both stations

Case 3

Headway = 30 minutes
MAGLEV fare = $10.00, transfers to other transit = $0.25
$5.00 Park-and-Ride Lots at both stations

By studying these three cases, the general effect of trip costs on ridership could be assessed. The first case, a $3.00 fare, is comparable to a premium Port Authority Transit fare. The second case raises the cost for a round trip for auto users (the majority of the riders) to $11.00 or approximately $0.28 per mile. Since a significant portion of the riders were found to access the system by automobile, the second case would also give an approximation of a higher MAGLEV fare with free parking. The third case raises MAGLEV fares to be more comparable to airport, bus and taxi service. The cost per mile is $0.52 for non-parkers, and approximately $0.66 for riders who park.

The results of the analysis were that under Case 1, an annual ridership of 1,421,310 is forecast, under Case 2, an annual ridership of 1,112,520 is forecast, and Case 3 results in annual ridership of 561,370. Tables 7-26, 7-27, and 7-28, Ridership Results, break down the ridership values into more detail.

The introduction of MAGLEV service to the Pittsburgh regional transit system has little impact on the existing modes of transit service. Construction of MAGLEV complements rather than competes with current transit routes. Table 7-29, MAGLEV Corridor Ridership, summarizes the twenty-four hour boardings for each of the available modes of service. Ridership statistics are compared for the no-build (no MAGLEV) versus build scenario. The build scenario summarizes the ridership estimates from Case 1 which represents the maximum MAGLEV ridership of the alternatives considered.

TABLE 7-26
CASE 1 RESULTS

Peak Period	Airport-Station Square	Station Square - Airport
Walk to Premium	26	26
Auto Access	380	380
Subtotal	406	406
Passengers per Hour	203	203
Off Peak Period		
Walk to Local	62	62
Walk to Premium	747	747
Auto Access	732	732
Subtotal	1541	1541
Passengers per Hour	128	128
Total Daily Volume (one way)	1947	1947
Total Daily Ridership	3,894 passengers	
Annual Ridership	1,421,310 passengers	

TABLE 7-27
CASE 2 RESULTS

Peak Period	Airport - Station Square	Station Square - Airport
Walk to Premium	26	26
Auto Access	259	259
Subtotal	285	285
Passengers per Hour	143	143
Off Peak Period		
Walk to Local	66	66
Walk to Premium	729	729
Auto Access	444	444
Subtotal	1239	1239
Passengers per Hour	103	103
Total Daily Volume (one-way)	1524	1524
Total Daily Ridership	3,048 passengers	
Annual Ridership	1,112,520 passengers	

TABLE 7-28
CASE 3 RESULTS

Peak Period	Airport - Station Square	Station Square - Airport
Walk to Premium	25	25
Auto Access	1	1
Subtotal	26	26
Passengers per Hour	13	13
Off Peak Period		
Walk to Local	66	66
Walk to Premium	677	677
Auto Access	0	0
Subtotal	743	743
Passengers per Hour	62	62
Total Daily Volume (one-way)	769	769
Total Daily Ridership	1538 passengers	
Annual Ridership	561,370 passengers	

The introduction of MAGLEV service produces a two percent increase in total transit system ridership. The ridership attracted to MAGLEV captures demand for new transit travel currently not being made. Minimal change in ridership of corridor routes parallel to MAGLEV service results. For all non-MAGLEV modes, there is less than one percent increase in ridership between the build and no-build scenarios. Closer examination of transit services in the MAGLEV corridor reveals a slight increase in ridership of modes that can transfer to MAGLEV at either end of the alignment, such as the Light Rail modes at Station Square and the Beaver County Transit Routes at the Airport end. The ridership of other potential transit services in the corridor remain constant between the no-build and build scenarios. The marginal increase in system ridership experienced with MAGLEV service reflects the demand for a new type of premium, express mode transit service not currently offered in this corridor. The type of service provided by MAGLEV is tailored towards a different market. The new demand generated by MAGLEV will complement and integrate with the existing transit system.

TABLE 7-29
MAGLEV CORRIDOR RIDERSHIP

Type of Service	24 Hour Boardings No-Build	Build	Percent Change
LRT/Trolley	49561	50747	2.4%
Express Bus	15149	15156	0.0%
Local Bus	145874	145590	-0.2%
Busway/HOV-Lane Bus	57609	57945	0.6%
All non-PAT Service	1803	1874	3.9%
Inclines	38	35	-7.9%
Total Existing Modes	270034	271347	0.5%
MAGLEV	--	3895	--
Totals	**270034**	**275242**	**1.9%**

Ridership Revenue

The above ridership and fare values result in the following annual potential operating revenues for the system:

- Case 1: $4,263,930 per year,
- Case 2: $5,093,210 per year (including parking fees),
- Case 3: $5,615,160 per year (including parking fees).

These ridership and revenue estimates may be considered to be conservative in that they do not consider any ridership that may be attracted by the presence of the system itself, which will undoubtedly be a tourist attraction due to being an innovative new technology.

Case 2, which used an overall $0.28 per mile fare for a significant number of riders, generated approximately $800,000 more in annual revenue than Case 1, which used $0.16 per mile for all riders. Case 3, which results in a $0.52 per mile fare for virtually all rides, causes a significant drop in ridership and the virtual elimination of Park-and-Ride riders, but produces the highest revenue. The Regional ridership model cited in Section 6 found an optimum revenue fare of approximately $0.37 per mile, which lies between the fares used for Cases 2 and 3. Therefore, conservatively estimating that the combination of additional riders attracted as "tourists" and additional revenue from an optimized fare will result in additional revenue of 10%, it can be confidently assumed that the system is capable of producing at least $6,000,000 in annual ridership revenues. As discussed previously, annual O & M costs are forecast to range from $4,950,000 to $5,450,000; therefore, the system is expected to generate more than enough revenue from ridership to cover the O & M costs.

The purpose of this portion of the ridership study is to develop an order of magnitude estimate of potential ridership and revenue for the Demonstration System within a limited budget, using an existing transit model to the extent possible. During the preliminary design phase, the model should be refined to better address specific impacts of high speed ground transportation on mode choice, based on research currently underway. A detailed fare and revenue analysis should then be done, examining a wide range of fare and parking cost options, to determine the optimum revenue producing fare structure.

7.5.4 OTHER ECONOMIC IMPACTS

Section 6 of this report describes non-transportation revenues which may be derived from the implementation of the Regional system. These revenues include economic growth and employment benefits. Although less quantifiable than projected ridership revenues, these revenues may be significant and can also be applied to the Demonstration System. Applying the results of the REMI model of the Regional system proportionately to the Demonstration System yields a value of 8700 person-years of jobs created. Of these, approximately 3700 would be a direct result of manufacturing and constructing the Demonstration System. These jobs would primarily be in the manufacturing, construction, transportation and mining industries. The model forecasts that the economic benefits are two to four times the investment, or $1 billion to $2 billion for the Demonstration System. Additionally, operation and maintenance of the system, described in Section 7.5.2, would provide 78 direct jobs, and approximately 100 indirect jobs. At a labor rate of $20.00 per hour, these 278 permanent direct and indirect jobs produce annual revenue of approximately $10 million.

