UMTA-MA-06-0126-84-5
DOT-TSC-UMTA-84-8

U.S. Department of Transportation
Urban Mass Transportation Administration

Supplement V
Cost Experience of Automated Guideway Transit Systems
Costs and Trends for the Period 1976-1982

Dynatrend, Inc.
21 Cabot Road
Woburn MA 01801

April 1984
Final Report

UMTA Technical Assistance Program

NOTICE

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA-MA-06-0126-84-5		

4. Title and Subtitle SUPPLEMENT V: COST EXPERIENCE OF AUTOMATED GUIDEWAY TRANSIT SYSTEMS - COSTS AND TRENDS FOR THE PERIOD 1976-1982	5. Report Date April 1984
	6. Performing Organization Code DTS-66
7. Author(s) Dynatrend, Inc.	8. Performing Organization Report No. DOT-TSC-UMTA-84-8
9. Performing Organization Name and Address Dynatrend, Inc. * 21 Cabot Road Woburn MA 01801	10. Work Unit No. (TRAIS) UM464/R4654
	11. Contract or Grant No. DTRS-57-80-C-00081
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration Office of Technical Assistance Washington DC 20590	13. Type of Report and Period Covered Final Report 1976 to 1982
	14. Sponsoring Agency Code URT-42

15. Supplementary Notes

*Under contract to: U.S. Department of Transportation
Research and Special Programs Administration
Transportation Systems Center
Cambridge MA 02142

16. Abstract

This report summarizes the cost experiences and trends of sixteen domestic AGT systems. Capital costs, operation and maintenance costs, system characteristics, operational statistics, and unit cost measures are presented to provide useful information to those contemplating the installation of AGT systems.

To provide insight into important cost variations in this data, analyses of basic cost measures, evaluation of trends, and comparison with other transportation modes are also included.

Sixth in a series, this report follows an initial report and four supplements. The supplemental reports have been published annually with updated information since 1979. Supplement V has been expanded to include more narrative and illustrations, and a new section which shows AGT system costs over time, thus giving a historical perspective in one volume.

The sixteen AGT systems examined in this report all utilize bottom-supported vehicles and operate in the following locations: Busch Gardens, Williamsburg; Dallas-Fort Worth Airport ("Airtrans"); Duke University Medical Center; Fairlane Shopping Center; Hartsfield Atlanta International Airport; Houston Intercontinental Airport; King's Dominion Amusement Park; Miami International Airport; Miami Metro Zoo; Minnesota Zoological Garden; Orlando International Airport; Pearlridge Center; Seattle-Tacoma International Airport; Tampa International Airport; Walt Disney World; and West Virginia University ("Morgantown").

17. Key Words	18. Distribution Statement
Automated Guideway Transit, Capital Costs, Operational and Maintenance Costs, Operational Statistics, Transit Systems	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

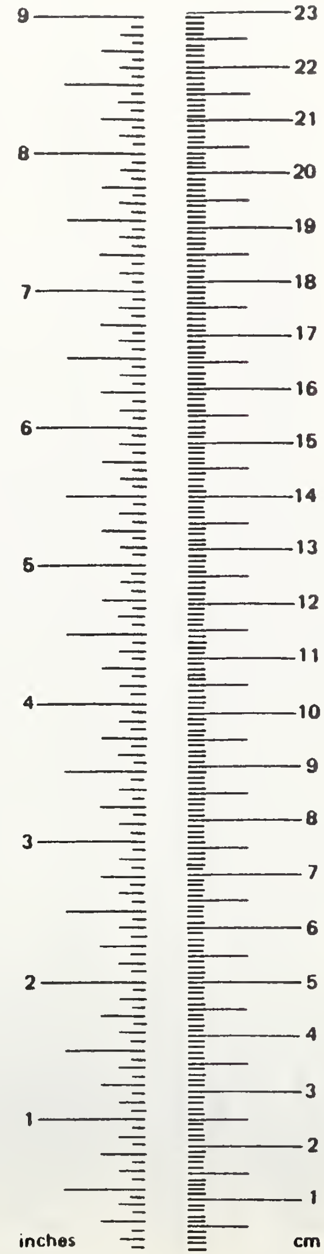
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	138	

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

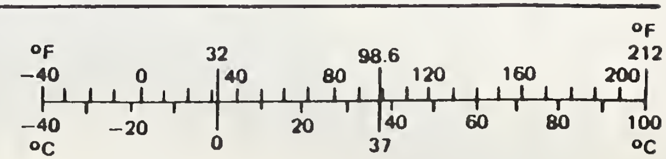
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in. = 2.54 cm (exactly). For other exact conversions and more detail tables see NBS Misc. Publ. 286. Units of Weight and Measures. Price $2.25 SD Catalog No. C13 10 286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Technical Report Documentation Pag

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA-MA-06-0126-84-5	PB84-212075	

4. Title and Subtitle	5. Report Date
SUPPLEMENT V: COST EXPERIENCE OF AUTOMATED GUIDEWAY TRANSIT SYSTEMS - COSTS AND TRENDS FOR THE PERIOD 1976-1982.	April 1984
	6. Performing Organization Code DTS-66
7. Author(s) Dynatrend, Inc.	8. Performing Organization Report No. DOT-TSC-UMTA-84-8
9. Performing Organization Name and Address Dynatrend, Inc. * 21 Cabot Road Woburn MA 01801	10. Work Unit No. (TRAIS) MA-06-0126(UM464/R4654) 11. Contract or Grant No. DTRS-57-80-C-00081
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration Office of Technical Assistance Washington DC 20590	13. Type of Report and Period Covered Final Report 1976 to 1982 14. Sponsoring Agency Code URT-42

15. Supplementary Notes

*Under contract to: U.S. Department of Transportation
Research and Special Programs Administration
Transportation Systems Center
Cambridge MA 02142

16. Abstract

This report summarizes the cost experiences and trends of sixteen domestic AGT systems. Capital costs, operation and maintenance costs, system characteristics, operational statistics, and unit cost measures are presented to provide useful information to those contemplating the installation of AGT systems.

To provide insight into important cost variations in this data, analyses of basic cost measures, evaluation of trends, and comparison with other transportation modes are also included.

Sixth in a series, this report follows an initial report and four supplements. The supplemental reports have been published annually with updated information since 1979. Supplement V has been expanded to include more narrative and illustrations, and a new section which shows AGT system costs over time, thus giving a historical perspective in one volume.

The sixteen AGT systems examined in this report all utilize bottom-supported vehicles and operate in the following locations: Busch Gardens, Williamsburg; Dallas-Fort Worth Airport ("Airtrans"); Duke University Medical Center; Fairlane Shopping Center; Hartsfield Atlanta International Airport; Houston Intercontinental Airport; King's Dominion Amusement Park; Miami International Airport; Miami Metro Zoo; Minnesota Zoological Garden; Orlando International Airport; Pearlridge Center; Seattle-Tacoma International Airport; Tampa International Airport; Walt Disney World; and West Virginia University ("Morgantown").

17. Key Words	18. Distribution Statement
Automated Guideway Transit; Capital Costs; Operational and Maintenance Costs; Operational Statistics; Transit Systems Characteristics	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	138	A07

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

PREFACE

This study was sponsored by the U.S. Department of Transportation, Urban Mass Transportation Administration, through the Analysis Division of the Office of Methods and Support under the Office of Technical Assistance. The research was performed and the report was written by Dynatrend, Inc., Woburn, MA, under contract to the U.S. Department of Transportation, Research and Special Programs Administration, Transportation Systems Center, Cambridge, MA (Contract No. DTRS-57-80-C-00081).

This report summarizes the cost experiences and trends of sixteen domestic AGT systems. Capital costs, operation and maintenance costs, system characteristics, operational statistics, and unit cost measures are presented to provide useful information to those contemplating the installation of AGT systems.

Data for this report were provided as a public service by several institutions. The following is a list of personnel at these institutions who contributed to this data collection effort.

Busch Gardens	D. Potter, Operations Manager
Dade County Aviation Department	R. Kemmink, Construction Manager
Dallas-Fort Worth Airport	D. Lefwich, Director of Transportation R. McKeig, Manager
Duke University Medical Center	A.E. Blalock, Maintenance Engineer L.A. Bergen, Medical Planning Architect
Ford Aerospace & Communications Corporation	R.G. Reed, Supervisor, ACT System
Greater Orlando Aviation Authority	G.W. Seel, Director of Facilities L. Hannon
Hartsfield International Airport	M.W. Walker, Director of Planning & Development K. Malone

Hillsborough County Aviation Authority	T.W. Leslie, Assistant Director of Facilities
King's Dominion Amusement Park	A. Ryland, Rides Manager D. Jeffers
Morgantown People Mover System	R. Bates, Director
Minnesota Zoological Garden	S.A. Iserman, Director D. Rickabaugh
P.M. Hawaii, Inc.	W.R. Bricker, President
Seattle-Tacoma International Airport	M.K. Bitts, Electronics Superintendent T. Watson, Transit System Specialist
Universal Mobility, Inc.	H. Pater, President R. Janzen
WED Transportation Systems, Inc.	R. Weidenbeck, General Manager D. Welsh, Manager of Transportation

Further support was provided by R. Adams, Chief, Analysis Division at the Urban Mass Transportation Administration, F.J. Rutyna, Chief Maintenance and Productivity Division at the Transportation Systems Center, and especially M.J. Miner, Analyst, Operations Assistance Division at the Transportation Systems Center, who coordinated this effort.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Concluded)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

1.0 EXECUTIVE SUMMARY

Automated Guideway Transit (AGT) systems in the United States are located primarily in nonurban areas; they serve a variety of transportation needs at airports, universities, hospitals, shopping centers, and theme parks. The cost of constructing, operating, and maintaining these systems and how these costs change from year to year is of interest in evaluating the service that each system provides.

This report summarizes the cost experiences and trends of sixteen domestic AGT systems. Capital costs, operations and maintenance costs, operational statistics, and unit cost measures are presented in an attempt to provide useful information to those contemplating the installation of AGT systems.

Significant variations in both capital and O&M costs result from many design-specific and site-specific factors which characterize these systems. For this reason, data contained in this report must be given careful consideration before attempting to project new system costs.

The total capital cost of AGT systems range from as little as $2 million to as much as $167.5 million. This wide variation in construction and installation costs is due to the following system characteristics: system size, site location, technology employed and system design, and bid competitiveness. While the costs may vary significantly, the average distribution among the capital cost categories is:

o Guideway	26%
o Stations	11%
o Maintenance & Support Capabilities	5%
o Power & Utilities	7%
o Vehicles	19%
o Command, Control, & Communications	13%
o Engineering & Project Management	19%

Total O&M costs for systems operating year-round range from approximately $300 thousand to $5.3 million. This disparity in O&M costs results from differences in system size, site location, technology employed and system design, and level of service. The average distribution among the O&M cost categories is:

- o Labor 61%
- o Utilities 8%
- o Materials & Services 28%
- o General & Administrative 2%

When comparing the capital costs and O&M costs of AGT systems with conventional transit modes, it is important to recognize that such comparisons are relevant only when all modes have similar operating environments and provide the same type of service. Existing AGT systems, with the exception of Morgantown, provide circulation service in relatively small, privately-owned activity centers, whereas existing bus and rail systems provide regional and corridor service to the general public in various urban settings. Therefore, these costs for AGT and conventional transit systems are not strictly comparable. However, cost comparisons are presented to indicate an overall contrast between the various modes.

The successful operation of the sixteen AGT systems considered in this report has done much to demonstrate and advance AGT technology. The acceptability of AGT as a viable mode of transportation is emphasized by the fact that a new domestic AGT system has been initiated every eight months for the past eleven years. It appears the trend will continue; four systems are presently under construction with operation planned to begin between March 1984 and March 1986. It is especially noteworthy that two of these systems are being built in conjunction with public transportation systems in downtown Miami and Detroit.

2.0 INTRODUCTION

2.1 HISTORY OF FEDERAL INVOLVEMENT IN AGT DEVELOPMENT

Federal support and funding for research in advanced transit technologies date back to the early 1960's. With the passage of the Reuss-Tyding Amendments in 1966, Congress requested federal study of the more advanced transit concepts through several research, development, and demonstration programs. In 1974, the U.S. Senate Transportation Appropriations Subcommittee, recognizing the increased interest in new types of fixed guideway systems, directed the Office of Technology Assessment (OTA) to investigate the potential of personal rapid transit (PRT) systems, the terminology then in use to refer to automated guideway transit (AGT), as an urban public transportation mode. In 1975, OTA published a report entitled Automated Guideway Transit: An Assessment of PRT and Other New Systems which included current AGT system developments both in the United States and abroad.

This report outlined the need for further research on the social acceptability, environmental impacts, and economic considerations related to AGT and its application in American cities. Based largely on these findings, the Senate recommended that a social and economic research program in AGT be initiated. As a result, the Urban Mass Transportation Administration (UMTA) established the AGT Socio-Economic Research Program in 1976. Its purpose, in part, was to determine where and under what conditions AGT would prove feasible as an urban public transportation mode.

To address these basic questions, the program was organized into five substantive areas of activity:

o Assessments of existing American and foreign operational AGT systems to compile information on technical, economic, and performance aspects of AGT as well as public responses to its implementation.

- Cost studies to analyze data on capital, operating, and maintenance costs as well as life cycle costing and cost trends.

- Alternatives analyses to examine the ability and potential of AGT systems compared with other transportation modes in meeting the travel and environmental needs of American cities.

- Market research at specific sites to ascertain the nature and magnitude of the potential market for AGT systems.

- Communications that assemble and synthesize results from program research activities to ensure the dissemination of data and findings.

2.2 BACKGROUND OF THE AGT COST EXPERIENCE REPORT SERIES

A series of reports dealing with the cost experiences of AGT systems was initiated to regularly disseminate this information to interested parties in a format useful to each. The initial report in this series, published in 1978, was managed by what was then known as the Office of Socio-Economic and Special Projects as part of its AGT Assessment Project. It summarized cost data compiled during the assessment of ten AGT systems by the U.S. Department of Transportation/Transportation Systems Center, SRI International, and N.D. Lea & Associates. This report has since evolved into a comprehensive source of AGT cost information for transportation decision makers involved with the development, construction, and operation of AGT systems.

Reports which supplement the initial report have been published on an annual basis. Presented in these supplemental documents are the capital costs, operations and maintenance (O&M) costs, and system characteristics obtained from selected AGT systems currently operating in the United States. To provide insight into important cost variations in this data, analyses of basic cost measures, evaluations of trends, and comparisons with other transportation modes are also included.

The vast array of factors that can influence these costs makes it virtually impossible to develop simple rules for projecting future costs. Therefore, these documents should not be considered cost estimating handbooks, but rather guides which indicate general cost relationships. Although additional AGT systems exist in foreign countries, data for these foreign systems have not been included in the supplemental reports because the availability and applicability of cost information from these systems are limited.

This effort represents the sixth report in this series. The format and content are consistent with the previous reports; however, additional narrative and illustrations have been provided to enhance the system descriptions found in those earlier reports and to further the understanding of the factors which affect the cost of building and operating an AGT system. Another addition to this year's report is a separate section which documents AGT system costs over time. The new section allows prior year costs to be examined from a historical perspective and reduces the need to constantly refer to the previous reports for basic information. Also featured for the first time in Supplement V is cost and performance data for Miami Zoo, which opened for service in December 1982.

The previous reports in the series are listed in Appendix A along with other AGT references that may be of interest.

3.0 OVERVIEW OF AGT SYSTEMS

3.1 INTRODUCTION

Automated Guideway Transit (AGT) is an innovative form of public transportation in which unmanned, automatically controlled vehicles are operated on fixed guideways along an exclusive right-of-way. AGT systems can be categorized according to the different service concepts and capabilities available. The four major types that have been identified are:

- Shuttle Loop Transit (SLT) - systems that provide service along a fixed route without switching. They are designed to move groups of 20 to 100 passengers back and forth on a short length of guideway (shuttle) or around a closed path (loop).

- Group Rapid Transit (GRT) - systems that utilize switches to provide multi-stop service for groups of 6 to 50 passengers with similar origins and destinations on a variety of routes.

- Personal Rapid Transit (PRT) - systems that provide non-stop origin-to-destination service for individuals or small groups (i.e., six or fewer passengers) over a complex network of guideways and switches.

- Advanced Group Rapid Transit (AGRT) - systems that incorporate the capacity of GRT with the efficiency of PRT. This concept is still undergoing development.

3.2 AGT SYSTEMS SELECTED FOR THIS REPORT

AGT systems have been installed at a number of sites in the United States and abroad and have been in operation in this country for over ten years. Sixteen domestic AGT systems, all utilizing bottom-supported vehicles, are examined in this report. Table 3-1 lists these systems, their location, type, and abbreviated system identifications (used throughout this report). Figure 3-1 shows the timing of their construction and operation. Also included in Figure 3-1 are four domestic systems (Detroit, Las Vegas, Miami Downtown, and New Orleans) presently being constructed or planned for construction. The geographic location of each of these systems across the United States is shown in Figure 3-2. Other domestic AGT systems currently in operation as well as foreign systems in operation or under construction are listed in Appendix B.

The sixteen systems described in this report carried more than 85 million passengers in 1982 and served a variety of transportation needs. Appendix C contains a synopsis of each system including system highlights and a brief statement of its purpose, a schematic diagram of the operation, the system supplier, and the local contact at each site.

Each of these systems represent a wide range of technology options, site conditions, and performance characteristics. The specific technological configuration employed varies from site to site depending on the mobility requirements of the target market and the design approach of the manufacturer. The operational and performance characteristics of these systems also vary, reflecting the adaptability of AGT systems to the service needs of the respective sites. Table 3-2 illustrates this diversity in applications by presenting the more prominent characteristics of each system. Appendix D contains a more detailed description of the subsystem characteristics for each of the AGT systems.