Other revenues which could result from implementation of the Demonstration System include station area development and advertising. At the downtown station, Station Square or Allegheny Center, the Demonstration System would bring annually over 1,000,000 additional people through these important commercial/retail centers. Many of them will be airline passengers, a group which tends to have significant disposable income. The addition of these potential customers through these centers may spur additional retail/office development, resulting in leasing income to the station owner. Advertisers would find both the Downtown and Airport Stations as attractive centers to place signs, kiosks, etc. to reach the passenger concentrations passing through the stations.

7.6 SUMMARY

This investigation into the feasibility of constructing the Pittsburgh MAGLEV Demonstration System leads to the following conclusions:

- The system is feasible from an engineering standpoint. Out of 7 alignments originally considered, 3 had to be dropped due to right-of-ways or other engineering constraints. The remaining 4 were conceptually designed to a level of detail which shows that they can be built.
- Although numerous environmental constraints exist in the potential alignment corridors, an overview based on existing secondary sources indicates that no conditions are known to exist that would preclude construction of the system.
- The system can be built for a capital cost of $490 million to $595 million. This cost places it in the same cost order of magnitude of several other recent successful transportation projects in the Pittsburgh area, including the Light Rail System, I-279 and the new Midfield Terminal. Expenditure of this magnitude on the MAGLEV system will give the area state-of-the-art facilities in each of the four major transportation modes that will likely comprise the transportation system into the next century.
- Conservatively estimated ridership revenue alone can cover the operating and maintenance cost of the system. Additional revenues in areas such as tourist ridership, station development and advertising could contribute toward capital costs.
- The system could produce 8700 direct and indirect construction jobs, injecting $1 to $2 billion into the economy. Permanent jobs for 278 people would provide $10 million per year after the system is operating.

- The system will effectively address the project purposes, which are to verify its costs and performance, increase MAGLEV's visibility and acceptance, define and test construction methods and establish the primary link of the Regional system.
- The system is an excellent candidate to receive Federal capital funding support for a Demonstration System as authorized by Congress in the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA). The ISTEA calls for a $725 million National Magnetic Levitation Prototype Program, to be developed through three phases of design and construction, with Federal funding ranging from 90% in Phase I (conceptual designs) to 75% in Phase III (construction). The requirements for the selected system include:

    * Sharing rights-of-way with other modes.
    * Being a minimum of 19 miles in length and allow significant speed.
    * Being constructed in three years after contract award.
    * Being convertible to commercial operation with a sufficient ridership.
    * Being intermodal by connecting a major metropolitan area with an airport, port, rail station or other transportation mode.
    * Having at least one switch.
    * Utilizing a technology applicable to most parts of the United States.
    * Demonstrating the ability to operate in varied climatic conditions, varied topography and tunnels.

The Pittsburgh Demonstration System meets all of the above requirements and has broad-based support among the area's labor, government and business sectors.

Assuming that construction of the Demonstration System will be completed under the provisions of the ISTEA Prototype Program, the following 6-year construction schedule could be followed:

Year 1 -- Phase I

Includes developing preliminary alignments, mapping, surveying, vehicle concepts, environmental analysis, detailed ridership study, guideway design, control/communications study, switch design and technology transfer.

Years 2 and 3 -- Phase II

Final engineering of above elements and obtaining options to purchase rights-of-way.

Years 4, 5 and 6 -- Phase III

Construction and testing.

With the completion of this DD and D plan, the next step in the process will be to select a preferred alignment. Several questions will be considered in addition to those outlined for the ISTEA Demonstration Program requirements:

- Which alignment is the most cost effective in providing a demonstration system?
- Which alignment will provide the least impact on environment, society and economy?
- Which alignment will provide the best public access and integration into the Regional system?
- Which alignment will allow for the greatest speed attainment and allow for the greatest engineering achievements?

These factors will provide a basis in selecting an alignment which will best serve the goals set by MAGLEV, Inc. and provide a demonstration of MAGLEV technology to the traveling public.

8.0 FINANCING PLAN

Securing financing for a massive new high-technology transportation project that uses magnetic levitation technology (MAGLEV) not yet tested in commercial operation is a challenge in today's economic and financial environment. MAGLEV, INC. of Pittsburgh, Pennsylvania, proposes a demonstration system that connects city-center Pittsburgh to the airport, some 19 miles distant; and provides for a multi-state regional system service to 5 states (Pennsylvania, Ohio, West Virginia, Maryland and Virginia) and the District of Columbia. Recent developments provide funding possibilities for this system.

The developments include the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which contains a program for the demonstration of magnetic levitation technology (the "National Magnetic Levitation Prototype Development Program"--Section 1036). This demonstration program is to be the final stage of a research and development effort designed to re-establish the United States of America, which originally developed MAGLEV technology, as the world leader in the field.

This program amounts to the first major federal financial commitment to MAGLEV technology since the High Speed Ground Transportation Program was canceled in the late 1970s. As such, it is capable of providing a foundation upon which a qualifying project can erect a financing plan using federal, state, local and--possibly--private sources.

This chapter provides a preliminary assessment of feasibility of a viable financing program for the demonstration and Regional System MAGLEV projects. The assessment was prepared by Booz-Allen & Hamilton, Inc.

<u>8.1 FEDERAL LEGISLATIVE FRAMEWORK AND FUNDING SOURCES</u>

To understand the current prospects for financing the Pittsburgh MAGLEV System (PMLS), it is useful to: examine the new legislative framework for MAGLEV policy created by the ISTEA; to understand how that new framework relates to the federal government's ongoing MAGLEV initiative program, which has been underway for the past few years; and to gain some familiarity with the criteria that the federal government generally applies to the financing of new fixed guideway projects.

8.1.1 NEW LEGISLATIVE FRAMEWORK

Section 1036 of the ISTEA, which amends section 302 of the High-Speed Ground Transportation Act, makes a definite choice about both a goal and an approach for the MAGLEV program. The goal for MAGLEV technology is "to establish in the shortest time practicable a United States designed and constructed magnetic levitation transportation technology capable of operating along Federal-aid highway rights-of-way, as part of a national transportation system of the United States." The policy is to achieve this goal through research, demonstration programs, a comprehensive development and integration scheme for such technologies and to minimize the long-term risks of investors.

To implement this goal the new legislation establishes three programs, a National Magnetic Levitation Prototype Development Program, a national high-speed ground transportation technology demonstration program, and a separate high-speed ground transportation research and development program. The first is more directly applicable to the type of demonstration project that comprises the first phase of the PMLS; however, the other two are alternative, potential sources of funds if PMLS is not selected under the NMLPDP.

The NMLPDP's approach, to develop a prototype in three phases includes:

Phase 1
Funding for five candidate projects for a conceptual design (requires a 10 percent local match)

Phase 2
Grants to three of the Phase 1 competitors for a detailed system design (requires a 20 percent local match)

Phase 3

Funding for one of the three Phase 2 ventures to construct the prototype system (requires a 25 percent local match).

Total federal funding available for the three project phases is $725 million.