3.3 APPLICABILITY OF EXISTING AGT COST EXPERIENCE TO URBAN, DOWNTOWN SETTINGS

AGT systems are being utilized extensively in activity centers as the primary source of public transportation. These are very different environments from the ones in which conventional transit systems (i.e., Motor Bus, Trolley Coach Bus, Heavy and Light Rail) are usually required to perform. Only the Morgantown system, connecting downtown Morgantown with the West Virginia University campuses, provides service in a setting that approximates that of an urban public transportation system. The other systems operate within an area owned by the corporation or authority managing the activity

TABLE 3-1. LIST OF DOMESTIC AGT SYSTEMS CONSIDERED IN THIS REPORT

SYSTEM LOCATION	SYSTEM TYPE	SYSTEM NAME	ABBREVIATED SYSTEM IDENTIFICATION
TAMPA INTERNATIONAL AIRPORT - TAMPA, FL	SLT	PASSENGER SHUTTLE SYSTEM	TAMPA (T)
SEATTLE-TACOMA INTERNATIONAL AIRPORT - SEATTLE, WA	SLT	SATELLITE TRANSIT SYSTEM	SEA-TAC (ST)
DALLAS-FORT WORTH AIRPORT - DALLAS, TX	GRT	AIRPORT TRANSPORTATION SYSTEM (AIRTRANS)	AIRTRANS (A)
KING'S DOMINION AMUSEMENT PARK - DOSWELL, VA	SLT	-	KING'S DOMINION (KD)
BUSCH GARDENS - WILLIAMSBURG, VA	SLT	AUTOMATED ANHEUSER-BUSCH SHUTTLE SYSTEM	BUSCH GARDENS (BG)
WALT DISNEY WORLD - ORLANDO, FL	SLT	WEDWAY PEOPLE MOVER	DISNEYWORLD (DW)
WEST VIRGINIA UNIVERSITY - MORGANTOWN, WV	GRT	MORGANTOWN PEOPLE MOVER	MORGANTOWN (M)
FAIRLANE TOWN CENTER - DEARBORN, MI	SLT	AUTOMATICALLY CONTROLLED TRANSPORTATION SYSTEM	FAIRLANE (F)
PEARLRIDGE CENTER - AIEA, HI	SLT	PALI MOMI EXPRESS	PEARLRIDGE (P)
MINNESOTA ZOOLOGICAL GARDEN - APPLE VALLEY, MN	SLT	-	MINNESOTA ZOO (MN)
MIAMI INTERNATIONAL AIRPORT - MIAMI, FL	SLT	SATELLITE TRANSIT SHUTTLE SYSTEM	MIAMI AIRPORT (MA)
DUKE UNIVERSITY MEDICAL CENTER - DURHAM, NC	SLT	AUTOMATED PEOPLE/CARGO TRANSPORTATION SYSTEM	DUKE (D)
HARTSFIELD INTERNATIONAL AIRPORT - ATLANTA, GA	SLT	-	ATLANTA (AT)
HOUSTON INTERCONTINENTAL AIRPORT - HOUSTON, TX	SLT	WEDWAY PEOPLE MOVER	HOUSTON (H)
ORLANDO INTERNATIONAL AIRPORT - ORLANDO, FL	SLT	AUTOMATED TRANSIT SYSTEM	ORLANDO (O)
MIAMI METRO ZOO - MIAMI, FL	SLT	-	MIAMI ZOO (MZ)

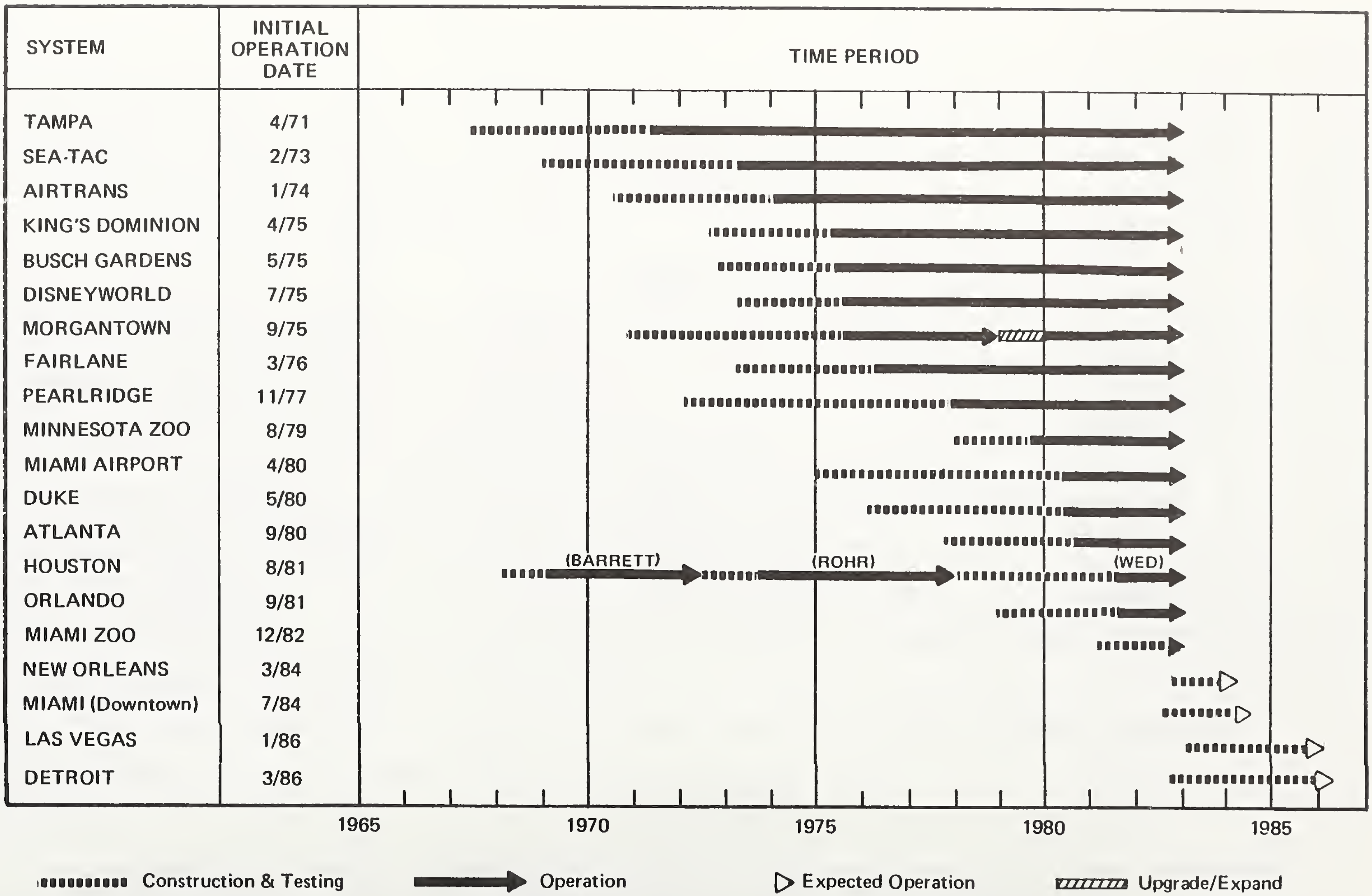


FIGURE 3-1. CHRONOLOGY OF SYSTEM DEPLOYMENTS

FIGURE 3-2. MAP OF SYSTEM LOCATIONS

TABLE 3-2. GENERAL SYSTEM CHARACTERISTICS

SYSTEM	SITE DESCRIPTION	SYSTEM CONFIGURATION	GUIDEWAY ELEVATION	GUIDEWAY LENGTH (LANE MILES)	NUMBER OF STATIONS	NUMBER OF VEHICLES	VEHICLE CAPACITY	PERIOD OF OPERATION HRS/DAY or WK	DAYS/YR
AIRTRANS	AIRPORT	SINGLE-LANE MULTI-LOOPS	ELEVATED/ AT-GRADE	12.8	14	52	40	24 HRS/DAY	365
ATLANTA	AIRPORT	DUAL-LANE SHUTTLE WITH BYPASS	UNDERGROUND	2.29	10	17	40	21 HRS/DAY	365
BUSCH GARDENS	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED/ AT-GRADE	1.33	2	1 (2 car train)	192	11 HRS/DAY** (APR.-OCT.)	136
DISNEYWORLD	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED	0.87	1	30 (5 car train)	20	12 HRS/DAY**	365
DUKE	MEDICAL CENTER	DOUBLE-LANE AND SINGLE-LANE SHUTTLE	ELEVATED/ AT-GRADE/ UNDERGROUND	0.56	3	4	22	24 HRS/DAY	365
FAIRLANE	SHOPPING CENTER	SINGLE-LANE SHUTTLE WITH BYPASS	ELEVATED	0.61	2	2	24	78.0 HRS/WK	365
HOUSTON	AIRPORT	SINGLE-LANE LOOP	UNDERGROUND	1.48	9	6 (3 car train)	36	21 HRS/DAY	365
KING'S DOMINION	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED/ AT-GRADE	2.06	1	6 (9 car train)*	96	8 HRS/DAY** (MAR.-OCT.)	124
MIAMI AIRPORT	AIRPORT	DUAL-LANE SHUTTLE	ELEVATED	0.51	2	2 (3 car train)	297	24 HRS/DAY	365
MIAMI ZOO	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED/ AT-GRADE	1.97	4	3 (10 car train)	149	7 HRS/DAY	365
MINNESOTA ZOO	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED/ AT-GRADE	1.25	1	3 (6 car train)	94	7 HRS/DAY**	365
MORGANTOWN	UNIVERSITY	DUAL-LANE SHUTTLE WITH OFF-LINE STATIONS	EVEVATED/ AT-GRADE	8.60	5	73	20	76 HRS/WK	304
ORLANDO	AIRPORT	2 DUAL-LANE SHUTTLES	ELEVATED	1.48	4	4 (2 car train)	200	24 HRS/DAY	365
PEARLRIDGE	SHOPPING CENTER	SINGLE-LANE SHUTTLE	ELEVATED	0.23	2	1 (4 car train)	64	69 HRS/WK	358
SEA-TAC	AIRPORT	2 SINGLE-LANE LOOPS WITH SHUTTLE CONNECTION	UNDERGROUND	1.71	6	24	102	20-24 HRS/DAY	365
TAMPA	AIRPORT	4 DUAL-LANE SHUTTLES	ELEVATED	1.35	8	8	100	24 HRS/DAY	365

* Includes a non-passenger lead car.

** Annual Average

center. Consequently, the transferability of documented cost and service information as well as operating experience to urban, downtown settings may be limited. To follow are some of the major items that should be considered when costing an urban deployment.

The decision to deploy AGT systems in downtown settings would be based on the mobility requirements of the area in conjunction with land use patterns and population densities. Urban areas are usually characterized by high population density, a mix of commercial and residential land use, and high levels of vehicular and pedestrian traffic. These conditions have major implications for the design and cost of AGT systems, subsystems, and components. Vehicle size and line haul capacity must accommodate passenger loads during peak periods. Station size and spacing are also influenced by the need for intermodal transfer points connecting AGT with other public transportation services (e.g., park and ride lots).

Other costs not identified with current AGT systems include right-of-way (ROW) acquisition, site modification, and costs associated with construction in an urban, downtown area. ROW acquisition costs depend on property values, local easements, and the extent to which existing rights-of-way can be utilized for portions of the network. Site modification costs are affected by site-specific variables such as utility and street relocations, traffic control, local codes, etc. Costs associated with construction in urban areas include the integration of the AGT system with existing commercial structures to minimize the disruptive impact on businesses in the downtown area and the installation of security systems to protect against vandalism and crime.

Additionally, there will be procedural and regulatory requirements in the deployment of any form of urban public transportation that existing activity center AGT systems do not have to adhere to. In order to use public funds to construct a new transportation system, an institutional/political process of design review, public acceptance, and funding commitment must take place. This process is a lengthy one, involving local, regional, state, and Federal government agencies. Substantial engineering costs can be incurred during this phase, especially if major revisions must be made to the system design.

The timetable for this phase is usually on the order of 2 to 5 years; hence, cost increases due to inflation may also occur before construction begins.

Limitations on the transferability of the AGT cost experience is not restricted to capital costs as shown above. The "controlled" environments of activity centers impact O&M costs as well. The added stress of rush hour traffic to normal everyday useage and other similar factors may work to undermine the maintainability, reliability, and operational performance of the system. Thus, the costs necessary to maintain an acceptable level of service will be greater.

While there are constraints and complexities associated with an urban AGT deployment that have not been encountered by AGT systems operating in activity centers, the existing AGT systems have exhibited a range of technology and performance sufficient to comply with urban system requirements. The point to be made, however, is that although extensive qualitative and quantitative analyses have been performed on the data herein, the total capital and O&M costs are not directly transferable. Any attempt to extrapolate the data for estimating the costs of an urban application of AGT without carefully considering the site-specific factors and operating needs which characterize urban, downtown settings will be misleading.

4.0 CAPITAL COST SUMMARY

4.1 INTRODUCTION

This section presents capital cost data compiled for sixteen AGT systems. Capital cost information was obtained primarily through responses by system operators and suppliers and site surveys performed as part of UMTA-sponsored assessments. Included for the first time is data for the system located at Miami Zoo which opened for service in December 1982. Also included for the first time is data for Duke and Pearlridge; however, only the total system cost for Pearlridge was available and some of Duke's costs could not be separated into the appropriate capital cost categories. Updated costs for new vehicles purchased at Miami and Sea-Tac have also been obtained.

To facilitate analysis and understanding of AGT capital costs, seven cost categories have been identified. They are defined as follows:

- Guideway - The vehicle roadway including site preparation, foundations, supporting structures, pedestrian walkways, running and guidance surfaces, wayside switching equipment, and special all-weather provisions, if required.

- Stations - Facilities related to the movement of passengers into and out of vehicles including site preparation, passenger loading platforms, shelters, and other access facilities such as ramps, stairways, escalators, elevators, graphics, fare collection equipment, and coordinated doors.

- Maintenance & Support Capabilities - Maintenance yards, repair shops, office buildings, and storage facilities including all the necessary furnishings as well as maintenance-of-way vehicles, equipment, materials, initial spares, and repair parts.

- Power & Utilities - All equipment and facilities for electric power distribution including transformers, feeders, switchgear, wayside power rails, integration with existing networks, and normal housekeeping power supply.

- Vehicles - The design, manufacture, and delivery of the rolling stock including car body, couplers, on-board control and communication equipment, propulsion and auxiliary power equipment, and other furnishings and comfort features.

- Command, Control, & Communications - Wayside and central control equipment, operational software, and voice and video communication systems including the purchase and installation of radio, telephone, public address, intercom, and television systems with appropriate cabling.

- Engineering & Project Management - Architectural engineering and consultant services, system design and integration, procurement and acceptance testing, and overall project management.

4.2 CAPITAL COST ADJUSTMENT METHODOLOGY

As shown in Figure 3-1, the AGT systems reviewed in this report were not all constructed at the same time. For the purpose of comparative analysis, the capital costs have been adjusted to a uniform 1982 price level. To accomplish this, price indices were applied to the appropriate capital costs as follows:

$$\text{Capital Cost (1982)} = \text{Capital Cost (Year Y)} \times \left[\frac{\text{Price Index (1982)}}{\text{Price Index (Year Y)}}\right],$$

where Y is the year being adjusted from.

In order to remain consistent with past reports, the same indices for cost adjustments have been used and are explained below:

- CPI-W: The Consumer Price Index for Urban Wage Earners and Clerical Workers is used to adjust all costs for engineering and project management.

- PPI-M&MP: The Producer Price Index for Machinery and Motive Products (previously called the Wholesale Price Index) is used to adjust all hardware costs.

- ENR-CCI: The Engineering News Record 20-City Construction Cost Index is used to adjust the cost of all fixed facility construction.

The yearly averages for these three indices and the cost categories that they adjust are shown in Tables 4-1 and 4-2, respectively. The initial capital cost adjustment for the systems presented in the original Summary Report was based on an estimated distribution of cost over the period of construction for each system. The starting point for adjusting the capital costs of systems included in subsequent reports was either the midpoint of construction or date of procurement.

Where available, actual capital acquisition costs were used. However, in many cases basic capital facilities were built as part of other structures and not accounted for as part of the total system cost. Thus, whenever possible, engineering estimates were used to duplicate the essential AGT features. These duplication costs generally did not consider the specific location of the system being examined, but rather were estimates based on up-to-date construction costs for equivalent generic systems.

Research and development (R&D) costs have been removed from the capital cost estimates. This has been done since future AGT systems will require little, if any, R&D work due to the experience gained from these earlier projects. The cost for non-passenger service elements (e.g., utility vehicles, employee stations, etc.) have also been deleted as much as possible.

TABLE 4-1. ANNUAL VALUES OF PRICE INDICES*

YEAR	CPI-W	PPI-M&MP	ENR-CCI
1975	161.2	156.2	206.0
1976	170.5	165.8	223.0
1977	181.5	176.6	240.0
1978	195.3	190.4	258.0
1979	217.7	206.9	280.0
1980	247.0	225.8	302.0
1981	272.4	256.7	329.0
1982	288.6	272.1	356.0

* All indices have a base of 100 for 1967.

TABLE 4-2 CAPITAL COST CATEGORY WITH CORRESPONDING PRICE INDEX

CAPITAL COST CATEGORY	PRICE INDEX
GUIDEWAY	ENR-CCI
STATIONS	ENR-CCI
MAINTENANCE & SUPPORT CAPABILITIES	ENR-CCI
POWER & UTILITIES	PPI-M&MP
VEHICLES	PPI-M&MP
COMMAND, CONTROL, & COMMUNICATIONS	PPI-M&MP
ENGINEERING & PROJECT MANAGEMENT	CPI-W

Capital costs for conventional transit were not available in the cost categories defined in the previous section. Therefore, their total system cost was adjusted to 1982 dollars by applying the ENR-CCI from the assumed midpoint of construction.

4.3 CAPITAL COST EXHIBITS

Capital cost data for sixteen AGT systems are summarized in Table 4-3. This table delineates the total system cost for each AGT system by cost category, shows its unit cost, and presents each subsystem cost in terms of percentage of total system cost. The data presented in this table include acquisition as well as duplication costs and therefore should be considered approximations of how the actual expenditures were apportioned.

Figure 4-1 shows the average distribution of capital costs among the major cost categories. Although each system has unique aspects, these averages can be used for estimating how the cost for new systems will be dispersed.

Tables 4-4 and 4-5 display guideway and vehicle cost measures, respectively. Figures 4-2, 4-3, and 4-4 correspond to these tables, graphically showing the correlations between guideway costs and equivalent elevated lane miles, and unit vehicle cost, equivalent passenger places, and empty vehicle weight.