In contrast, the technology demonstration program (ISTEA section 1035(c)(1), section 309(b)(1)) is directed toward:

> "the research and development of ground transportation technologies in order to foster the implementation of magnetic levitation and high-speed steel wheel on rail transportation systems as alternatives to existing transportation systems."

Applicants eligible for funds under this technology demonstration program include:

> "any United States private business, State government, local government, organization of State or local government, or any combination thereof. The term does not include any business owned in whole or in part by the Federal Government."

The research and development program (ISTEA section 1035(c)(1), Section 309(c)(1)) is structured to authorize the Secretary "to enter into one or more funding agreements with United States companies for the purpose of:

> "(A) conducting research to overcome technical and other barriers to the development and construction of practicable high-speed ground transportation systems and to help advance the basic generic technologies needed for these systems; and
>
> "(B) transferring the research and basic generic technologies described in subparagraph (A) to industry in order to help create a viable commercial high-speed ground transportation industry within the United States."

In addition to the $725 million authorized for the NMLPDP (ISTEA Section 1035 (d)1(A) and (d)2(A)) , the technology demonstration program is authorized another $50 million (ISTEA section 1035 (d)1(B) and (d)2(B)), and the research and development program another $25 million (ISTEA section 1035 (d)2(C). In all cases, the funds are available until expended.

8.1.1.1 STATUS

The establishment of the NMLPDP is significant not only in its own right, but also in terms of the change it represents in the direction of MAGLEV policy at the Federal level. At present, national MAGLEV policy is being implemented through the National Magnetic Levitation Initiative (NMLI). This program is designed to determine, through a careful program of technological, economic and operational studies, the optimal course for the United States to pursue in acquiring and putting into operation magnetic levitation technology. The NMLI is examining three options: buying foreign technology; forming U.S.-foreign joint ventures to acquire the technology; and developing an all U.S. system.

In 1993, the Clinton Administration has taken the position that it should not move forward to fund the NMLPDP or the technology demonstration or research and development programs until the results of the NMLI evaluation are completed. Thus, it is not requesting the appropriation of any funds for the new programs. Obviously, the Congress and the Executive must reach a compromise on this issue if the funding logjam for NMLPDP and the technology demonstration and research and development programs are to be broken.

8.1.1.2 FINANCING CRITERIA FOR FIXED GUIDEWAY PROJECTS

The transportation infrastructure financing criteria most applicable to the Pittsburgh MAGLEV system are those established in 1984 by the Federal Transit Administration (then the Urban Mass Transportation Administration) for so-called "New Start Fixed Guideway Projects." The three fundamental criteria are:

- The level and proportion of local financial commitments for capital costs relative to Federal funds sought, in particular, the degree of local financing in excess of minimum statutory requirements--overmatch;
- The strength of the local capital financing plans as determined by the stability and reliability of local financing sources and the ability of localities to fund unanticipated cost overruns from local resources; and
- The capability of local transit agencies to operate and maintain the transit system once the proposed project is built and operating. The sensitivity of local financial projections to changes in ridership, operating costs, local economic conditions, and other related issues is as important as the level of funds available for ongoing operations and maintenance.

There is nothing in the ISTEA legislation that specifically requires the Secretary of Transportation to apply these specific criteria in funding the NMLPDP. General experience with FTA and FRA funding programs for transit, high-speed rail, and rail freight programs, however, suggests very strongly that the closer the project gets to the capital funding of an operating system (as opposed to a relatively small-scale demonstration project) the greater the application.

8.1.2 FEDERAL FUNDING SOURCES

Since the National Magnetic Levitation Prototype Development Program is the keystone on which any successful project will almost certainly have to be built, it is appropriate to begin with potential federal sources of financing in general and with the NMLPDP in particular. This section will also address potential funding under ISTEA's MAGLEV Technology Demonstration Program, the newly restructured Highway Trust Fund, as well as Section 3 funds, available through the Federal Transit Administration.

8.1.2.1 THE NATIONAL MAGNETIC LEVITATION PROTOTYPE DEMONSTRATION PROGRAM (NMLPDP)

The following are considerations in selecting the detailed design for a prototype, overall structure of the program, and funding for prototype development:

Factors to be Considered in Selection of the Detailed Prototype Design

Section 1036(B)(4)(C) of ISTEA specifies that the following factors are to be considered by the selection committee in choosing the detailed design for the MAGLEV demonstration prototype:

"(i) The project shall be capable of utilizing Interstate highway rights-of-way along or above a significant portion of its route, and may also use railroad rights-of-way along or above any portion of the railroad route.

"(ii) The total length of guideway shall be at least 19 miles and allow significant full-speed operations between stops.

"(iii) The project shall be constructed and ready for operational testing within 3 years after the award of the contract or grant.

"(iv) The project shall provide for the conversion of the prototype to commercial operation after testing and technical operation is completed.

"(v) The project shall be located in an area that provides a potential ridership base for future commercial operation.

"(vi) The project shall utilize a technology capable of being applied in commercial service in most parts of the contiguous United States.

"(vii) The project will have at least 1 switch.

"(viii) The project shall be intermodal in nature connecting a major metropolitan area with an airport, port, passenger rail station, or other transportation mode."

The Secretary is to consider additional factors enumerated in section 1036(B)(4)(D), to include awarding any grant or contract to encourage "the development of domestic manufacturing capabilities" and to consider "existing railroads and equipment manufacturers with excess production capacity, including railroads that have experience in advanced technologies (including self-propelled cars)."

Structure of the Prototype Development Program

The NMLPDP's approach to prototype development is central to the financing strategy for the PMLS. The approach is to develop a prototype MAGLEV system in three phases:

- Phase 1--Provides funding for five candidate projects for a conceptual design, (requires a 10-percent local match)
- Phase 2--Involves grants to three of the Phase 1 competitors for a detailed system design (requires a 20-percent local match)
- Phase 3--Funds one of the three Phase 2 ventures to construct the prototype system (requires a 25-percent local match).

Total federal funding available for the three project phases is $725 million.

8.1.2.2 THE HIGH SPEED GROUND TECHNOLOGY TRANSPORTATION DEMONSTRATION PROGRAM (HSGTTDP)

The $50-million High-Speed Ground Transportation Technology Demonstration Program (HSGTTDP), established by an ISTEA amendment, section 309, can be used by MAGLEV, INC. as a potentially valuable supplement to the NMLPDP, assuming that the current funding logjam is cleared. The program is for both MAGLEV and for steel-wheel-on-steel-rail systems.

Grants under this program exist for two purposes:

- To fund projects which demonstrate that HSGT is a safer, more efficient intercity transportation system.
- To fund projects which demonstrate any advancement in HSGT or related technologies.

The "criteria to be considered" in awarding grants under this element of the program "shall include":

- (I) feasibility of guideway or track design and construction;
- (II) safety and reliability;
- (III) impact on the environment in comparison to other high-speed ground transportation technologies;
- (IV) minimization of land use;
- (V) effect on human factors related to high-speed ground transportation;
- (VI) energy and power consumption and cost;
- (VII) integration of high-speed ground transportation systems with other modes of transportation;
- (VIII) actual and projected ridership; and
- (IX) design of signaling communications, and control systems.

This latter category of demonstration is better suited to the needs of the PMLS than the first type of demonstration, and can conceivably play a significant role in the technology development that the PMLS must undergo to be effective in the NMLPDP competition.

There has been some concern that the language of section 309(b)2(B)(i) would prohibit the use of HSGTTDP funds on the PMLS, since it is not yet a "revenue service high-speed ground transport system under construction or in operation," which it is required to be under the language of this section "at the time the application is made." Discussions with Federal Railroad Administration officials in both the program and research and development offices indicate that-if the program is funded-the interpretation of "under construction" is likely to be quite flexible. MAGLEV, Inc. should definitely plan on pursuing funding under this program, if and when funds are appropriated.

8.1.2.3 THE HIGH-SPEED GROUND TRANSPORTATION RESEARCH AND DEVELOPMENT PROGRAM (HSGTRDP)

The $25-million High-Speed Ground Transportation Research and Development Program (HSGTRDP) is also established by the ISTEA amendment that adds a new section 309 to the High-Speed Ground Transportation Act. Like the HSGTTDP, this new research and development program can also be used by MAGLEV, INC. as a potentially valuable supplement to the NMLPDP, assuming that the current funding logjam is cleared away. The program, as is the case with the HSGTTDP, is for both MAGLEV and for steel-wheel-on-steel-rail systems.

Eligible grantees under this program are "United States companies . . . (A) conducting research to overcome technical and other barriers . . . and (B) transferring the research and basic generic technologies . . . to industry to help create a viable commercial high-speed ground transportation industry within the United States." This program calls for financial participation by private industry in the form of at least a 20 percent matching share, of which "Not less than 5 percent of the non-Federal entity's share of the cost of any such project shall be paid in cash."

The HSGTRDP is designed to be implemented through "cooperative research and development agreements (as defined by section 12 of the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3710a)), and . . . funding agreements (as defined by section 201(b) of title 35, United state code). . .."

As with the technology demonstration program, it should be remembered that if the research and development program proves valuable, it is possible to add additional funding in future sessions of Congress.

8.1.2.4 THE HIGHWAY TRUST FUND (AS RESTRUCTURED UNDER ISTEA)

Provisions of federal legislation dealing with the structure and operation of the Highway Trust Fund were radically restructured through the Intermodal Surface Transportation Efficiency Act of 1991. Some of these new provisions could potentially be valuable sources of funding for the PMLS.

A good example is the set of projects funded under Section 1107 of ISTEA, entitled "Innovative Projects," whose purpose is described as "to provide assistance for highway projects demonstrating innovative techniques of highway construction and finance." These innovative techniques include: "state-of-the-art technology for pavement, safety, and other aspects of highway construction; innovative financing techniques; or accelerated procedures for construction." The

204-project list includes $97.5 million for "land and right-of-way acquisition and guideway construction for magnetic levitation project" in Orlando, Florida. An effective legislative effort could provide funding for similar purposes related to the PMLS.

Another example is Section 1108 of ISTEA, "Priority Intermodal Projects," which authorizes funding "for the construction of innovative intermodal transportation projects" of a general kind that could fit well into the infrastructure funding requirements of the Pittsburgh MAGLEV System. In fact, the list of projects being funded under section 1108 includes several related to the improvement of highways and busways serving Pittsburgh International Airport.

Thus, in addition to seeking specific PMLS-related funding through the definition and enactment of legislation amending section 1108 in the future, it would also be useful for MAGLEV, INC., to investigate the possibility of incorporating into the design for the Pittsburgh-area highway and busway projects authorized under ISTEA, features that would be compatible with the PMLS Airport Connector line.

8.1.2.5 SECTION 3 FUNDING AVAILABLE FROM THE FEDERAL TRANSIT ADMINISTRATION

The program of the Federal Transit Administration (FTA) under Section 3 of the Federal Transit Act is designed to fund "new starts"; consequently, should be evaluated as a potential funding source for the urban portions of the PMLS, particularly the initial demonstration phase to connect downtown Pittsburgh to its airport. The Section 3 program is managed by FTA's Office of Capital and Formula Assistance.

In structuring what are termed "major urban mass transportation investment" projects for potential funding under Section 3, the criteria examined in the previous section relating to "New Starts" of fixed guideway projects definitely apply. A "major urban mass transportation investment" is any capital project that involves the construction of a new fixed guideway segment for the exclusive use of bus or rail vehicles. The project evaluation and ratings process designed to implement FTA's New Start policy includes two primary components:

- An assessment of the cost-effectiveness of the capital investment; and
- An evaluation of the local fiscal commitment to the project.

The level of local fiscal commitment to the project is the key component of the financial project's financial *pro forma's* that FTA examines in assessing new start projects. The level of local financial commitment is measured by the following guidelines:

- The degree or percent of project capital costs proposed to be funded from non-Federal sources in excess of the 25 percent statutory minimum.
- An assessment of the capital financing plan.
- A judgment on the stability and reliability of non-Federal funding sources to maintain system operations following implementation of the new fixed guideway system.

A recent evaluation of seventeen new start projects documented the growing trend toward "overmatch" by local jurisdictions. In the past, most projects were funded with the maximum-allowable 75-percent share. Table 8-1 indicates that more than two-thirds of the projects evaluated clearly involve significant levels of local overmatch.

The Section 3 funding allocation for the current fiscal year is approximately $500 million for the total U.S. All "new start" money is earmarked in the legislative conference report.

8.1.2.6 SECTION 511 LOAN GUARANTEES UNDER THE 4-R ACT

A category of federal financing that is not eligible for use by the PMLS as currently structured, is nevertheless of interest. The Railroad Revitalization and Regulatory Reform Act of 1976 (the "4-R Act") included in Section 511 a provision authorizing $1 billion in loan guarantees to aid in the rehabilitation of the railroad industry after several decades of punitive and ineffective federal policies toward railroads. Section 1036(e) of ISTEA amends the 4-R Act to permit guarantee of financing for various purposes related to "high-speed rail facilities or equipment." As currently defined (transportation available to the general public that runs "on rails" at speeds greater than 125 miles per hour), the

TABLE 8-1
FEDERAL FUNDING RANGES FOR 17 NEW START PROJECTS
FY 1989 - 2010

60% - 75%	40% - 59%	20% - 39%	< 20%
Jacksonville	Atlanta	Chicago	Baltimore
Los Angeles	Boston	Dallas	
Orange County, CA	Cleveland	Honolulu	
Portland	Houston		
San Francisco	New Jersey		
	New York		
	Salt Lake City		
	San Jose		

511 guarantees cannot be used for magnetic levitation projects, but a further amendment could broaden the scope of the provision to include MAGLEV.

8.2 STATE AND LOCAL SOURCES

At the state and local level, there are a variety of potential funding sources, some from purely state or local sources and some that are tied to federal programs or legislation. Those exclusively from state or local levels will be treated first.

8.2.1 DIRECT STATE APPROPRIATION TO MATCH FEDERAL FUNDS

The proposed Pittsburgh MAGLEV System has already secured a commitment from the State legislature for $2 million in capital funding as a local match to support MAGLEV, Inc.'s bid to secure funding under the NMLPDP.