Tables 4-6 and 4-7 present total system costs per lane mile and equivalent elevated lane mile for AGT and conventional transit systems.

4.4 DISCUSSION OF CAPITAL COST VARIATIONS

4.4.1 Variations Among the Cost Categories

The average distribution of capital costs for fifteen AGT systems operating in the United States is shown in Figure 4-1. However, a wide range of distributions exists and, in some cases, differs significantly from the

TABLE 4-3. SUMMARY OF CAPITAL COSTS (THOUSANDS OF 1982 DOLLARS)

	AIRTRANS	ATLANTA	BUSCH GARDENS	DISNEY-WORLD	DUKE (1)	FAIRLANE	HOUSTON	KING'S DOMINION	MIAMI AIRPORT(2)	MIAMI ZOO	MINNESOTA ZOO	MORGAN-TOWN	ORLANDO	PEARL-RIDGE (3)	SEA-TAC (4)	TAMPA
GUIDEWAY																
TOTAL COST	20,501	22,262	2,732	3,131	2,629	3,306	9,265	1,716	3,907	4,414	3,491	42,885	6,121	N/A	19,707	5,483
% OF TOTAL SYSTEM COST	.21	.30	.36	.16	.22	.33	.36	.19	.22	.39	.34	.26	.20		.29	.24
COST PER LANE MILE	1,602	9,721	2,054	3,599	4,695	5,420	6,260	833	7,661	2,241	2,793	4,987	4,136		11,525	4,061
STATIONS																
TOTAL COST	11,061	11,702	207	2,560	269	663	5,603	286	4,293	1,192	416	7,826	4,895	N/A	8,804	3,576
% OF TOTAL SYSTEM COST	.11	.16	.03	.13	.02	.07	.22	.03	.24	.10	.04	.05	.16		.13	.15
COST PER STATION	790	1,170	104	2,560	269	332	623	286	2,147	298	416	1,565	1,224		1,467	447
MAINT. & SPT. CAPABILITIES																
TOTAL COST	6,116	4,324	365	956	N/A	189	407	329	1,187	850	867	6,732	2,546	N/A	4,577	1,454
% OF TOTAL SYSTEM COST	.06	.06	.05	.05		.02	.02	.04	.07	.07	.08	.04	.08		.07	.06
COST PER LANE MILE	478	1,888	274	1,099		310	275	160	2,327	431	694	783	1,720		2,677	1,077
POWER & UTILITIES																
TOTAL COST	8,141	4,136	621	1,297	N/A	1,534	650	526	657	755	974	10,604	1,120	N/A	2,656	3,491
% OF TOTAL SYSTEM COST	.08	.06	.08	.06		.15	.03	.06	.04	.07	.10	.06	.04		.04	.15
COST PER LANE MILE	636	1,806	467	1,491		2,515	439	255	1,288	383	779	1,233	757		1,553	2,586
VEHICLES																
TOTAL COST	20,087	14,742	1,356	5,253	1,415	1,205	1,340	3,705	3,596	2,850	3,099	22,129	5,982	N/A	19,380	4,446
% OF TOTAL SYSTEM COST	.20	.20	.18	.26	.12	.12	.05	.41	.21	.25	.30	.13	.20		.29	.19
COST PER SINGLE VEHICLE	386	867	678	35	354	603	74	69	599	95	172	303	748		806	556
COMMAND, CONTROL, & COMMU.																
TOTAL COST	10,636	5,431	835	5,301	4,261	1,206	2,820	57	1,303	58	459	32,147	6,661	N/A	3,347	2,272
% OF TOTAL SYSTEM COST	.11	.07	.11	.26	.37	.12	.11	.01	.07	.01	.05	.19	.22		.05	.10
COST PER LANE MILE	831	2,372	628	6,093	7,609	1,977	1,905	28	2,555	29	367	3,738	4,501		1,957	1,683
ENGINEERING & PROJECT MGT.																
TOTAL COST	22,431	10,641	1,423	1,380	3,112	1,838	5,374	2,395	2,688	1,243	914	45,256	3,032	N/A	8,735	2,480
% OF TOTAL SYSTEM COST	.23	.15	.19	.07	.27	.19	.21	.26	.15	.11	.09	.27	.10		.13	.11
COST PER LANE MILE	1,752	4,647	1,070	1,586	5,557	3,013	3,631	1,163	5,271	631	731	5,262	2,049		5,108	1,837
TOTAL SYSTEM COST	98,973	73,238	7,539	19,878	11,686	9,941	25,459	9,014	17,631	11,362	10,220	167,579	30,357	2,006 (est.)	67,206	23,202

(1) Station cost is for just one station. The second station, maintenance and support capabilities, and power and utilities were provided as part of the North Building Facility and could not be separated.

(2) Two new vehicles were added in 1981 at a cost of $1,798K.

(3) A breakdown by cost category was not available. However, since the initial cost was known, an estimate of total cost in current year dollars was made.

(4) Twelve new vehicles were added in 1982 at a cost of $11,230K.

N/A Not Available

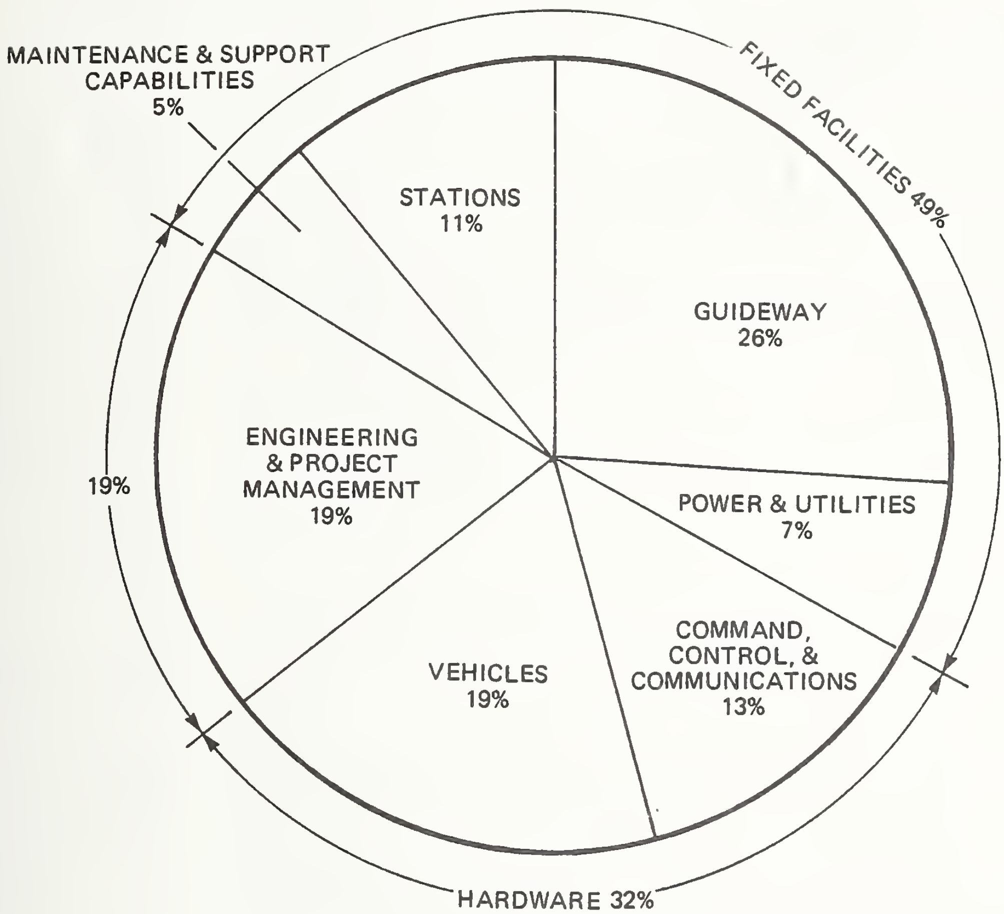


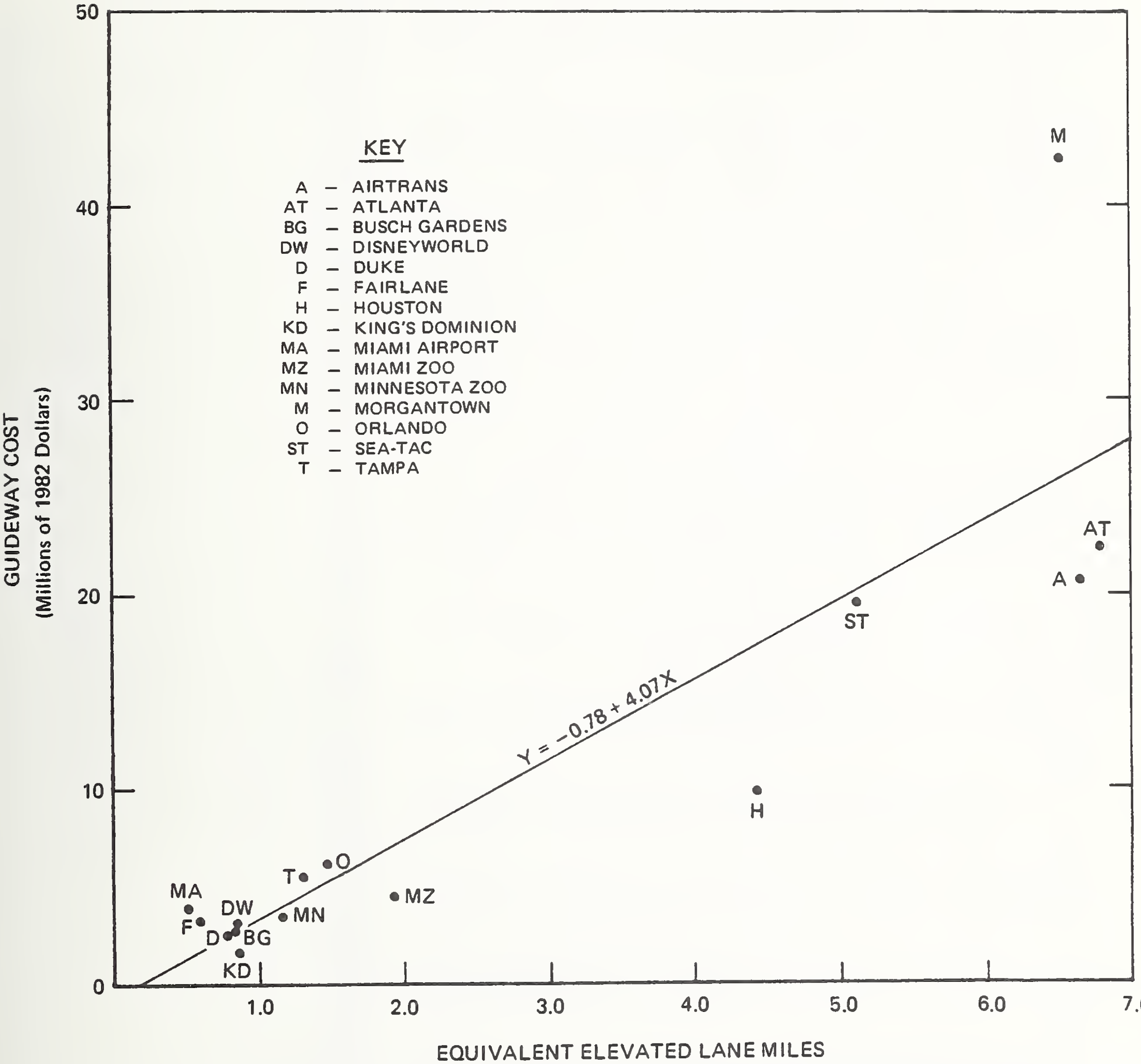
FIGURE 4-1. DISTRIBUTION OF CAPITAL COSTS AMONG COST CATEGORIES (FIFTEEN SYSTEM AVERAGE)

TABLE 4-4. GUIDEWAY COST MEASURES
(1982 DOLLARS)

SYSTEM	TOTAL GUIDEWAY COSTS (K$)	NUMBER OF LANE MILES	EQUIVALENT ELEVATED LANE MILES*	COST PER LANE MILE (K$)	COST PER EQUIVALENT ELEVATED LANE MILE (K$)
AIRTRANS	20,501	12.80	6.66	1,602	3,078
ATLANTA	22,262	2.29	6.87	9,721	3,240
BUSCH GARDENS	2,732	1.33	0.84	2,054	3,252
DISNEYWORLD	3,131	0.87	0.87	3,599	3,599
DUKE	2,629	0.56	0.81	4,695	3,246
FAIRLANE	3,306	0.61	0.61	5,420	5,420
HOUSTON	9,265	1.48	4.44	6,260	2,087
KING'S DOMINION	1,716	2.06	0.88	833	1,950
MIAMI AIRPORT	3,907	0.51	0.51	7,661	7,661
MIAMI ZOO	4,414	1.97	1.92	2,241	2,299
MINNESOTA ZOO	3,491	1.25	1.18	2,793	2,958
MORGANTOWN	42,885	8.60	6.54	4,987	6,557
ORLANDO	6,121	1.48	1.48	4,136	4,136
PEARLRIDGE	N/A	0.23	0.23	N/A	N/A
SEA-TAC	19,707	1.71	5.13	11,525	3,842
TAMPA	5,483	1.35	1.35	4,061	4,061

N/A Not Available

* Actual lengths of at-grade, elevated, and underground guideways have been converted to Equivalent Elevated Lane Miles by use of the following factors: 0.4 - at-grade; 1.0 - elevated; and 3.0 - underground. The normalizing factors have been developed by the USDOT/Transportation System Center based upon analysis of actual cost data as well as estimates for proposed projects.



NOTE: The regression curve is based on all points and has a coefficient of determination equal to 0.766.

FIGURE 4-2. REGRESSION OF GUIDEWAY COST ON EQUIVALENT ELEVATED LANE MILES

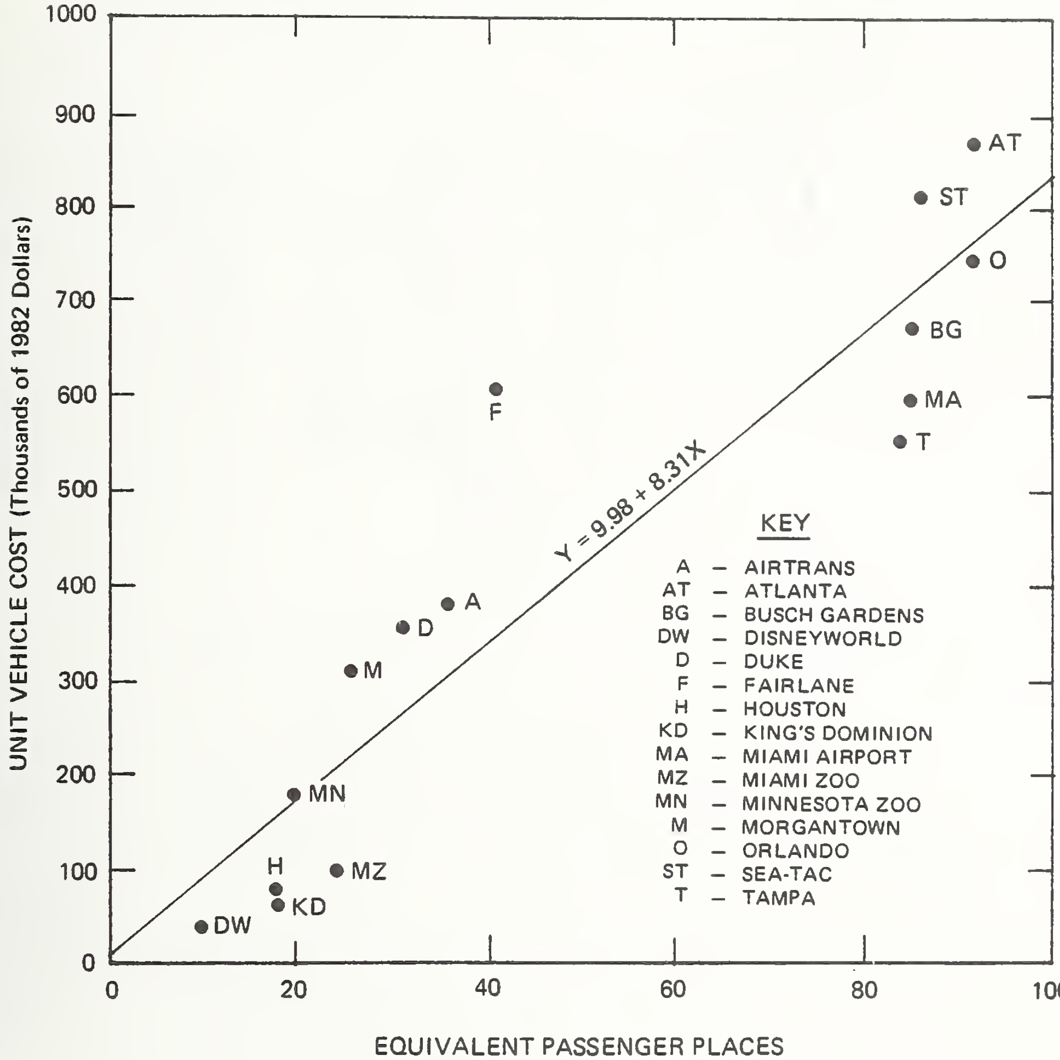
TABLE 4-5. VEHICLE COST MEASURES* (1982 DOLLARS)

SYSTEM	TOTAL FLEET COST (K$)	NUMBER OF VEHICLES	EQUIVALENT PASSENGER PLACES**	EMPTY VEHICLE WEIGHT (LBS)	COST PER VEHICLE (K$)	COST PER EQUIVALENT PASSENGER PLACE (K$)	COST PER POUND (K$)
AIRTRANS	20,087	52	37	14,000	386.3	10.4	27.6
ATLANTA	14,742	17	91	27,500	867.2	9.5	31.5
BUSCH GARDENS	1,356	2	85	26,500	678.0	8.0	25.6
DISNEYWORLD	5,253	150	10	940	35.0	3.5	37.2
DUKE	1,415	4	31	10,200	353.8	11.4	34.7
FAIRLANE	1,205	2	41	12,500	602.5	14.7	48.2
HOUSTON	1,340	18	18	2,400	74.4	4.1	31.0
KING'S DOMINION	3,705	54	18	1,900	68.6	3.8	36.1
MIAMI AIRPORT	3,596	6	85	25,800	599.3	7.1	23.2
MIAMI ZOO	2,850	30	24	3,150	95.0	4.0	30.2
MINNESOTA ZOO	3,099	18	20	7,970	172.2	8.6	21.6
MORGANTOWN	22,129	71	26	8,600	311.7	12.0	36.2
ORLANDO	5,982	8	91	25,600	747.8	8.2	29.2
PEARLRIDGE	N/A	4	25	7,300	N/A	N/A	N/A
SEA-TAC	19,380	24	86	25,500	807.5	9.4	31.7
TAMPA	4,446	8	84	21,500	555.8	6.6	25.9

* Data based on single vehicles.