This will obviously serve as one of the basic building blocks at the State and local level in the project's financial structure. Other potential State and local sources include funding available through Pittsburgh's Metropolitan Planning Organization (MPO) under the new flexibility provisions of ISTEA, tax increment financing, industrial revenue bonds, and funding available from revenues generated by airport passenger facility charges.

8.2.2 FUNDS POTENTIALLY AVAILABLE THROUGH FUNDING FLEXIBILITY DISCRETION OF MPOS UNDER ISTEA

Perhaps the most fundamental changes enacted through ISTEA were in the planning processes for metropolitan and statewide transportation planning. As part of these changes, metropolitan planning organizations have been given increased authority to decide how to use their allocation of federal and state funding under the Highway Trust Fund. This change provides yet another source of potential funding for the PMLS.

The components of this new flexibility are described in a Federal Transit Administration publication circulated under a letter from FTA Administrator Brian Clymer, dated April 30, 1992. It describes the program elements included within the Surface Transportation Program (STP) and defines eligibility for transit expenditures under the STP as "any non-operating assistance transit program or project eligible under the Federal Transit Act." Included within the scope of flexible funding opportunities applicable to Pennsylvania for transit are program monies from the following:

(a) Surface Transportation Program (STP) and STP Apportionment Adjustments. Each State receives an apportionment under the Title 23 formula and then an adjustment to that apportionment designed to achieve equity in funding levels among States. These adjustments include: "Hold Harmless" payments that guarantee each State a legislative percentage of the nationwide total of selected Title 23 highways funds; and the "90% of Payments" provision that returns to each State a minimum of 90 cents for every dollar they are estimated to have contributed to the Highway Trust Fund. All funds are transit-eligible except for the Safety and Transportation Enhancement setasides from the half of the Apportionment Adjustments that follow STP distribution rules.

(b) Interstate Maintenance Program. These funds are apportioned according to criteria based on interstate lane miles and vehicle miles traveled established under Title 23. Without condition, a State may transfer up to 20 percent of its Interstate Maintenance apportionment to the Surface Transportation Program and/or National Highway System. If approved by the Secretary of Transportation, a State may transfer the portion of its apportionment in excess of its maintenance needs to the STP/NHS. All Interstate Maintenance monies eligible for STP use may be obligated in any area of the State. Interstate Maintenance funds transferred to the STP may be used to fulfill any STP purpose.

(c) Bridge Program. States are apportioned replacement and rehabilitation money based on the square footage of "deficient" highway (not rail) bridges surveyed by the State and inventoried in a priority system established under Title 23. Up to 40 percent of these funds may be transferred by States to their STP or NHS Programs; and any transfer to the STP may be used anywhere in a State. Bridge program funds transferred to the STP may be used for any STP purpose.

(d) National Highway System (NHS). States are apportioned NHS funds in the same ratio and under the same distribution rules as under the Surface Transportation Program. Up to 50 percent of the NHS may be transferred to the STP, or with the Secretary's permission, the entire amount if it is judged to be in the public interest.

(e) Congestion Mitigation and Air Quality (CMAQ) Improvement Program. CMAQ funds are apportioned to States "in the ratio which the weighted non-attainment area population of each State bears to the total weighted non-attainment area population of all States. States that have ozone and/or CO non-attainment areas must use their apportioned funds in such areas. Eligibility criteria for CMAQ funds include: any transit or transit-related project or program contained in an approved SIP; Transportation control Measures (TCMs) established by the Clean Air Act Amendments of 1990;

the development of new Traffic Demand Management programs; and the construction of pedestrian and bicycle facilities. Basic transit operating and maintenance costs are not eligible.

(f) Reimbursement for Segments of the Interstate System Constructed Without Federal Assistance. Under the 1991 reauthorization, a total of $4 billion are authorized for repayments to states that built-without federal assistance-roads that are now part of the Interstate highway system. Under Section 1014 of ISTEA, Pennsylvania will receive an allocation of 6.43 percent of the funds authorized for such reimbursement.

Table 8-2 reflects the funding slated for the Pittsburgh area's Surface Transportation Program under the Intermodal Surface Transportation Efficiency Act of 1991. The Surface Transportation Program (STP) funds are those allocated to the Pittsburgh-area MPO for urban use for each year; the discretionary funds will only be available for STP use if the MPO takes a positive action to transfer them to the STP.

TABLE 8-2
SURFACE TRANSPORTATION PROGRAM AND FLEXIBILITY FUNDING AVAILABLE UNDER ISTEA TO PITTSBURGH'S MPO
1992 - 1997
($ Millions)

PROGRAM	YEAR						
ELEMENT	1992	1993	1994	1995	1996	1997	Total
Surface Transportation Program (STP) Allocation	3.3	4.5	5.2	12.3	12.3	12.3	49.9
Discretionary Elements*	49.6	69.1	69.1	69.1	101.3	101.3	459.5
TOTAL	52.9	73.6	74.3	81.4	113.6	113.6	509.4

* The amounts listed reflect the maximum percentage of funds from each category permitted to be used as part of the STP for each of the flexible funding categories described in the text. Namely, interstate maintenance, bridge, national highway system, congestion mitigation and air quality, and interstate reimbursement.

Conversations with both the Office of Policy at the Federal Highway Administration and with legislative lobbyists who worked directly with the ISTEA legislation during its drafting and consideration by the Congress confirm that the provisions establishing the formulas are complex; FHWA has not published (or perhaps not even completed) its official calculations of available flexibility funding amounts for the out-years (1994-1997) of the ISTEA authorization period.

8.2.3 TAX INCREMENT FINANCING

Under a Pennsylvania law enacted in July 1990, redevelopment authorities and industrial and commercial development authorities have the power to create and approve project plans for what is called "tax increment financing." Tax increment financing is a project financing technique under which a jurisdiction can finance or assist in the financing of a project by committing a portion of the increased revenue stream expected to be collected as a result of the increased economic and commercial activity expected to be generated by a project to the financing of that project.

The principal difficulties with this form of financing are twofold. The first is that from the lenders' perspective, it is likely to be difficult to establish with any certainty exactly what will be the amount of the increase in tax revenues resulting from the project. The second is that the locality may well believe, and with good reason based on the experiences of other projects and other communities, that the full amount of any increased tax revenues will be required to fund additional facilities and services needed to mitigate the effects of the project on the community. Increased costs for public safety and traffic management are only two of the more obvious potential costs of major public facilities development projects.

For these reasons, Booz-Allen does not believe it is likely that tax increment financing will provide any significant portion of the PMLS development costs.

8.2.4 TAX-EXEMPT BONDS

The Internal Revenue Code provides that states and local governments may issue bonds, exempt from federal taxes, for the development of certain facilities essential to the economy. The general practice is that a city or county issues tax-exempt securities to finance the construction of a facility that is then leased to industry. Included in the categories of facilities exempted from taxes are airports, docks and wharves, mass commuting facilities, and sewage facilities, among others. Unfortunately, federal tax-exempt status has not been available for bond financing for high-speed ground transportation facilities.