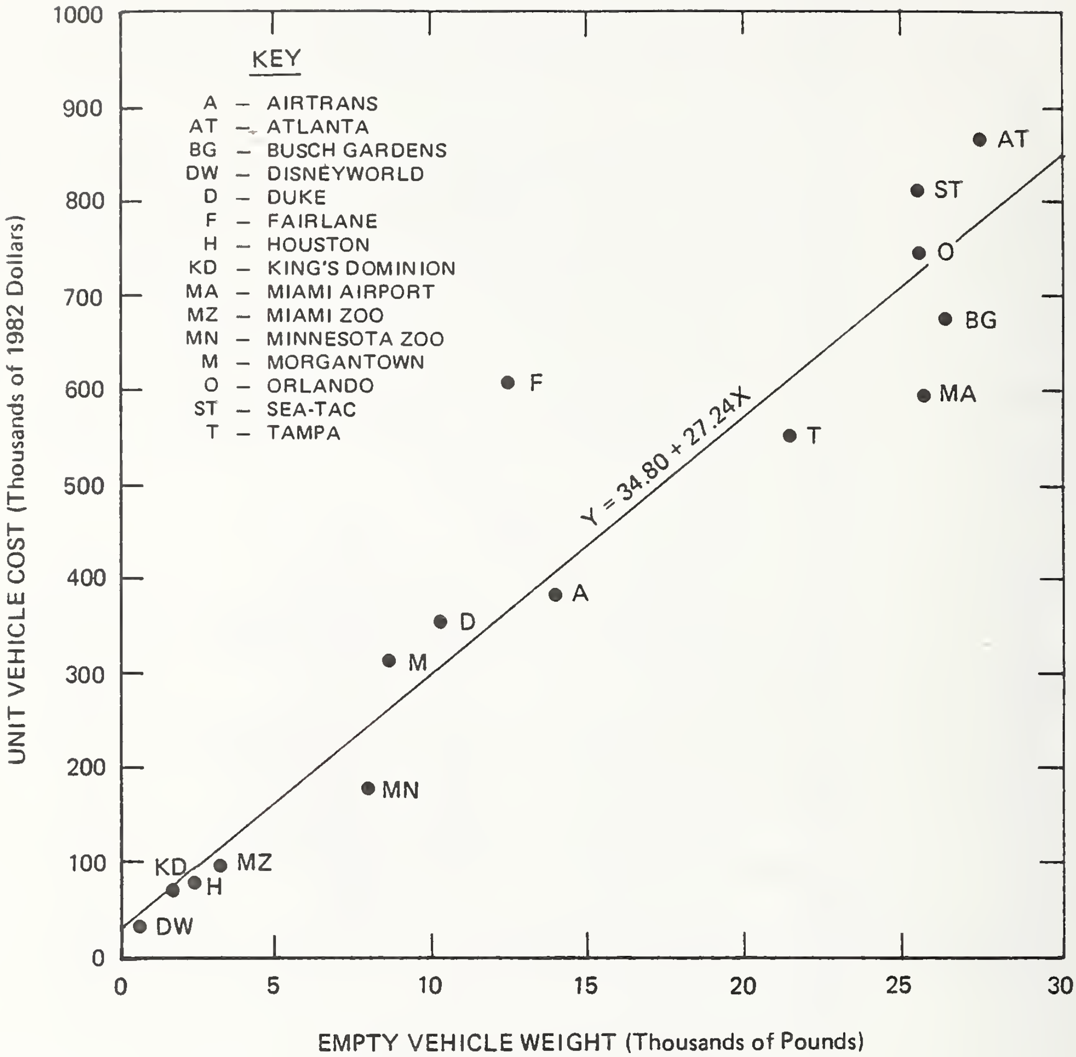
** Equivalent Passenger Places per vehicle have been calculated on an allocation of four square feet per passenger, based on the gross area (length x width) of the vehicles for each system. The normalizing factors have been developed by the USDOT/Transportation System Center based upon analysis of actual cost data as well as estimates for proposed projects.

N/A Not Available



NOTE: The regression curve is based on all points and has a coefficient of determination equal to 0.856.

FIGURE 4-3. REGRESSION OF UNIT VEHICLE COST ON EQUIVALENT PASSENGER PLACES



NOTE: The regression curve is based on all points and has a coefficient of determination equal to 0.909.

FIGURE 4-4. REGRESSION OF UNIT VEHICLE COST ON EMPTY VEHICLE WEIGHT

TABLE 4-6. AGT SYSTEM COST MEASURES
(1982 DOLLARS)

SYSTEM	TOTAL SYSTEM COST ($ Millions)	NUMBER OF LANE MILES	NUMBER OF EQUIVALENT ELEVATED LANE MILES	COST PER LANE MILE ($ Millions)	COST PER EQUIVALENT ELEVATED LANE MILE ($ Millions)
AIRTRANS	98.97	12.80	6.66	7.73	14.86
ATLANTA	73.24	2.29	6.87	31.98	10.66
BUSCH GARDENS	7.54	1.33	0.84	5.67	8.98
DISNEYWORLD	19.88	0.87	0.87	22.85	22.85
DUKE	11.68	0.56	0.81	20.86	14.42
FAIRLANE	9.94	0.61	0.61	16.30	16.30
HOUSTON	25.46	1.48	4.44	17.20	5.73
KING'S DOMINION	9.01	2.06	0.88	4.37	10.24
MIAMI AIRPORT	17.63	0.51	0.51	34.57	34.57
MIAMI ZOO	11.36	1.97	1.92	5.77	5.92
MINNESOTA ZOO	10.22	1.25	1.18	8.18	8.66
MORGANTOWN	167.58	8.60	6.54	19.49	25.62
ORLANDO	30.36	1.48	1.48	20.51	20.51
PEARLRIDGE	2.01	0.23	0.23	8.74	8.74
SEA-TAC	67.21	1.71	5.13	39.30	13.10
TAMPA	23.20	1.35	1.35	17.19	17.19

TABLE 4-7. CONVENTIONAL TRANSIT SYSTEM COST MEASURES
(1982 DOLLARS)

SYSTEM	TOTAL SYSTEM COST ($ Millions)	NUMBER OF LANE MILES*	NUMBER OF EQUIVALENT ELEVATED LANE MILES	COST PER LANE MILE ($ Millions)	COST PER EQUIVALENT ELEVATED LANE MILE ($ Millions)
BUSWAY:					
El Monte[1]	125.4	22.0	8.8	5.7	14.3
Shirley Highway[2]	13.0	22.0	8.8	0.6	1.5
LRT:					
San Diego[3]	145.7	31.8	12.7	4.6	11.5
HRT:					
San Francisco (BART)[4]	4891.6	142.0	189.6	34.4	25.8

* These are all double track/lane systems, therefore this figure is twice the total system mileage.

1 "El Monte Busway Marks Decade of Service to L.A. County", Passenger Transport, Sept. 5, 1983, pg. 12.

2 The Operation and Management of the Shirley Highway Express Bus-on-Freeway Demonstration Project - Final Report, Northern Virginia Transportation Commission, Sept. 1976, pp. III-1,2, VII-3, 10.

3 "San Diego Trolly Still Source of Inspiration", Mass Transit, Vol. X, No. 7, July 1983, pp. 12,13,30,32,40.

4 BART in the San Francisco Bay Area - Final Report of the BART Impact Program, Metropolitan Transportation Commission, June 1979, pp. xx, 9, 29.

average. Therefore, high and low values for each capital cost category are shown below:

- o Guideway:
  - High - Miami Zoo (39%)
  - Low - Disneyworld (16%)
- o Stations:
  - High - Miami Airport (24%)
  - Low - Duke (2%)
- o Maintenance & Support Capabilities:
  - High - Minnesota Zoo, Orlando (8%)
  - Low - Fairlane, Houston (2%)
- o Power & Utilities:
  - High - Fairlane, Tampa (15%)
  - Low - Houston (3%)
- o Vehicles:
  - High - King's Dominion (41%)
  - Low - Houston (5%)
- o Command, Control, & Communications:
  - High - Duke (37%)
  - Low - Miami Zoo (1%)
- o Engineering & Project Management:
  - High - Morgantown, Duke (27%)
  - Low - Disneyworld (7%)

One reason for the disparity within cost categories is that various AGT systems maintained their capital cost records in different formats. This makes it impossible to disaggregate the capital costs to correspond precisely with the cost categories used in this report. For example, Morgantown and Minnesota Zoo reported on-board vehicle control equipment as part of command, control, and communications costs instead of vehicle costs. Miami Zoo reported maintenance track as part of guideway costs instead of maintenance and support capabilities. Other inconsistencies in capital cost reporting may also exist.

Major variations are also attributable to the large number of design-specific and site-specific factors that influence capital costs. Some of these factors that may result in cost variations within the seven major capital cost categories are enumerated below.

Among the factors resulting in guideway cost variations are:

- Beam shape, width, and span length.
- Single- or dual-lane construction.
- Guideway materials and construction techniques.
- Guideway design (cast-in-place vs. precast vs. prefabricated; continuous vs. simple)
- Guideway load capacity.
- Guideway curvature and column height.
- Emergency egress provisions.
- Percent of guideway elevated, at-grade, and underground.
- Number and type of switches, crossovers, and turntables.
- Climate and all-weather provisions.
- Guideway aesthetics and environmental considerations.
- Local topographical and soil conditions.
- Local labor and material rates and availability.

Among the factors resulting in station cost variations are:

- Size and number of stations.
- Station materials and construction techniques.
- Number of stations elevated, at-grade, and underground.
- Station design (open vs. enclosed; freestanding vs. contiguous vs. joint use).
- Platform design (side or island).
- Amount and type of graphics.
- Amount and type of fare collection equipment.
- Amount and type of bi-parting doors or separations.
- Amount and type of elevators and escalators.

- o Climate control and amenities.
- o Station aesthetics and environmental considerations.
- o Local topographical and soil conditions.
- o Local labor and material rates and availability.

Among the factors resulting in maintenance and support capability cost variations are:

- o Number and size of vehicles.
- o Overall size of the maintenance facility.
- o Size of administrative space.
- o Amount and type of tools and equipment.
- o Storage of vehicles (indoor vs. outdoor).
- o Climate and all-weather provisions.
- o Facility aesthetics and environmental considerations.
- o Local topographical and soil conditions.
- o Local labor and material rates and availability.

Among the factors resulting in power and utility cost variations are:

- o Type of power supply available.
- o Type of power system (basic or redundant).
- o Total length of system.
- o Number and size of vehicles.
- o Number and size of stations.
- o Amount and type of maintenance and support capabilities.
- o Single- or dual-lane construction.
- o Climate and all-weather provisions.

Among the factors resulting in vehicle cost variations are:

- o Number, size, and weight of vehicle.
- o Vehicle propulsion systems.
- o Vehicle control systems.

- o Type of operation (independent units vs. trains).
- o Type of vehicle (active vs. passive).
- o Vehicle switching capabilities.
- o Emergency and failure requirements.
- o Climate control and interior design.
- o Performance requirements.

Among the factors resulting in command, control, & communications cost variations are:

- o Number of vehicles.
- o Number of lane miles.
- o Number of stations.
- o Type of central control.
- o Type of vehicle control.
- o Type of guideway and wayside control.
- o Type of station control.
- o Amount and type of two-way radios.
- o Amount and type of PA's, CCTV's, and telephones.

Among the factors resulting in engineering and project management cost variations are:

- o Size of system.
- o Length of construction schedule.
- o Seasonal changes.
- o Degree of regulatory requirements.
- o Amount of systems testing required.
- o Size of staff and number of consultants.

4.4.2 Variations Among the AGT Deployments

To provide further insight into how the design-specific and site-specific factors may impact the construction and installation costs at the AGT deployments, the following system characteristics will be discussed: system size, site location, technology employed and system design, and bid competitiveness.

Variations in total system costs are related to differences in overall system size. A larger system such as Airtrans, which has approximately thirteen miles of guideway, provides opportunities for economy of scale cost reductions which are not possible at a smaller system such as Miami Airport, where the guideway is just over one-half mile in length.

Locations of domestic AGT systems vary from sites near metropolitan areas such as Atlanta and Miami to nonurban settings such as Doswell, Virginia and Apple Valley, Minnesota. AGT deployments in urban locations can be expected to cost more than similar deployments in nonurban settings. Studies have shown that construction in urban areas may cost 25 to 50 percent above projects in nonurban locations; among urban locations, construction cost indices may vary by 30 to 50 percent. This is due primarily to the increased amount of construction time required in an urban environment and the higher prices for labor and materials generally found in urban areas. More lengthy urban construction times are estimated to add 17 to 25 percent to civil costs, while higher urban prices for labor, materials, and contingencies are estimated to add 8 to 26 percent to civil costs. The climate of various sites also imposes special conditions that impact subsystem costs as well as total system costs. Generally, the more severe the climate, the higher the costs. This is a result of slowdowns in or suspension of construction and the amount of weather protection necessary for system equipment. Examples of all-weather provisions are the guideway heating systems at Fairlane, Morgantown, and Minnesota Zoo to aid in snow/ice removal and the wide flanged structure at Miami Zoo to help withstand the rain and high winds associated with hurricanes. Poor soil and/or irregular terrain, such as that found at Morgantown, can also inhibit construction and raise costs by requiring special foundations.

The technology employed and system design will also cause costs to vary. Complex guideway systems with numerous branch and merge points require sophisticated command and control equipment which result in higher costs than would be found with simple loop systems. Systems utilizing state-of-the-art on-board vehicle controls will also reflect higher costs than those that have simple, passive vehicles in service. Underground guideway designs have been found to be more expensive than at-grade or elevated configurations due to tunneling costs. Likewise, composite steel and concrete are not generally considered to be as cost-effective as the prestressed concrete designs. Aside from these basic differences in technical sophistication, performance requirements such as capacity, safety, and reliability can also influence total system cost.

Another factor contributing to cost variations is the variety of suppliers associated with AGT systems. The diversity in technology, construction practices, design philosophy, and management strategies available to meet the technical and performance specifications of the system can cause diverse project cost estimates. Significant differences in cost can also result from systems, subsystems, and components being built at different times. Timing can influence the amounts paid due to inflation and prevailing interest rates. As a general rule, systems bid competitively can be expected to be cheaper than those granted on a sole source basis. However, a supplier's previous experience, which may result in learning curve economies, must be weighed heavily when making the final choice.

4.5 ANALYSIS OF CAPITAL COST MEASURES

The previous section discussed many of the factors that cause significant capital cost differences among AGT systems. Table 4-3 indicates that there is also a considerable spread among unit costs at the various systems. One of the primary reasons for this is the diversity in system size. Although smaller systems usually have lower total costs, it will be found that their unit costs are customarily higher than those systems with longer guideways, larger vehicle orders, several stations, etc. To account for size differentials when comparing subsystem unit costs for both large and small systems, the cost data should be normalized around size-related parameters.

To more fully understand the effects of size differentials, the cost sensitivity of each capital cost category to quantity must be considered. Since the capital costs for the guideway and vehicle subsystems are the largest contributors to the fixed facilities and hardware areas, these two subsystems will be discussed in more depth than the other cost categories. A linear regression analysis has been performed to correlate these costs as a function of various parameters. (The specific routine used was the Stepwise Multi-Variate Linear Regression Procedure in the Statistical Package for the Social Sciences (SPSS)).

Guideway cost measures for each system are contained in Table 4-4. The wide variation in cost per lane mile between individual systems is apparent. Guideway elevation also accounts for cost differences. Thus, when guideway lengths are normalized on the basis of equivalent elevated lane miles, the correlation between guideway cost and length improves by 60 percent. The resulting regression curve is shown on Figure 4-2. Morgantown is significantly off the curve because of the guideway heating system that had to be installed and the type of construction necessitated by the terrain in the area. Houston's low unit cost compared with other underground systems is most likely related to its small tunnel bore.

Vehicle cost measures for each system are contained in Table 4-5. Although the unit costs vary greatly from one system to the next, good cost correlations are obtained when vehicle size is normalized on the basis of area (i.e., equivalent passenger places) and weight. The resulting regression curves are shown in Figures 4-3 and 4-4. The high unit costs at Fairlane are probably due to the inclusion of development costs for incorporating numerous improvements over the initial vehicle design demonstrated at TRANSPO '72.

4.6 COMPARISON OF AGT AND CONVENTIONAL TRANSIT CAPITAL COSTS

When comparing the capital costs of AGT with conventional transportation modes it is important to recognize that such comparisons are relevant only when all modes have similar operating environments. AGT systems, with the exception of Morgantown, are all located at privately-owned activity centers while conventional transit systems are found in various urban settings. Therefore, the capital costs of these systems are not strictly comparable because AGT systems do not include many of the cost elements unique to urban construction.

It is also difficult to compare the capital costs of these systems since historical records for the older, well-established conventional transit systems are not readily available, if at all. Also, many of these systems have undergone modernization, further compounding the difficulty of identifying the cost of the original system. Although several studies (see Appendix A - Other Documents) have been conducted to determine transit construction costs, they usually result in estimates of cost ranges for each of the categories rather than provide a breakdown of the capital costs for various systems. For these reasons, the costs for only a few of the more recent conventional transit system deployments are able to be compared with AGT systems.

Table 4-6 shows the system cost per lane mile and equivalent elevated lane mile for each of the AGT systems examined in this report. Table 4-7 presents these same measures for the following conventional transit systems: the busway systems in El Monte/San Bernadino, CA; the light rail transit (LRT) system in San Diego, CA; and the heavy rail transit (HRT) system in San Francisco, CA.