Representative Coyne of Pennsylvania and Senator Graham of Florida have introduced legislation (H.R. 3348 and S.1492, respectively) to put tax-exempt bonds for high-speed ground transportation systems under the same rules that apply to airport tax-exempt bonds. This legislation, which can be found in Appendix VI, has not yet been enacted by the Congress.

8.2.5 REVENUES FROM AIRPORT PASSENGER FACILITY CHARGES

One new category of funding available under federal law at the discretion of local officials is the revenue from passenger facility charges at airports. This program, available under sections 9110 and 9111 of the Aviation Safety and Capacity Expansion Act of 1990, permits a public agency to impose an airport passenger facility charge (PFC) of $1, $2, or $3 per enplaned passenger at a commercial service airport it controls.

The proceeds from such PFCs are to be used to finance eligible airport-related projects that preserve or enhance safety, capacity, or security of the national air transportation system, reduce noise from an airport that is part of the system, or furnish opportunities for enhanced competition between or among air carriers. A project of the type represented by the PMLS would be classified under capacity expansion of the airport's landside facilities. Appendix VII contains relevant excerpts from the Federal Aviation Administration's rules governing PFCs. These rules also address the issue of the reduction of Federal grant funds apportioned to large and medium hub airports imposing a PFC.

If we assume that Pittsburgh International Airport had imposed a $3 PFC in 1989, a year in which there were 8.9 million enplanements, the associated revenues would have been more than $26 million. Under the PFC regulations, these funds would be eligible for the construction of mass transit facilities on airport property. In the case of the PMLS, the airport MAGLEV terminal and the portion of the guideway that is on airport property would be eligible uses of the PFC revenues.

8.3 PRIVATE SOURCES

The environment for large capital investments in urban public transportation systems is inimical in terms of basic components of the right-of-way and fixed facilities to major private sector investments. The use of the term 'private sector investment' means financing provided from non-governmental sources to construct or acquire facilities or equipment. In the construction of the PMLS, there will likely be some private sector investment for facilities that are auxiliary to the principal elements of the transport system (parking lots, commercial real estate development), but the general financial performance of transit systems in major metropolitan areas does not meet the tests required by private lenders.

Perhaps the most overwhelming single reason for this is the combination of enormous subsidies afforded the automobile in urban settings. These subsidies skew the demand curve away from other urban transportation options and artificially lower the cost curve for automobiles, thereby driving down the fare levels that public transit can charge and increasing the requirements for transit's direct, obvious, and large subsidies for capital investment and operating expenses. In contrast to transit's direct and well-publicized subsidies, the huge subsidies to automobile transport are indirect, diffuse, hidden, and well-integrated into the daily habits of American auto users.

A recent report by the World Resources Institute entitled The Going Rate: What It Really Costs to Drive, provides estimates of the various subsidies to the automobile. The report indicates that subsidies in the form of free and subsidized parking, funding of road maintenance, construction and repair, and funding of highway services such as police and fire from other than road users approximate $174 billion per year. Other estimates indicate that the total market costs of congestion on the nation's roadways amount to at least another $100 billion per year. And the total costs not borne by drivers for accidents add yet another $55 billion. These three components total some $329 billion in annual subsidies to highways users.

And the subsidies to competing modes do not end with auto transport. Total federal subsidies to commercial aviation through mid-1988 amounted to some $32.8 billion. This excludes spin-off benefits to airlines from the defense aerospace research program and the tax-free bonds used to finance airports. As for user charges to air passengers, the federal government has invested in air facilities at almost five times the rate of the federal tax on air passenger tickets. Against this backdrop, it is little wonder that the private sector finds it difficult to invest in major urban or intercity transport projects that compete with the automobile and the airplane.

Thus, for any project as massive as even the demonstration segment of the Pittsburgh MAGLEV System, public funding sources will ultimately have to play the major role. There are, however, some possibilities for the introduction of private sector financing into the PMLS. This section will examine the potential role for private financing in the areas of equipment financing, guideway financing and public-private partnerships.

8.3.1 PRIVATE SECTOR EQUIPMENT FINANCING

If the right conditions exist, equipment financing in a project of this type can be provided by the private sector. The ability to attract private investment to finance equipment is related to the ability to isolate and dedicate a stream of revenues (that may include both public and private monies) to service the equipment debt. Ultimately, PMLS equipment financing will be handled privately or publicly depending on a number of factors that will determine the availability and cost of financing from both sources.

Two important factors will drive the decision concerning the source of equipment financing. The first is the need for and availability of non-federal public funding to handle any required "non-federal" share of project financing; this assumes substantial federal funding is secured for the project. The second is whether the project has the financial characteristics necessary, and can be appropriately structured, to attract private investment.

Since it is unlikely that the full regional project can be financed without a preponderance of federal funding, it is a virtual certainty that there will be a requirement for a substantial amount of "non-federal" funding, regardless of the source. Given the financial constraints on state and local governments in these times, it will be imperative to attract private investment as part of the non-federal share. In the light of this determination, assuming that the project has the necessary financial performance characteristics, a structure can be developed, based on existing models, to serve as an effective vehicle for private investment.

Amtrak has developed a unique type of leasing instrument that avoids taxation on the private party. Termed a "lease-leaseback," it involves the purchase of equipment by Amtrak, the lease of the equipment to the equity party, and then the leaseback of the equipment to Amtrak.

The tax benefits inure to the equity party in the form of tax deductions, such as depreciation, that flow from "ownership" of the property. The key to making the transaction work, therefore, is to establish a sufficient ownership interest in the equity party deemed to have "the benefits and burdens of ownership" for purposes of the Internal Revenue Code. There is a well-developed body of law dealing with this subject. Anything depreciable can be financed using this method; the shorter the depreciation period, however, the more financially advantageous it tends to be.

Although this mechanism cuts costs, it is extremely cumbersome and expensive to use. Each transaction is unique and the paperwork for each deal is voluminous and complex. Amtrak would prefer that their problem be solved by legislative action exempting their private sector equipment financiers from taxation, but that does not appear likely in the near future. In the meantime, the "lease-leaseback" mechanism does get the job done and it has not been challenged by the Internal Revenue Service.

Amtrak officials indicate, however, that absent the special legislation they are seeking, a general eligibility for tax-exempt financing through industrial revenue bonds would be a preferred option to the "lease-leaseback" technique. Their view is that the investment community is much more comfortable with tax-exempt bonds and that such bonds would provide a much simpler and easier-and perhaps cheaper-means of equipment financing than the leasing technique.

In respect to tax-exempt bond financing, an important planning factor is the safety factor of revenues that must be available to achieve a high (and thus less expensive) bond rating. Greater stringency by financial institutions in today's environment now requires that a revenue safety factor as high as 35 percent more than the base load amount be pledged to secure a commitment. This augments the already important need for conservative financial planning.

To provide an idea of the value of tax-free financing, under the safe harbor leasing program that expired several years ago, New York's MTA saved some $500 million amounting to 22 percent of final car costs in some transactions. It might be more realistic for MAGLEV, Inc. to expect to save on the order of 5-7 percent of overall equipment procurement costs through such a mechanism.