Although data for only a few conventional transit systems have been collected, comparisons indicate that AGT, with an average cost of $17.5 million per lane mile and $14.9 million per equivalent elevated lane mile, is competitive on the basis of initial investment with conventional transit modes. It should be remembered that many design-specific and site-specific factors impact these unit cost measures. As was already mentioned, the isolated environment in which most of the AGT systems operate shelter them from many of the typical costs associated with urban construction. However, AGT systems will soon be operating in downtown Miami (1984) and Detroit (1986) as part of the public transportation system. These urban applications should provide a better data base from which to determine the cost-competitiveness of AGT in relation to other modes of transportation.

There are other examples of how these factors impact total system costs.

- The relatively low cost per lane mile for the LRT system in San Diego can be attributed to the fact that this system was built on the already existing right-of-way of an abandoned railroad. Similarly, the low cost per lane mile of the busway systems results, at least partially, from these systems' inclusion as part of an existing and expanding highway network.

- The average length of the AGT systems, excluding Airtrans and Morgantown, is approximately one and one-quarter miles, while the conventional transit systems are much more extensive. For example, the LRT system in San Diego is sixteen miles in length and is being expanded by seventeen miles; the HRT system in San Francisco is seventy-one miles in length and is being expanded by fifty-one miles. Also, the conventional transit systems are all double tracked/laned per mile whereas most of the AGT systems consist of single lanes. Combined, these factors may result in economy of scale cost reductions in the construction of the larger conventional transit systems.

5.0 OPERATIONS AND MAINTENANCE COST SUMMARY

5.1 INTRODUCTION

This section presents operations and maintenance (O&M) cost data for sixteen AGT systems. O&M cost information was obtained primarily through responses by system operators and suppliers and site surveys performed as part of UMTA-sponsored assessments. Included for the first time is cost and performance information for the system at the Miami Zoo which opened for service in December 1982. Ford Motor Company elected not to make available any O&M costs or labor statistics on the system at Fairlane. A breakdown of total O&M costs for King's Dominion was also not completed.

To aid in the analysis of this data, O&M costs were reported in the four cost categories described below:

- Labor - All manpower, including supervisors, station attendants, and custodians needed for the efficient operation, upkeep, and repair of equipment and facilities.

- Utilities - Energy for propulsion and command and control units as well as general station lighting, shop power, etc., any fuels necessary for heating, and telephone/telegraph service.

- Materials & Services - Any maintenance work performed by an outside contractor or organization on a cost-reimbursable basis and any consumable supplies.

- General & Administrative - Overall system management as well as support services such as accounting, engineering, and legal consultation.

5.2 O&M COST ADJUSTMENT METHODOLOGY

Since the O&M cost and performance data are for calendar year 1982, no cost adjustments are necessary. O&M cost data for conventional transit were obtained from the American Public Transit Association. This information will appear in the Transit Fact Book 1983 scheduled for publication in October 1983. Costs for conventional transit have been adjusted to exclude amounts spent for traffic solicitation, advertising, depreciation, amortization, taxes, licenses, rents, etc., since the AGT O&M costs do not include them. Because of the time required to compile the data for the Transit Fact Book, totals for 1982 are subject to change. Changes in totals for years prior to 1982 result from subsequently available data.

5.3 O&M COST EXHIBITS

A detailed accounting of 1982 O&M costs by cost category for each system is shown in Table 5-1.

O&M cost data for the sixteen AGT systems are summarized in Table 5-2. This table delineates the total O&M cost for each AGT system by cost category and presents each category in terms of percentage of total O&M cost.

Table 5-3 presents pertinent operating statistics for each system. The operational statistics included are vehicle miles traveled, equivalent place miles, vehicle-hours, passengers carried, passenger-miles, system operating hours, and equivalent full-time employees.

A breakdown of O&M cost measures for each system is shown in Table 5-4. This table illustrates the relationship between total O&M costs and the key operating parameters recorded in Table 5-3.

Figure 5-1 shows the average distribution of O&M costs among the major cost categories. These averages can be used to estimate how O&M costs for new systems may be dispersed.

Figure 5-2 presents the correlation of total O&M cost for each system as a function of vehicle miles traveled.

TABLE 5-1. OPERATIONS AND MAINTENANCE COST BREAKDOWN (1982 DOLLARS)

	AIRTRANS	ATLANTA	BUSCH GARDENS	DISNEYWORLD	DUKE	FAIRLANE	HOUSTON	KING'S DOMINION	MIAMI AIRPORT	MIAMI ZOO (1)	MINNESOTA ZOO	MORGANTOWN	ORLANDO	PEARLRIDGE	SEA-TAC	TAMPA
LABOR																
ADMINISTRATIVE & ENGINEERING	364,988	-	-	PAC	30,800	N/A	0	-	PAC	3,789	0	252,177	PAC	60,563	130,490	15,373
OPERATIONS	381,656	-	59,939	173,170	70,500	N/A	PUC	-	PAC	11,558	91,100	222,513	PAC	55,340	-	6,232
MAINTENANCE	2,343,528	-	PUC	79,294	306,500	N/A	PUC	-	PUC	7,421	130,600	638,722	515,413	125,942	-	9,707
OTHER	796,017	2,690,696	0	0	0	N/A	0	-	0	0	0	0	0	58,509	572,964	0
UTILITIES																
ELECTRICITY	357,886	143,383	54,100	69,782	16,000	N/A	29,416*	21,432	41,852	2,643	28,000	243,883	124,385	10,598	25,912	85,285
OTHER	0	0	0	0	0	N/A	0	0	0	0	0	131,872	0	2,379	0	0
MATERIALS & SERVICES																
SPARE PARTS & MATERIALS	660,414	155,011	21,703	36,303	80,000	N/A	PUC	-	PUC	2,011	35,900	261,019	85,110	21,697	PUC	104,335
CONTRACT SERVICES	297,510	266,671	50,795	0	0	N/A	784,639	-	600,000	0	0	227,638	38,089	0	132,745	591,230
OTHER	0	0	0	0	0		0	-	0	0	0	208,097	7,746	0	0	0
GENERAL & ADMINISTRATIVE																
PRO RATA SHARE	110,736	PUC	PAC	34,620	PAC	N/A	PUC	-	PAC	1,500	22,500	90,000	PAC	9,892	PAC	PAC
OTHER	0	0	0	60,802	0	N/A	0	-	0	2,558	0	0	128,246	0	0	16,500
TOTAL O&M COST	5,312,735	3,255,761	186,537	453,971	503,800	N/A	814,055	N/A	641,852	31,480	308,100	2,275,921	898,989	344,920	862,111	828.662

\- No entry in this category in the accounting records of the system.

N/A Not Available

PAC Provided as part of the Activity Center

PUC Provided Under Contract

* Total reflects cost for eight months (May-December); data for January-April invalid due to faulty meters.

(1) Totals reflect cost for one month of service (December).

TABLE 5-2. SUMMARY OF OPERATIONS AND MAINTENANCE COSTS (1982 DOLLARS)

	AIRTRANS	ATLANTA	BUSCH GARDENS	DISNEYWORLD	DUKE	FAIRLANE	HOUSTON	KING'S DOMINION	MIAMI AIRPORT	MIAMI ZOO	MINNESOTA ZOO	MORGANTOWN	ORLANDO	PEARLRIDGE	SEA-TAC	TAMPA
LABOR																
TOTAL COST	3,886,189	2,690,696	59,939	252,464	407,800	N/A	0	N/A	0	22,768	221,700	1,113,412	515,413	300,354	703,454	31,312
% OF TOTAL O&M COST	.73	.83	.32	.56	.81	N/A	0	N/A	0	.72	.72	.49	.57	.87	.82	.04
UTILITIES																
TOTAL COST	357,886	143,383	54,100	69,782	16,000	N/A	29,416	21,432	41,852	2,643	28,000	375,755	124,385	12,977	25,912	85,285
% OF TOTAL O&M COST	.07	.04	.29	.15	.03	N/A	.04	N/A	.07	.09	.09	.16	.14	.04	.03	.10
MATERIALS & SERVICES																
TOTAL COST	957,924	421,682	72,498	36,303	80,000	N/A	784,639	N/A	600,000	2,011	35,900	696,754	130,945	21,697	132,745	695,565
% OF TOTAL O&M COST	.18	.13	.39	.08	.16	N/A	.96	N/A	.93	.08	.12	.31	.15	.06	.15	.84
GENERAL & ADMINISTRATIVE																
TOTAL COST	110,736	0	0	95,422	0	N/A	0	0	0	4,058	22,500	90,000	128,246	9,892	0	16,500
% OF TOTAL O&M COST	.02	0	0	.21	0	N/A	0	0	0	.13	.07	.04	.14	.03	0	.02
TOTAL O&M COST	5,312,735	3,255,761	186,537	453,971	503,800	N/A	814,055	N/A	641,852	31,480	308,100	2,275,921	898,989	344,920	862,111	828,662

N/A Not Available

TABLE 5-3. OPERATIONAL STATISTICS

	AIRTRANS	ATLANTA	BUSCH GARDENS	DISNEYWORLD	DUKE	FAIRLANE	HOUSTON	KING'S DOMINION	MIAMI AIRPORT	MIAMI ZOO (1)	MINNESOTA ZOO	MORGANTOWN	ORLANDO	PEARLRIDGE	SEA-TAC	TAMPA
VEHICLE MILES TRAVELED	2,817,668	818,140	24,210	618,154	92,845	72,749	200,621	13,626	289,230	1,310	6,648	911,857	288,888	11,420	596,200	328,022
EQUIVALENT PLACE MILES (2)	104,253,716	74,450,740	4,115,700	30,907,700	2,878,195	2,982,709	10,833,534	1,962,144	73,753,650	314,400	797,760	23,708,282	52,577,616	1,142,000	50,677,000	27,553,848
VEHICLE-HOURS	281,767	84,222	1,532	129,183	-	3,859	35,989	-	10,950	507	2,894	NCR	33,983	3,663	49,683	58,400
PASSENGERS CARRIED	5,613,812	23,542,500	1,286,305	5,317,116	1,367,200	2,306,000	NCR	598,685	4,178,990	62,693	300,700	2,860,885	6,725,631	1,075,577	11,042,200	19,355,480
PASSENGER-MILES	15,887,088	51,793,500	1,710,786	4,572,714	642,584	1,153	NCR	1,197,370	1,086,537	119,117	408,952	5,292,637	2,421,227	247,383	10,158,824	3,677,541
SYSTEM OPERATING HOURS	8,447	7,503	1,532	4,379	8,760	3,941	7,856	976	8,760	196	2,449	3,886	8,760	3,663	8,030	8,760
EQUIVALENT FULL-TIME EMPLOYEES (3)	146.0	61.0	22.0	15.0	14.7	N/A	12.0	12.0	19.0	18.7	11.6	55.5	15.0	13.1	13.0	8.1

\- No entry in this category in the accounting records of the system.

N/A Not Available

NCR System Not Capable of Recording.

(1) Totals reflect one month of service (December).

(2) Equivalent Place Miles are computed by multiplying equivalent passenger places per vehicle by the vehicle miles traveled for each system.

(3) Equivalent Full-Time Employees are computed on the basis of 2,000 man-hours per year.

TABLE 5-4. OPERATIONS AND MAINTENANCE COST MEASURES
(1982 DOLLARS)

SYSTEM	O&M COST PER VEHICLE MILE TRAVELED	O&M COST PER EQUIVALENT PLACE MILE	O&M COST PER VEHICLE HOUR	O&M COST PER PASSENGER CARRIED	O&M COST PER PASSENGER MILE
AIRTRANS	1.89	0.051	18.86	0.95	0.33
ATLANTA	3.98	0.044	38.66	0.14	0.06
BUSCH GARDENS	7.70	0.045	121.76	0.15	0.11
DISNEYWORLD	0.73	0.015	3.51	0.09	0.10
DUKE	5.43	0.175	N/A	0.37	0.78
FAIRLANE	N/A	N/A	N/A	N/A	N/A
HOUSTON	4.06	0.075	22.62	N/A	N/A
KING'S DOMINION	N/A	N/A	N/A	N/A	N/A
MIAMI AIRPORT	2.22	0.009	58.62	0.15	0.59
MIAMI ZOO	24.03	0.100	62.09	0.50	0.26
MINNESOTA ZOO	46.34	0.386	106.46	1.03	0.75
MORGANTOWN	2.50	0.096	N/A	0.80	0.43
ORLANDO	3.11	0.017	26.45	0.13	0.37
PEARLRIDGE	30.20	0.302	94.16	0.32	1.39
SEA-TAC	1.45	0.017	17.35	0.08	0.08
TAMPA	2.53	0.030	14.19	0.04	0.23

(1) Approximately one month of data.

N/A Not Available

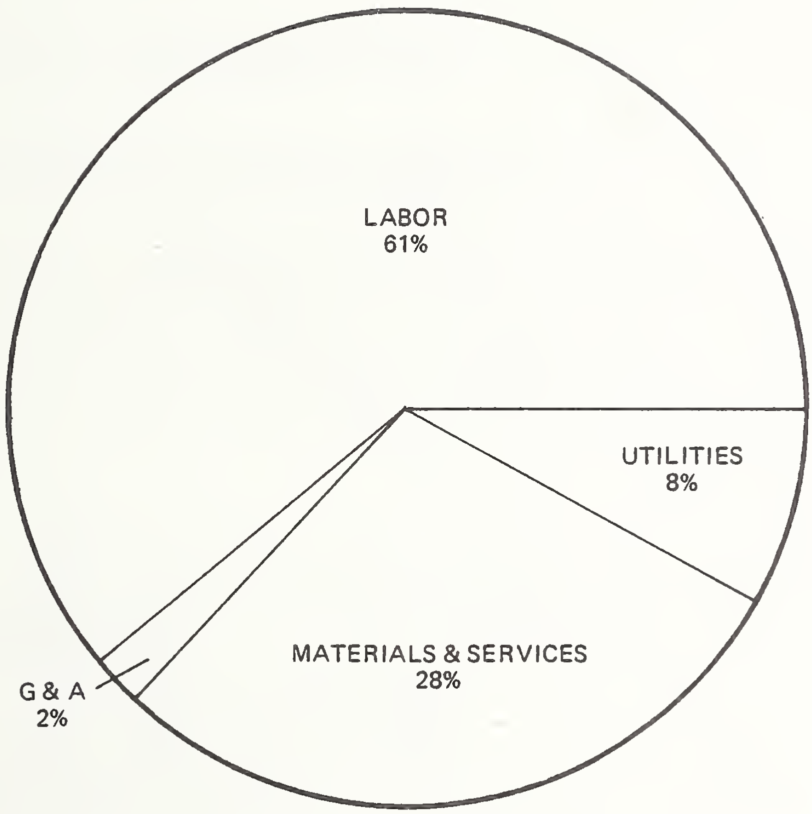
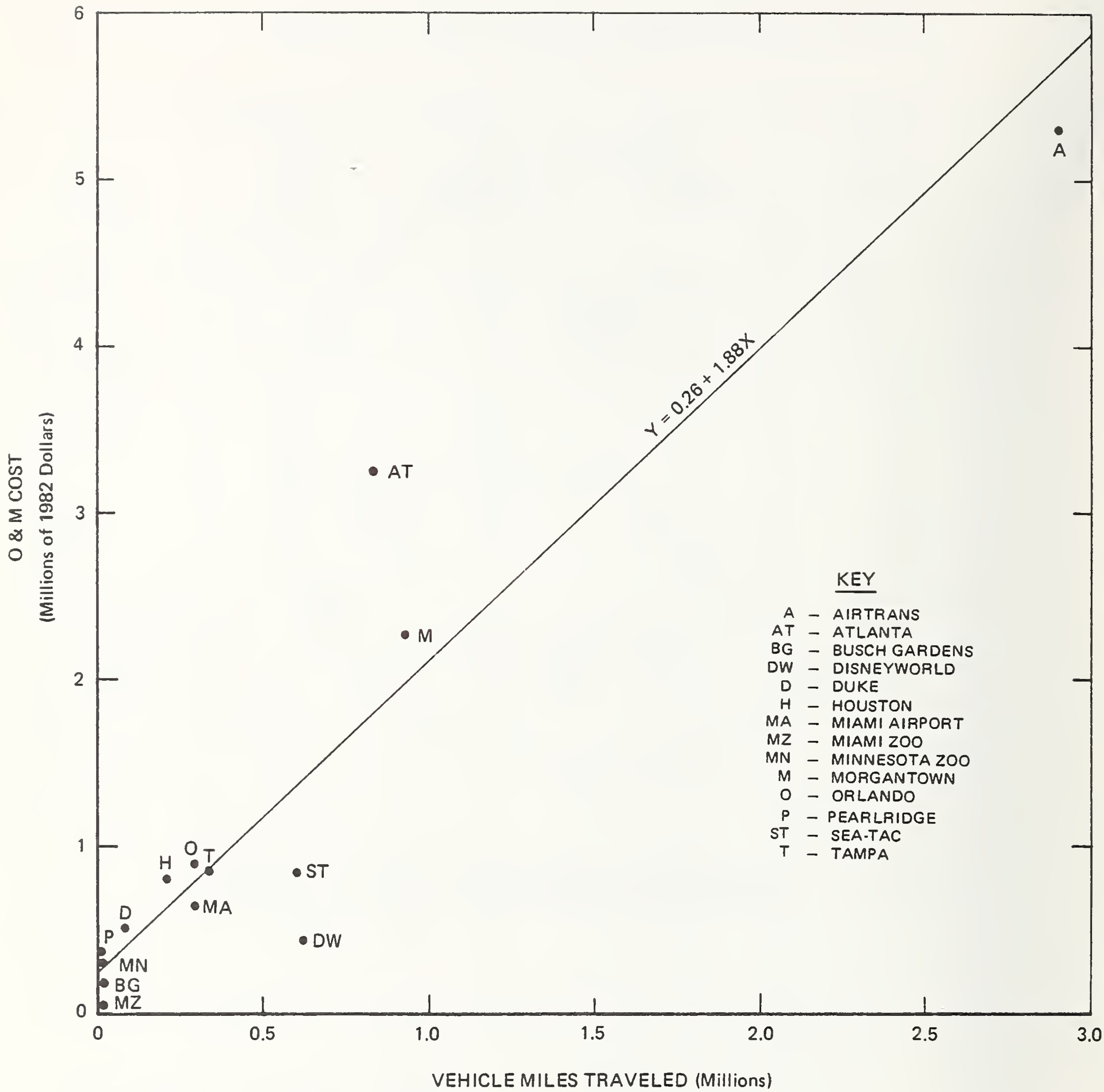


FIGURE 5-1. DISTRIBUTION OF O&M COSTS AMONG COST CATEGORIES (FOURTEEN SYSTEM AVERAGE)



NOTE: The regression curve is based on all points and has a coefficient of determination equal to 0.872.