There is a need from a financial standpoint to focus on equipment acquisition and financing during the period when the equipment is being manufactured. For work in progress there are financial models that effectively demonstrate how such matters, as alternative progress payment schedules, interest rates, and delivery cycles, can lower the price of a car by 15 percent or more, with no changes in technical specifications.

Equipment financing is an exceptionally complex matter, capable of swinging the cost of equipment by a substantial amount. MAGLEV, Inc. will profit greatly by seeking professional counsel to assist in structuring the financing for the construction and purchasing of their equipment, whether that financing is provided by the vendor, other private sources, or through an appropriate public financial instrument.

8.3.2 PRIVATE FINANCING FOR SELECTED LINE SEGMENTS ON THE REGIONAL SYSTEM

Preliminary analysis indicates that the regional system as a whole could only pay back 10% to 20% of its capital expenses and that certain line segments have much greater potential to be financially self-supporting than others. Thus, it should be noted that the same principles can be applied to securing private investment for discrete line segments as for equipment acquisition. Again, the important factor is to be able to isolate a stream of revenues, perhaps even a combined stream of public subsidies and operating revenues, that is large and stable enough to serve as security for the financing instruments.

In the case of line segments of a regional system, it may be more difficult financially and politically to attempt to break a single segment or set of segments out of the network for private financing. Financially it can be difficult to allocate revenues and expenses with enough accuracy to create a consensus that a given segment is indeed profitable. And politically, it is important to ensure that if specific segments are able to be privately financed, the financial benefits of that financing be distributed to the system as a whole.

Conversations with the investment banking community and multilateral international lending institutions concerning the potential for private financing of right-of-way have confirmed that it will be difficult. In contrast to major infrastructure projects with more predictable levels of cost, demand, and technological risk (such as an electric utility plant, for example), a MAGLEV system's performance in all three areas is not comparable to anything currently in existence. The issue of public subsidy to other modes is also of concern given the revenue-eroding effect these subsidies will have on an unsubsidized MAGLEV. If a stream of revenues (subsidies plus farebox) can be isolated, there will be a requirement for a high safety factor and many other restrictive conditions in the financing agreement.

8.3.3 LOCAL PUBLIC-PRIVATE PARTNERSHIPS

The other major means through which private financing can play a significant role in the PMLS is public-private partnerships. The essence of such partnerships in the context of a major system development is the juncture between the subsidized public transport system and a related function or activity with profit-making potential. When that is the case, it is possible to structure ventures that involve private capital in concert with public investment to the mutual benefit of both.

Major downtown station redevelopment and multimodal terminal projects provide excellent opportunities for such joint ventures. Terminals such as the one required for the MAGLEV system at Pittsburgh International Airport are also potential sites for such cooperation. Washington Union Station, Terminal Tower in Cleveland, and South Station in Boston are only three of many such successful projects that have been carried out in the U.S. over the last 10 years.

In the case of Washington's Union Station, a Congressionally-created Union Station Redevelopment Corporation has overseen restoration of the station and helped select a private developer. Amtrak provided $70 million from revenues and reprogrammed appropriated funds to repair and restore the building to a condition that would allow a developer to lease and complete the commercial space. A consortium of three private firms developed the space.

The total cost of the redevelopment was $150 million, including $80 million in private sector financing, but the privately-provided financial benefits do not stop with the private investment capital. For the extensive and creative development of retail shops, restaurants, and movie theaters within the station does not just serve the needs of travelers, visitors, and the surrounding community, it also provides a solid financial base for the operation and future maintenance of the building without further cost to the government.

The interest and willingness of private sector investors to participate in selected elements of the PMLS demonstration project will hinge ultimately on whether a source of basic anchor funding for the system can be secured. If it is, then the prospects for private sector participation will be dramatically improved.

8.4 STRATEGIES FOR FINANCING

A useful starting point in devising strategies for financing the Pittsburgh MAGLEV System is to review the sources or means of financing described in the foregoing sections of the report. Table 8-3 serves that purpose by indicating, for each financing source, the elements of the system to which it is most likely to apply.

An examination of Table 8-3 indicates the relative applicability of the various financing sources for the PMLS. Obviously, the sources with the greatest potential applicability are the ones that have the prospect of serving as the anchor funding for the project. But the reality of their availability to acquire available funding, and to secure the needed amounts is another important factor to take into account.

Based on these factors, it is clear that there are two major potential sources of anchor funding for the system. The first is the National Magnetic Levitation Prototype Development Program. The other is the Surface Transportation Program under Title 23, which is available through metropolitan and statewide transportation planning. The other two means with general applicability, FTA Section 3 funding and Pennsylvania Tax Increment Financing, do not have the fiscal strength to support a program of this size.

Each of the potential sources of anchor funding for the project can serve as the basis for a funding strategy. Strategies for financing the Pittsburgh MAGLEV system, then, can be based on either of two assumptions. The first is that MAGLEV, Inc. will be successful in winning the Phase III award. The second is that it will not.

If MAGLEV, Inc. wins the Phase II award, the project can look forward to a much faster track for its initial prototype and demonstration phase than will be the case if it must rely principally on Title 23 Surface Transportation Program funding (which would not be adequate to finance the regional system). For while the potential is present under Title 23, the political difficulty of getting as much as is needed to move the project forward at the fastest realistic pace will be much greater than is the case under NMLPDP funding.

The remaining financing sources can be melded with the anchors to assist in funding the other elements of the program, removing pressure from the main sources.

TABLE 8-3

Eligible Funding Sources For Different Elements Of The MAGLEV Demonstration and Regional Systems ('#' indicate most likely uses)

	NMLPDP	HSGTDP	Title 23 Surface Transportation Program; (MPO Flexibility)	FTA Section 3 Program	PA Tax Increment Financing	Tax-Exempt Bonds	Airport Passenger Facility Charges	Private Sector Financing	Local Public-Private Partnerships for Stations
Equipment	#		#	#		#		#	
Downtown Terminus	#		#	#	#	#		#	#
Right-of-Way/Guide way	#		#	#	#	#		#	
Right-of-Way/Guide way on NHS	#		#	#	#	#		#	
Right-of-Way/Guide way at Separated Highway Crossings	#		#	#	#	#		#	
Right-of-Way/Guide way on Airport Property	#		#	#	#	#	#	#	
Airport Terminus	#		#	#	#	#	#	#	#
R & D	#	#	#					#	

- For R&D and demonstration work, the HSGTTDP and HSGTRDP can be used.
- As part of regional outreach efforts in Southwestern Pennsylvania, discussions with local communities and counties should explore the potential for tax increment financing for those locales that will receive actual service.
- The potential for getting funding augmentation for on-airport facilities through a passenger facility charge should be discussed with the Pittsburgh-area aviation community.
- For the demonstration program segment, help in funding the downtown and airport terminals should be sought from the local industrial, commercial, and real estate development communities.
- Depending upon the outcome of federal tax legislation, tax-exempt bonds should be sought and pursued as an additional increment.
- And finally, work should get underway in the near future to plan the approach of financing the equipment for the system, a very complex and important undertaking.

These prescriptions are for the "secondary" sources of funding. With regard to the potential primary sources, major initiatives are needed.

- For the NMLPDP, a substantial government and public relations effort is required for the following objectives:
  - To monitor the translation of the legislation into a working program so that the PMLS remains well-positioned to compete at each stage of the three-phase process.
  - To pressure the Executive Branch and the Congress to support funding to get the program underway.
- For the Title 23 Surface Transportation Program, a campaign should begin at once to work with the MPO and the Pennsylvania Department of Transportation to develop appropriate instruments and procedures under the new metropolitan and statewide planning guidelines to ensure that the PMLS receives a steady flow of funds directed to its most critical elements.

It is important to emphasize that as complex and revolutionary as are the technological and engineering elements of this program, the institutional and financial aspects are equally challenging. New technologies, new planning systems and procedures, and growing competition for relatively smaller sources of funds will add to the challenge that MAGLEV, Inc. faces as it seeks to implement a workable financing strategy.

However, MAGLEV, Inc. believes that current legislation and congressional rhetoric reflects the changing attitude towards public transportation as an attractive alternative to constantly expanding the highway system and airport network. In addition, recent positive changes in the political world have decreased our need for massive defense spending. As defense spending is reduced, a logical alternative for federal investment is to improve our transportation infrastructure. Investment in public transportation provides the highest potential return of these infrastructure investments according to Transportation Spending and Economic Growth.

One tremendous, virtually untapped potential, is the gas tax. Currently, the United States has one of the lowest per gallon gasoline prices of any industrialized nation. This is about a third of what is paid in Japan or Germany, countries with tremendous public transportation systems. A one cent increase in gas tax generates approximately $1 billion in revenue. Thus, all the potential high speed MAGLEV systems identified in the U.S. in Chapter 4 with an estimated cost of $210 billion, could be paid for over thirty years with less than a 10 cent increase in the gas tax. A small price to pay for such a promising solution to our future transportation needs and the potential socio-economic benefits it can provide.

It is therefore, easy to be optimistic about the future. Once the demonstration system is built and high speed MAGLEV technology is recognized for the potential it has for solving the impending transportation crises, building of the Regional system should be easier to support. With ISTEA framework as a foundation, future legislation will expand the Federal role for improved public transportation.

9.0 SUMMARY

This report began by discussing the congestion and mobility problems currently facing travelers within the United States today. A review of existing High Speed Ground Transportation (HSGT) systems that offer a potential solution to this congestion was then completed.

An evaluation of both the potential domestic high speed MAGLEV market and the ability of the Pittsburgh area to become the center for manufacturing for this technology was then addressed.

A 1300-mile MAGLEV Regional System alignment, a 316 mile Suburban system alignment and a 20-mile Demonstration system alignment were then developed and analyzed to establish the costs, ridership, revenues and economic impacts that would result from construction of these systems. Potential funding sources were also assessed.

9.1 CONCLUSIONS

- Expanding congestion and reduced mobility in highway and air modes are projected to cost between $50 and $70 billion annually by the year 2005.
- Highway programs attempting to mitigate this congestion are expected to cost $100 billion per year, while airport expansion solutions are estimated at $44-63 billion.
- HSGT would provide an uncongested mode of travel that would greatly improve mobility and interface well with existing modes of transportation.
- Based on cost, energy efficiency, environmental impact, speed, safety, revenue readiness, maneuverability and ride quality the Transrapid MAGLEV system is the technology of choice.
- The estimated potential high speed MAGLEV market in North America is estimated at $210 billion.
- Pittsburgh's proximity and central location to a substantial portion of this market, as well as its extensive steel and manufacturing industries, is positioned for establishing it as the manufacturing center for this technology.
- An opportunity exists to transfer and improve this proven technology, thus making it both more cost effective and more conducive to application within North America.

- A 1300-mile Regional system connecting several major cities in the midwest with the populous east coast is a logical initial application for this technology, with the first phase of this project being a 19-mile Demonstration system extending from Downtown Pittsburgh to the Airport.
- Use of existing Rights-of-Way for high speed MAGLEV in the region was evaluated and found <u>not</u> to be a viable approach except in certain locations (such as near metropolitan areas).
- Various potential financing sources were identified to fund construction of the Regional and Demonstration systems. However, as with all public transportation systems, the opportunity for non-public investment is limited.

Mid-Atlantic Regional System:

- The capital cost for the 1300-mile Regional system approaches $40 billion.
- Over 675,000 jobs will be created over the construction lifetime, of which 34% will be in the manufacturing field.
- Over $78 billion in direct economic benefits are estimated to result from manufacturing and construction of the Regional system.
- Upon completion, the Regional system is expected to carry over 17 million riders annually resulting in farebox revenues of over $1 billion per year, which could cover operating and maintenance costs and contribute to retirement of the capital debt.

Pittsburgh Suburban System:

- A Suburban system offering a cost-effective mode of public transportation can easily be overlaid on a regional MAGLEV network.
- The incremental capital cost required to construct the off-line suburban stations on the Regional system lines is estimated to be $242 million.
- The farebox revenue for the Suburban system is sufficient to pay the annual operation and maintenance cost, with some remaining for repayment of the capital debt.
- When completed, the Suburban system is forecast to carry 15 million passengers annually.

Pittsburgh Demonstration System:

- Four alternative Demonstration systems alignments were evaluated, with capital costs between $490 and $595 million.
- The farebox revenue for the Demonstration system is anticipated to be $6 million annually, which is sufficient to pay the operating and maintenance costs.
- The Demonstration system is estimated to generate 9300 construction jobs resulting in a $1-2 billion in economic benefits.
- No environmental conditions are known to exist in any of the four corridors evaluated that cannot be addressed through the standard process of avoidance, minimization or mitigation.
- The Pittsburgh Demonstration system is well positioned to compete for the ISTEA funding, meeting the length, terrain, climate, intermodal connectivity and commercial operation criteria set forth in the legislation.
- The Demonstration system has a broad base of support among business, labor, and government in the area, which should serve to make it attractive as a Federally supported demonstration system.

9.2 FUTURE RECOMMENDATIONS

This report has endeavored to cover implementation of a MAGLEV system within the Pittsburgh Region in a detailed manner. As the study progressed, however, it has become evident that a number of issues need to be evaluated in a more detailed manner. Therefore, the study team recommends the following items:

- An effort to secure a technology transfer and begin the Americanization of this technology must begin as soon as possible.
- A franchise to build and operate the Demonstration system must be obtained from the local transit authority.
- The Demonstration and Suburban systems must be added to the local Metropolitan Planning Organization's (MPO) Transportation Implementation Plan.
- Discussions must begin with the major airlines to ensure that the integrated operations of the two systems are maximized.
- Discussions need to begin with retail developers regarding station development to ensure that these opportunities are maximized.

- An Operations Plan must be established which evaluates the ability to operate the Suburban System with the Regional System, and further optimizes utilization of the System.
- A manufacturing conference needs to be held where it can be established which local companies have the interest and ability to produce the required MAGLEV components.
- A finance-quality ridership analysis of the Regional System must be completed which looks at the short and long-range forecast, the regional versus the network approach to implementation, the integration of the airport access system, and a more detailed evaluation of the impact of a Suburban System overlaid on the Regional System.