FIGURE 5-2. REGRESSION OF O&M COST ON VEHICLE MILES TRAVELED

Figures 5-3 and 5-4 indicate graphically how average O&M costs per vehicle mile traveled and passenger carried for AGT compares with that of conventional transit. To provide a more representative comparison, only data from the five AGT systems which most closely approximate public transportation service have been used.

5.4 DISCUSSION OF O&M COST VARIATIONS

5.4.1 Variations Among the Cost Categories

The average distribution of O&M costs for fourteen AGT systems operating in the United States is shown in Figure 5-1. However, a wide range of distributions exists and, in some cases, differs significantly from the average. Therefore, high and low values for each O&M cost category are shown below:

- Labor:
  - High - Pearlridge (87%)
  - Low - Atlanta, Houston, Miami Airport, Orlando (0%)
- Utilities:
  - High - Busch Gardens (29%)
  - Low - Duke, Sea-Tac (3%)
- Materials & Services:
  - High - Atlanta, Houston (96%)
  - Low - Pearlridge (21%)
- General & Administrative:
  - High - Disneyworld (21%)
  - Low - Atlanta, Busch Gardens, Duke, Houston, Miami Airport, Sea-Tac (0%)

Despite a general atmosphere of cooperation on the part of systems operators and suppliers in reporting performance and cost data, differences in record keeping were observed. This was probably due to the fact that most existing systems are privately owned and not intended for public transit revenue operation. This lack of uniformity in reporting tends to distort the

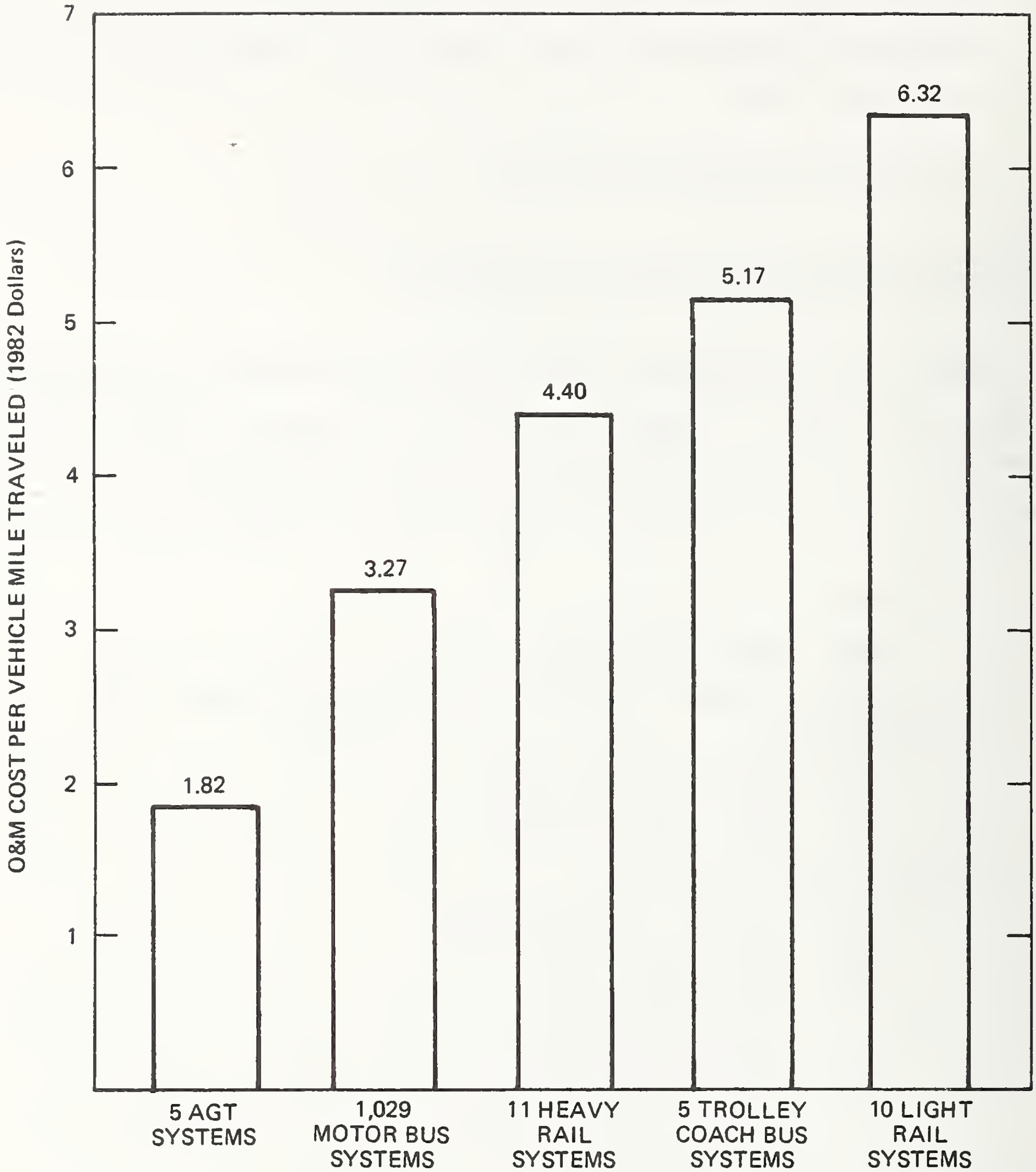


FIGURE 5-3. COMPARISON OF O&M COST PER VEHICLE MILE TRAVELED FOR FIVE DIFFERENT TRANSIT MODES

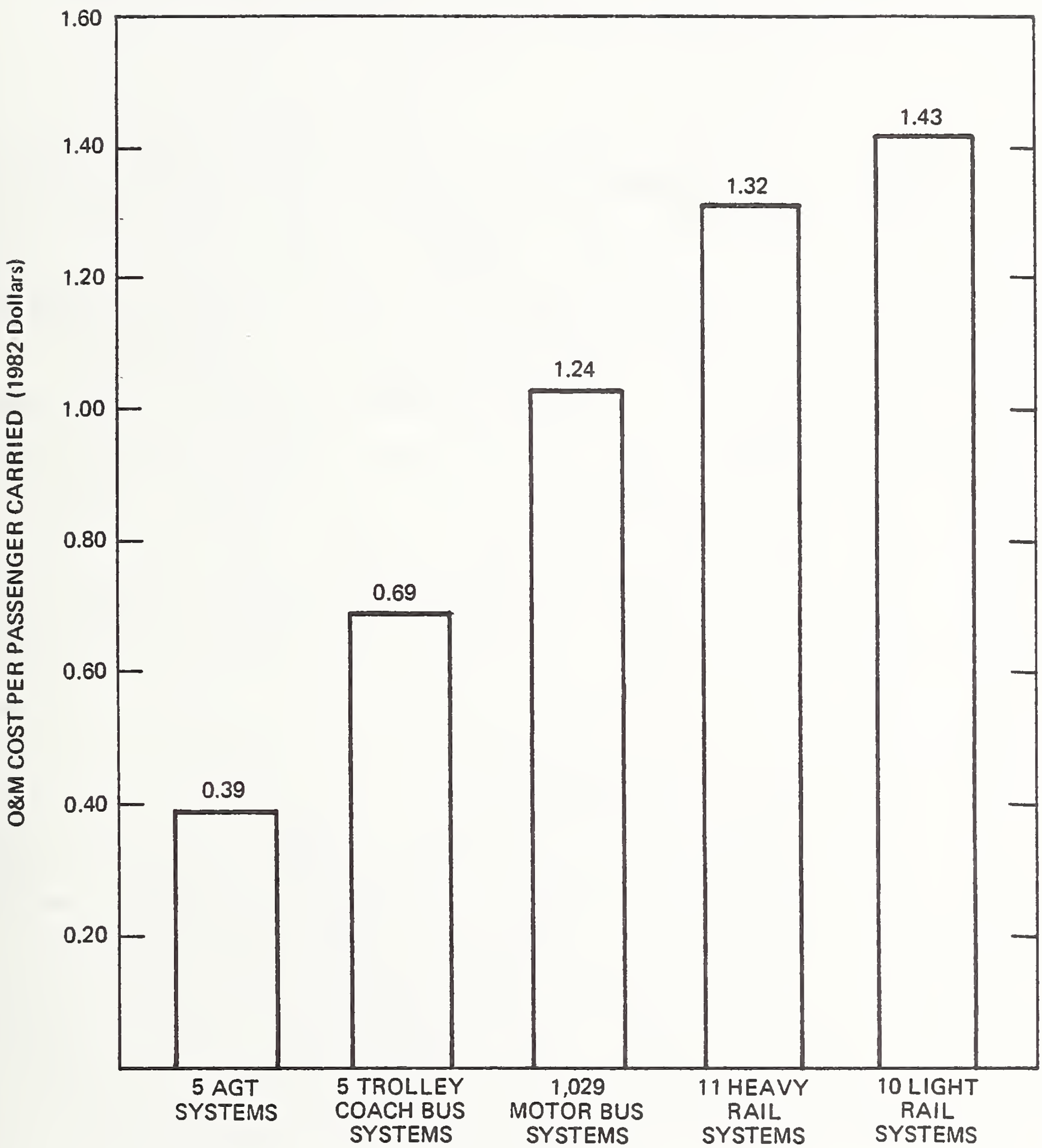


FIGURE 5-4. COMPARISON OF O&M COST PER PASSENGER CARRIED FOR FIVE DIFFERENT TRANSIT MODES

distributions and make it difficult to compare O&M costs by cost category. To follow are some instances where cost data were not able to be recorded according to the categories defined in this report.

Labor costs are often reflected in the Materials & Services category when the total operation and maintenance of the system is provided under a contract services agreement. This is the case at Houston. Busch Gardens and Miami Airport however, have maintenance only contracts. Although Atlanta, Orlando, and Tampa also have such agreements, the labor portion was separated from the other services. Some O&M costs are considered to be associated with the normal functions of the overall facility for which the system is a part and are not separately recorded. This is the case with administrative and operations labor at Miami Airport and Orlando as well as with general and administrative costs at Busch Gardens, Duke, Miami Airport, and Sea-Tac. Distinctions cannot always be made between subcategories because the systems do not always differentiate between them. An example of this is the operations and maintenance labor costs at Sea-Tac.

5.4.2 Variations Among the AGT Deployments

As noted in the previous section, variations in O&M costs by cost category are generally caused by differences in the system's approach to identifying them. However, the totals are reasonably accurate. The major determinants of O&M costs are the operational capabilities and site-specific factors that characterize each AGT system. These characteristics include system size, site location, technology employed and system design, and level of service. The following remarks are intended to provide a better understanding of how these characteristics affect O&M costs.

Variations in O&M costs are often related to system size. Larger systems, with numerous vehicles and extensive guideways, have the potential for economy of scale cost reductions not available to smaller systems offering comparable services.

Site location can affect O&M costs through its impact on labor and utility rates. The largest share of O&M costs is associated with labor costs. Variations in labor costs are often due to differences in wage rates found in different geographic areas. The cost of electric power also varies considerably from one region of the country to the next. The Pacific Northwest traditionally has the lowest power costs in the country (e.g., $0.019/kwh at Sea-Tac), while the Northeast and Southeast are typically at the high end of the range (i.e., an average of $0.06/kwh). Systems located in areas with severe weather conditions tend to incur higher energy and maintenance expenses. The larger fuel bills are due to the substantial amounts of energy needed to heat the guideway, stations, vehicles, and maintenance and support facilities. The increase in general repair costs result from the more frequent maintenance required by system equipment exposed to these conditions.

Complexity and sophistication of the technology employed and system design causes fluctuations in O&M costs. To furnish a premium, non-stop service such as the one provided at Morgantown, superior command and control equipment is required. This requirement in turn increases the demands put on the O&M staff to sustain an acceptable level of service. Systems with simple components and/or passive vehicles with few moving parts will require less frequent maintenance. Moreover, a high initial investment in well-designed equipment with quality components will generally result in significantly fewer breakdowns and required repair. Conversely, less expensive hardware generally requires more upkeep and increased demands on the maintenance force to achieve a comparable level of service. O&M costs also tend to vary in accordance with route geometry and system design. The combination of sharp curves and steep grades will decrease overall system efficiency and increase energy consumption. Elaborate stations and facilities filled with amenities will cost more to maintain than those with just essential structures.

The primary reason for O&M cost variations is the level of service desired, that is, the amount of interruption or degradation a system can withstand without seriously inconveniencing its passengers. More stringent operating policies such as those found at airport systems requiring almost 100 percent availability, 24 hours per day, 365 days per year are likely to amass higher O&M costs than a recreation center needing just 80 percent availability, 12 hours per day, 140 days per year. Consequently, the operating policy at each type of system will strongly influence the maintenance philosophy there as well. A system like Sea-Tac that provides the sole means of intra-airport transportation and requires around-the-clock availability will often need to adopt a vigorous preventative maintenance program. This type of program, with its additional routine maintenance and emergency repair capabilities, translates into higher O&M costs than are found at systems practicing a reactive, corrective maintenance policy. It must also be remembered that while certain O&M cost elements such as maintenance labor, spare parts, vehicle power, etc., vary as a function of service provided, other cost elements do not. Regardless of the fleet size or vehicle miles traveled, there will be a fixed minimum annual cost associated with the operation and administration of the system on a daily basis.

5.5 ANALYSIS OF O&M COST MEASURES

The previous section discussed many of the factors that cause significant O&M cost differences among AGT systems. Table 5-4 indicates that there is also a considerable spread among unit costs at the various systems. One of the primary reasons for this is the diversity in level of service.

To determine the effect of level of service on O&M costs, a linear regression analysis has been performed. (The specific routine used was the Stepwise Multi-Variate Linear Regression Procedure in the Statistical Package for the Social Sciences (SPSS)). The correlations found between O&M costs and various operating parameters are listed in Table 5-5. Of the several measures examined, vehicle miles traveled has the strongest relationship to O&M costs. The resulting regression curve, shown on Figure 5-2, represents average cost data from which future O&M costs can be projected based on estimated vehicle mileage.

TABLE 5-5. REGRESSION ANALYSIS RESULTS

DEPENDENT VARIABLE	INDEPENDENT VARIABLE	COEFFICIENT OF DETERMINATION*
O&M COST	VEHICLE MILES TRAVELED	0.872
O&M COST	EQUIVALENT PLACE MILES	0.585
O&M COST	VEHICLE-HOURS	0.011
O&M COST	PASSENGERS CARRIED	0.135
O&M COST	PASSENGER-MILES	0.401

* A measure of the degree of association or correlation between the dependent and independent variables indicating the proportion of variation that has been accounted for or explained by the relationship expressed in the regression line.

Although poor correlations were found with the other measures, they did show how specific operating characteristics can impact the various cost rates, making comparisons between systems difficult. For example:

- o Cost per equivalent place mile reflects the influence of vehicle size. While a moderate degree of correlation was obtained, much of it is dependent on the number of vehicle miles traveled.

- o Cost per vehicle-hour is associated with the amount of time individual vehicles are actually operating. This will vary with the fleet size and the type of service (i.e., continuous, periodic, or on-demand).

- o Cost per passenger carried obviously varies according to the amount of patronage, but is also linked to whether or not the system is the sole means of transportation within the activity center.

- o Cost per passenger-mile is related to average passenger trip length. Determining this distance is not a simple task when the system operates on a multi-stop route with passengers entering and exiting at various points along the way rather than on a closed path with an exclusive origin and destination.

5.6 COMPARISON OF AGT AND CONVENTIONAL TRANSIT O&M COSTS

When comparing the O&M costs of AGT systems with conventional transportation modes, it is important to recognize that such comparisons are relevant only when all modes provide the same type and level of service. Existing AGT systems provide circulation service in relatively small, specialized activity centers, whereas existing bus and rail systems provide regional or corridor service. In contrast to conventional transit systems which experience peak service periods twice a day, AGT systems require a relatively high level of service and intense utilization of vehicles throughout the day. Therefore, comparisons between AGT and conventional transit are presented simply to indicate an overall contrast between the various modes.

Figures 5-3 and 5-4 show comparisons of average O&M costs per vehicle mile traveled and passenger carried for AGT and four conventional transit modes: Motor Bus, Trolley Coach Bus, Heavy Rail, and Light Rail. To provide a more representative comparison, data from the AGT systems which most closely approximate public transportation system service (i.e., Airtrans, Disneyworld, Morgantown, Sea-Tac, and Tampa) have been used.

On the basis of O&M cost per vehicle mile traveled, AGT systems compare favorably to conventional transit modes. The lower unit cost for AGT may be due to more vehicle miles being generated for their relatively small size. Similarly, the O&M cost per passenger carried for AGT is less than conventional transit. Differences in this unit cost may be attributed to the average trip length per passenger on AGT systems being shorter than the average length of a trip on conventional transit. Another reason why these unit costs for conventional transit are higher is the additional G&A expenses required for the marketing and advertising activities that are so essential to the successful operation of urban public transportation systems.

6.0 HISTORICAL COST SUMMARY

6.1 INTRODUCTION

This section presents historical cost data for sixteen AGT systems. The capital and O&M cost information for these systems were obtained from previously published supplements in this series.

6.2 COST ADJUSTMENT METHODOLOGY

All capital costs have been adjusted to current year price levels so that trends are distinguishable from inflationary increases. When comparing the actual 1982 O&M costs for AGT systems with prior year O&M costs for both AGT and conventional transit, the Consumer Price Index for Urban Wage Earners and Clerical Workers in the United States (CPI-W) was used to adjust the costs to average 1982 dollars. The methodology and indices used to make these adjustments have already been explained in Sections 4.2 and 5.2.

6.3 COST EXHIBITS

Table 6-1 presents historical data pertaining to capital costs, O&M costs, and selected operational statistics for each of the systems.

Figures 6-1 through 6-5 depict trends in O&M costs, vehicle miles traveled, passengers carried, and their associated cost measures.

Figures 6-6 and 6-7 display trends in average O&M costs per vehicle mile traveled and passenger carried for AGT in relation to conventional transit.

TABLE 6-1. SYSTEM COST HISTORY

AIRTRANS

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway	12,900			16,125	17,415	18,982	20,501
Stations	6,960			8,700	9,396	10,242	11,061
Maintenance & Support Capabilities	3,820			4,775	5,195	5,663	6,116
Power & Utilities	4,990			6,238	6,737	7,680	8,141
Vehicles	12,200			15,250	16,623	18,950	20,087
Command, Control, & Communications	6,460			8,075	8,802	10,034	10,636
Engineering & Project Management	13,300			17,024	19,237	21,161	22,431
Total System	60,630			76,187	83,405	92,712	98,973

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor	1,840	1,725	1,919	1,876	3,064	3,418	3,886
Utilities	242	268	288	276	297	342	358
Materials & Services	1,064	1,107	1,147	896	940	888	958
General & Adminstrative	N/A	N/A	N/A	249	82	91	111
Total System	3,146	3,100	3,360	3,297	4,383	4,739	5,313

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled	3,700	3,630	3,470	3,358	3,283	2,983	2,818
Passengers Carried				6,745	7,014	6,499	5,614

TABLE 6-1. SYSTEM COST HISTORY (Continued)

ATLANTA

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway				17,510	18,911	20,613	22,262
Stations				9,204	9,940	10,835	11,702
Maintenance & Support Capabilities				3,385	3,673	4,004	4,324
Power & Utilities				3,169	3,423	3,902	4,136
Vehicles				11,193	12,200	13,908	14,742
Command, Control, & Communications				4,124	4,495	5,124	5,431
Engineering & Project Management				8,076	9,126	10,039	10,641
Total System				56,661	61,768	68,425	73,238

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor						2,447	2,691
Utilities						114	143
Materials & Services						232	422
General & Adminstrative						250	0
Total System						3,043	3,256

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled						768	818
Passengers Carried						26,652	23,543

TABLE 6-1. SYSTEM COST HISTORY (Continued)

BUSCH GARDENS

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway				2,149	2,321	2,530	2,732
Stations				163	176	192	207
Maintenance & Support Capabilities				286	310	338	365
Power & Utilities				476	514	586	621
Vehicles				1,030	1,122	1,279	1,356
Command, Control, & Communications				634	691	788	835
Engineering & Project Management				1,080	1,220	1,342	1,423
Total System				5,818	6,354	7,055	7,539

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor					---	112	60
Utilities					14	14	54
Materials & Services					---	57	72
General & Adminstrative					---	0	0
Total System					N/A	183	186

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled					45	23	24
Passengers Carried					1,365	1,342	1,286

TABLE 6-1. SYSTEM COST HISTORY (Continued)

DISNEYWORLD

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway	1,970			2,463	2,660	2,899	3,131
Stations	1,610			2,013	2,174	2,370	2,560
Maintenance & Support Capabilities	596			745	812	885	956
Power & Utilities	795			994	1,074	1,224	1,297
Vehicles	3,190			3,988	4,347	4,956	5,253
Command, Control, & Communications	3,220			4,025	4,387	5,001	5,301
Engineering & Project Management	819			1,048	1,184	1,302	1,380
Total System	12,200			15,276	16,638	18,637	19,878

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor	233	243	246	173	288	272	252
Utilities	44	47	52	53	64	68	70
Materials & Services	39	59	49	60	---	50	36
General & Adminstrative	33	17	16	17	32	31	95
Total System	349	366	363	303	384	421	453

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled	712	705	710	621	720	578	618
Passengers Carried	4,660			5,017	5,329	4,885	5,317

TABLE 6-1. SYSTEM COST HISTORY (Continued)

DUKE

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway				2,068	2,233	2,434	2,629
Stations				211	228	249	269
Maintenance & Support Capabilities				N/A	N/A	N/A	N/A
Power & Utilities				N/A	N/A	N/A	N/A
Vehicles				1,074	1,171	1,335	1,415
Command, Control, & Communications				3,235	3,526	4,020	4,261
Engineering & Project Management				2,362	2,669	2,936	3,112
Total System				8,950	9,827	10,974	11,686

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor						388	408
Utilities						14	16
Materials & Services						60	80
General & Adminstrative						0	0
Total System						462	504

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled						69	93
Passengers Carried						968	1,367

TABLE 6-1. SYSTEM COST HISTORY (Continued)

FAIRLANE

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway				2,600	2,808	3,061	3,306
Stations				521	563	614	663
Maintenance & Support Capabilities				149	161	175	189
Power & Utilities				1,175	1,269	1,447	1,534
Vehicles				915	997	1,137	1,205
Command, Control, & Communications				915	998	1,138	1,206
Engineering & Project Management				1,395	1,576	1,734	1,838
Total System				7,670	8,372	9,306	9,941

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor						N/A	N/A
Utilities						N/A	N/A
Materials & Services						N/A	N/A
General & Adminstrative						N/A	N/A
Total System						1,372 (est.)	N/A

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled						73	73
Passengers Carried						2,250	2,306

TABLE 6-1. SYSTEM COST HISTORY (Continued)

HOUSTON

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway					7,871	8,579	9,265
Stations					4,760	5,188	5,603
Maintenance & Support Capabilities					346	377	407
Power & Utilities					538	613	650
Vehicles					1,109	1,264	1,340
Command, Control, & Communications					2,333	2,660	2,820
Engineering & Project Management					4,609	5,070	5,374
Total System					21,566	23,751	25,459

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor						0	0
Utilities						9	29
Materials & Services						328	785
General & Adminstrative						0	0
Total System						337	814

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled						76	201
Passengers Carried						N/A	N/A

TABLE 6-1. SYSTEM COST HISTORY (Continued)

KING'S DOMINION

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway				1,350	1,458	1,589	1,716
Stations				225	243	265	286
Maintenance & Support Capabilities				259	280	305	329
Power & Utilities				403	435	496	526
Vehicles				2,813	3,066	3,495	3,705
Command, Control, & Communications				43	47	54	57
Engineering & Project Management				1,818	2,054	2,259	2,395
Total System				6,911	7,583	8,463	9,014

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor						30	---
Utilities						39	21
Materials & Services						8	---
General & Adminstrative						0	---
Total System						77	N/A

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled						51	14
Passengers Carried						770	599

TABLE 6-1. SYSTEM COST HISTORY (Continued)

MIAMI AIRPORT

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway				3,073	3,319	3,618	3,907
Stations				3,377	3,647	3,975	4,293
Maintenance & Support Capabilities				929	1,008	1,099	1,187
Power & Utilities				504	544	620	657
Vehicles				1,365	1,488	1,696	3,596
Command, Control, & Communications				989	1,078	1,229	1,303
Engineering & Project Management				2,040	2,305	2,536	2,688
Total System				12,277	13,389	14,773	17,631

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor					---	0	0
Utilities					20	60	42
Materials & Services					---	256	600
General & Adminstrative					---	0	0
Total System					N/A	316	642

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled					76	233	289
Passengers Carried					4,618	4,725	4,179

TABLE 6-1. SYSTEM COST HISTORY (Continued)

MIAMI ZOO

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway							4,414
Stations							1,192
Maintenance & Support Capabilities							850
Power & Utilities							755
Vehicles							2,850
Command, Control, & Communications							58
Engineering & Project Management							1,243
Total System							11,362

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor							23
Utilities							3
Materials & Services							2
General & Adminstrative							4
Total System							32

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled							1
Passengers Carried							63

TABLE 6-1. SYSTEM COST HISTORY (Continued)

MINNESOTA ZOO

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway				2,745	2,965	3,232	3,491
Stations				327	353	385	416
Maintenance & Support Capabilities				679	737	803	867
Power & Utilities				746	806	919	974
Vehicles				2,353	2,565	2,924	3,099
Command, Control, & Communications				349	380	433	459
Engineering & Project Management				694	784	862	914
Total System				7,893	8,590	9,558	10,220

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor					199	204	222
Utilities					31	30	28
Materials & Services					26	15	36
General & Adminstrative					---	9	23
Total System					256	258	309

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled					8	7	7
Passengers Carried					374	288	301

TABLE 6-1. SYSTEM COST HISTORY (Continued)

MORGANTOWN

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway	19,100			23,875	36,429	39,708	42,885
Stations	2,550			3,188	6,648	7,246	7,826
Maintenance & Support Capabilities	1,060			1,325	5,718	6,233	6,732
Power & Utilities	2,710			3,388	8,775	10,004	10,604
Vehicles	8,970			11,194	18,312	20,876	22,129
Command, Control, & Communications	10,200			12,750	26,603	30,327	32,147
Engineering & Project Management	13,300			17,024	38,813	42,694	45,256
Total System	57,890			72,744	141,303	157,088	167,579

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor	498	521	582	N/A	1,087	1,100	1,113
Utilities	205	183	185	N/A	368	403	376
Materials & Services	541	472	399	N/A	699	591	697
General & Adminstrative	143	147	167	N/A	---	165	90
Total System	1,387	1,323	1,330	N/A	2,154	2,259	2,276

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled	631	581	550	N/A	1,219	995	912
Passengers Carried		1,944		N/A	3,010	3,114	2,861

TABLE 6-1. SYSTEM COST HISTORY (Continued)

ORLANDO

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway				6,168	5,200	5,668	6,121
Stations				4,554	4,158	4,532	4,895
Maintenance & Support Capabilities				2,307	2,162	2,357	2,546
Power & Utilities				941	927	1,057	1,120
Vehicles				5,162	4,950	5,643	5,982
Command, Control, & Communications				1,932	5,512	6,284	6,661
Engineering & Project Management				3,981	2,600	2,860	3,032
Total System				25,045	25,509	28,401	30,357

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor						307	515
Utilities						37	124
Materials & Services						14	131
General & Adminstrative						3	128
Total System						361	899

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled						184	289
Passengers Carried						1,804	6,726

TABLE 6-1. SYSTEM COST HISTORY (Continued)

PEARLRIDGE

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway		N/A	N/A	N/A	N/A	N/A	N/A
Stations		N/A	N/A	N/A	N/A	N/A	N/A
Maintenance & Support Capabilities		N/A	N/A	N/A	N/A	N/A	N/A
Power & Utilities		N/A	N/A	N/A	N/A	N/A	N/A
Vehicles		N/A	N/A	N/A	N/A	N/A	N/A
Command, Control, & Communications		N/A	N/A	N/A	N/A	N/A	N/A
Engineering & Project Management		N/A	N/A	N/A	N/A	N/A	N/A
Total System		1,300	1,404 (est.)	1,540 (est.)	1,694 (est.)	1,880 (est.)	2,006 (est.)

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor					253	221	300
Utilities					7	11	13
Materials & Services					31	15	22
General & Adminstrative					35	68	10
Total System					326	315	345

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled					13	12	11
Passengers Carried					1,200	1,021	1,076

TABLE 6-1. SYSTEM COST HISTORY (Continued)

SEA-TAC

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway	12,400			15,500	16,740	18,247	19,707
Stations	5,540			6,925	7,479	8,152	8,804
Maintenance & Support Capabilities	2,800			3,600	3,888	4,238	4,577
Power & Utilities	3,660			2,035	2,198	2,506	2,656
Vehicles	4,950			6,188	6,745	7,689	19,380
Command, Control, & Communications	---			2,541	2,770	3,158	3,347
Engineering & Project Management	5,180			6,630	7,492	8,241	8,735
Total System	34,530			43,418	47,312	52,231	67,206

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor	461	371	490	492	602	637	703
Utilities	8	10	17	16	18	22	26
Materials & Services	274	272	211	211	157	143	133
General & Adminstrative	8	N/A	N/A	0	20	0	0
Total System	751	653	718	719	797	802	862

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled	411	461	505	529	551	574	596
Passengers Carried	10,100			7,012	10,941	10,721	11,042

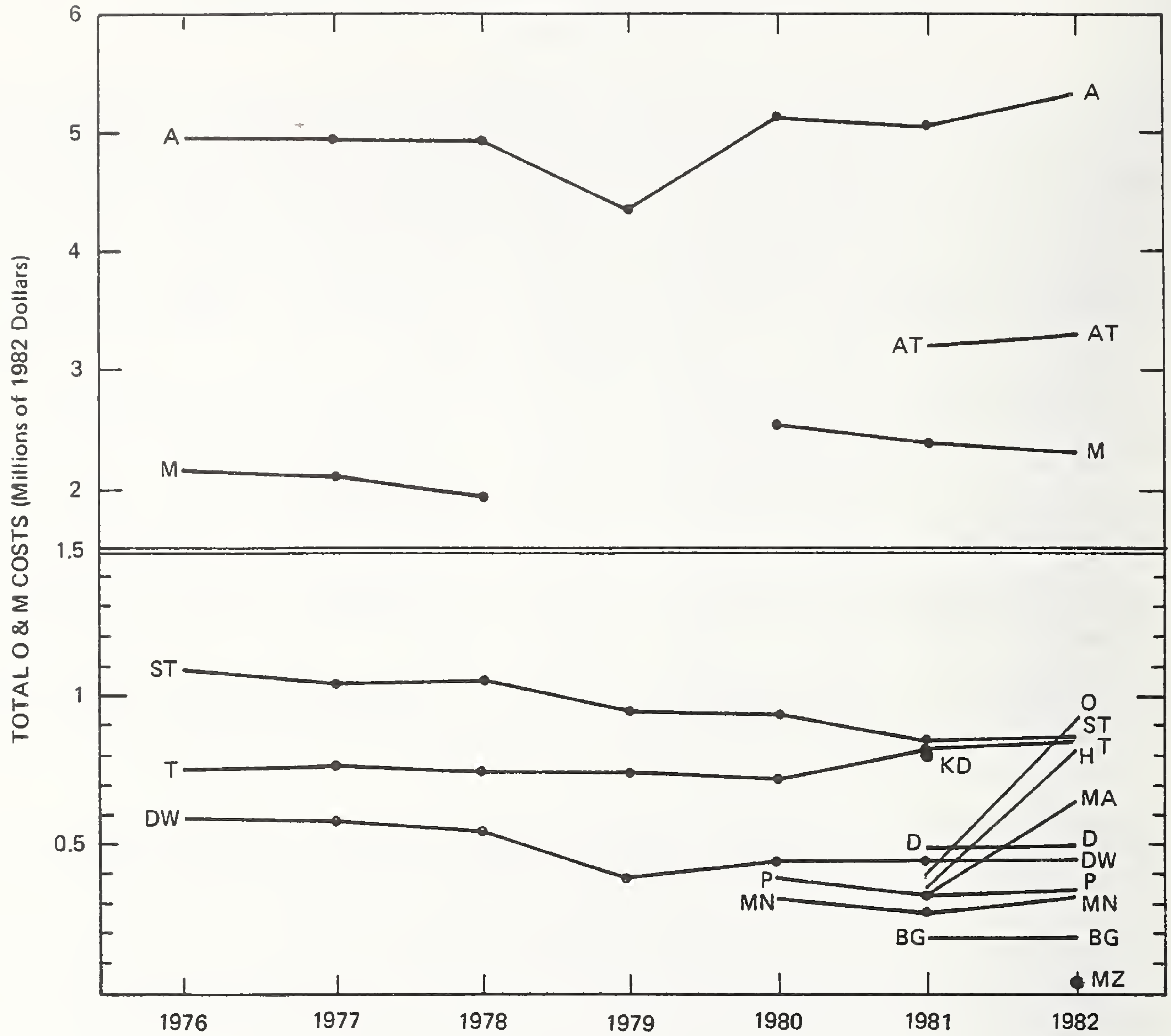
TABLE 6-1. SYSTEM COST HISTORY (Concluded)

TAMPA

CAPITAL COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Guideway	3,450			4,313	4,658	5,077	5,483
Stations	2,250			2,813	3,038	3,311	3,576
Maintenance & Support Capabilities	913			1,141	1,235	1,346	1,454
Power & Utilities	2,140			2,675	2,889	3,293	3,491
Vehicles	2,700			3,375	3,679	4,194	4,446
Command, Control, & Communications	1,380			1,725	1,880	2,143	2,272
Engineering & Project Management	1,470			1,882	2,127	2,340	2,480
Total System	14,303			17,924	19,506	21,704	23,202

O&M COSTS (K$)	1976	1977	1978	1979	1980	1981	1982
Labor	47	13	14	16	18	31	31
Utilities	57	62	74	77	86	89	85
Materials & Services	365	398	415	466	494	629	696
General & Adminstrative	10	11	11	13	14	17	17
Total System	479	484	514	572	612	766	829

OPERATIONAL STATISTICS (K)	1976	1977	1978	1979	1980	1981	1982
Vehicle Miles Traveled	405	396	412	412	365	355	328
Passengers Carried	14,500			16,356	19,224	17,223	19,355



KEY

A	– AIRTRANS	MZ	– MIAMI ZOO
AT	– ATLANTA	MN	– MINNESOTA ZOO
BG	– BUSCH GARDENS	M	– MORGANTOWN
DW	– DISNEYWORLD	O	– ORLANDO
D	– DUKE	P	– PEARLRIDGE
H	– HOUSTON	ST	– SEA-TAC
KD	– KING'S DOMINION	T	– TAMPA
MA	– MIAMI AIRPORT		

FIGURE 6-1. TREND OF O&M COSTS

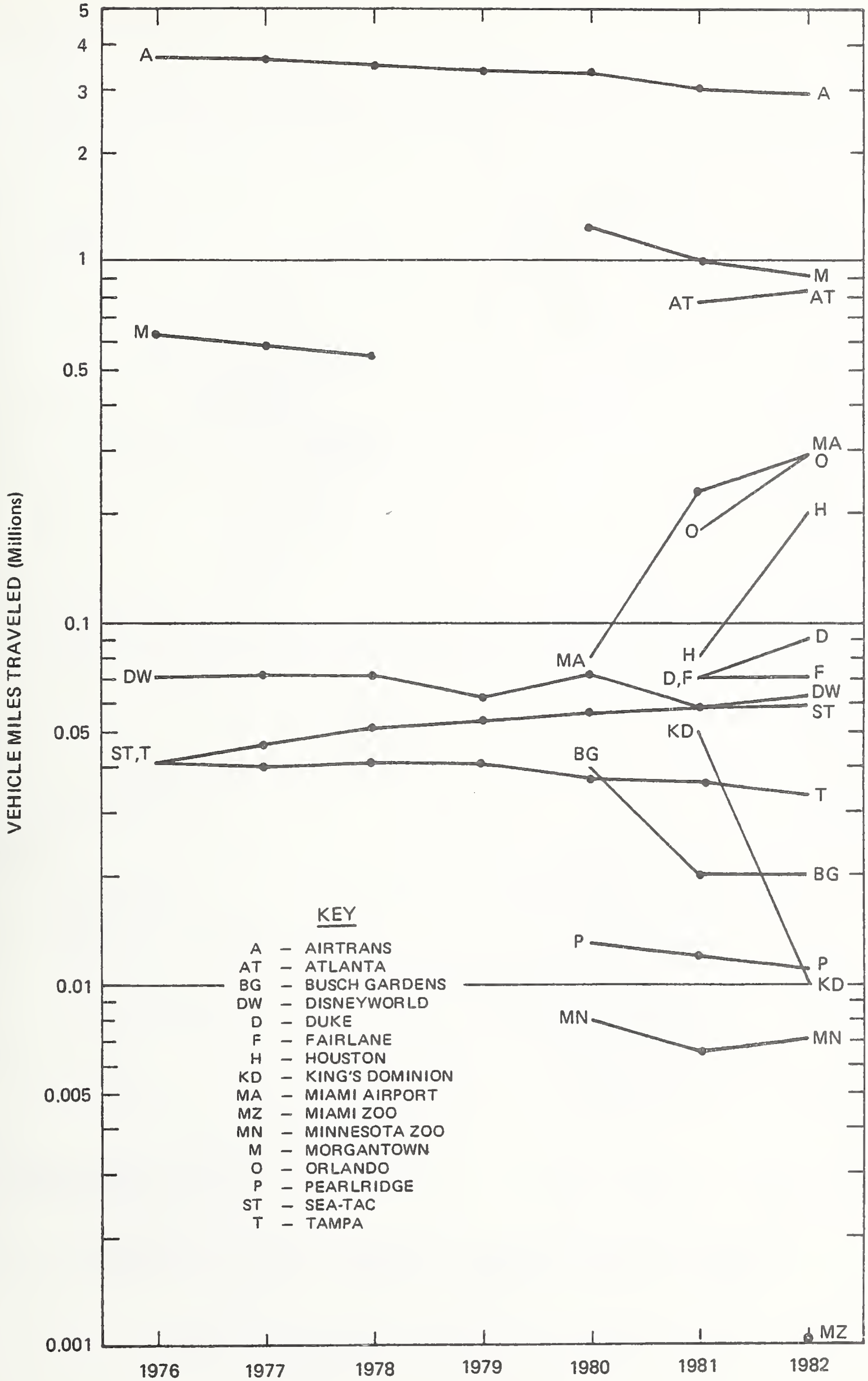


FIGURE 6-2. TREND OF VEHICLE MILES TRAVELED

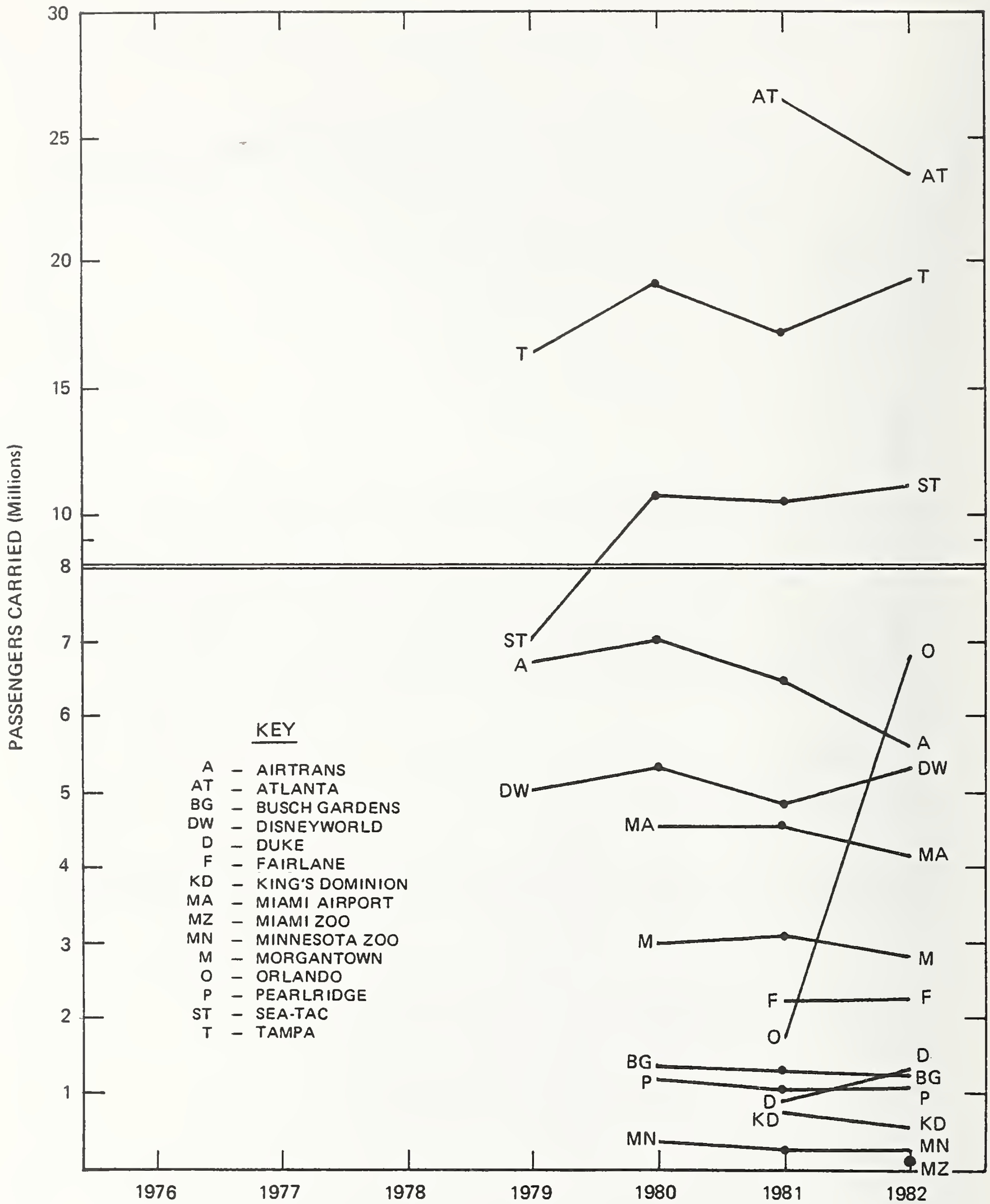


FIGURE 6-3. TREND OF PASSENGERS CARRIED

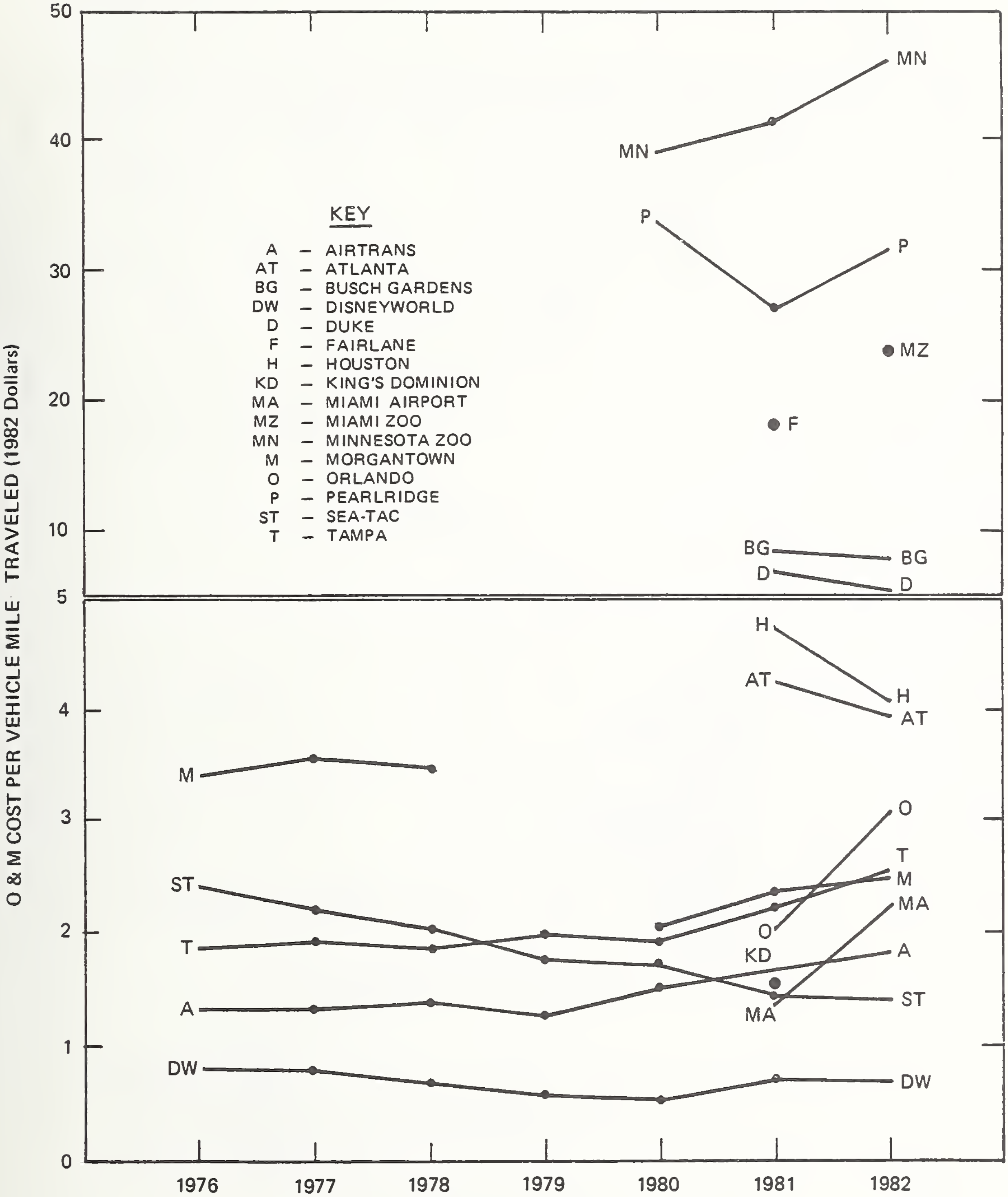


FIGURE 6-4. TREND OF O&M COST PER VEHICLE MILE TRAVELED

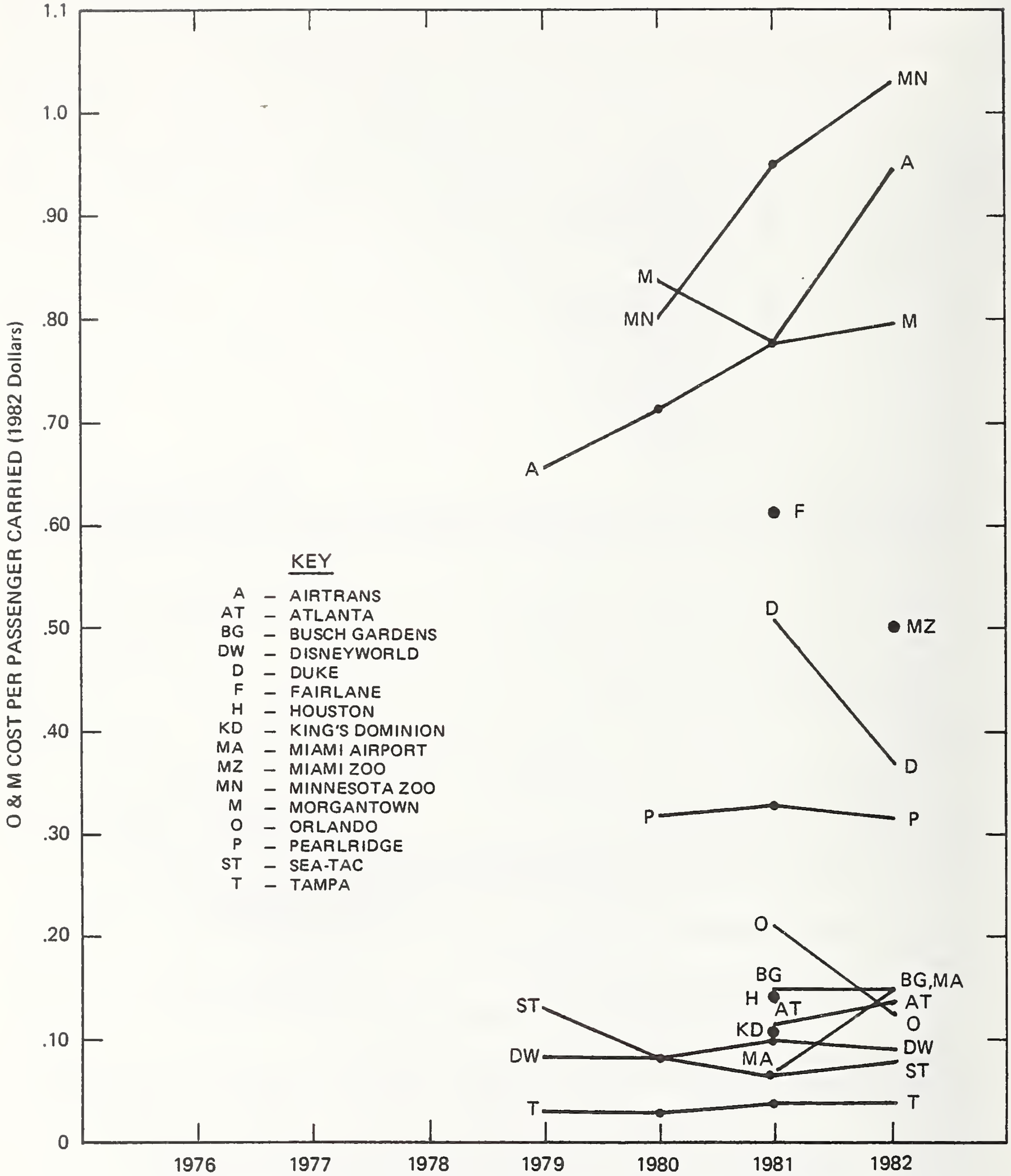
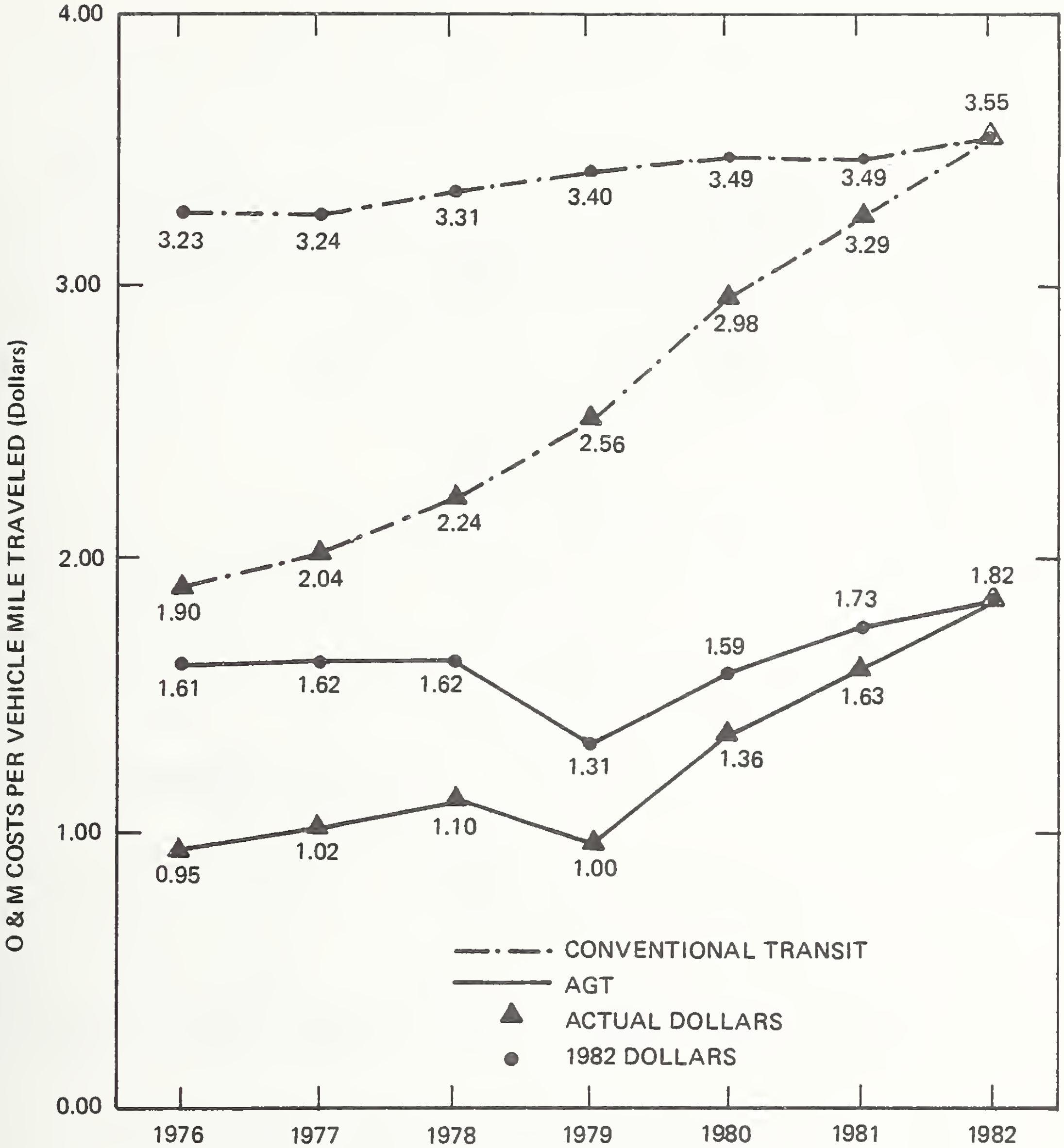
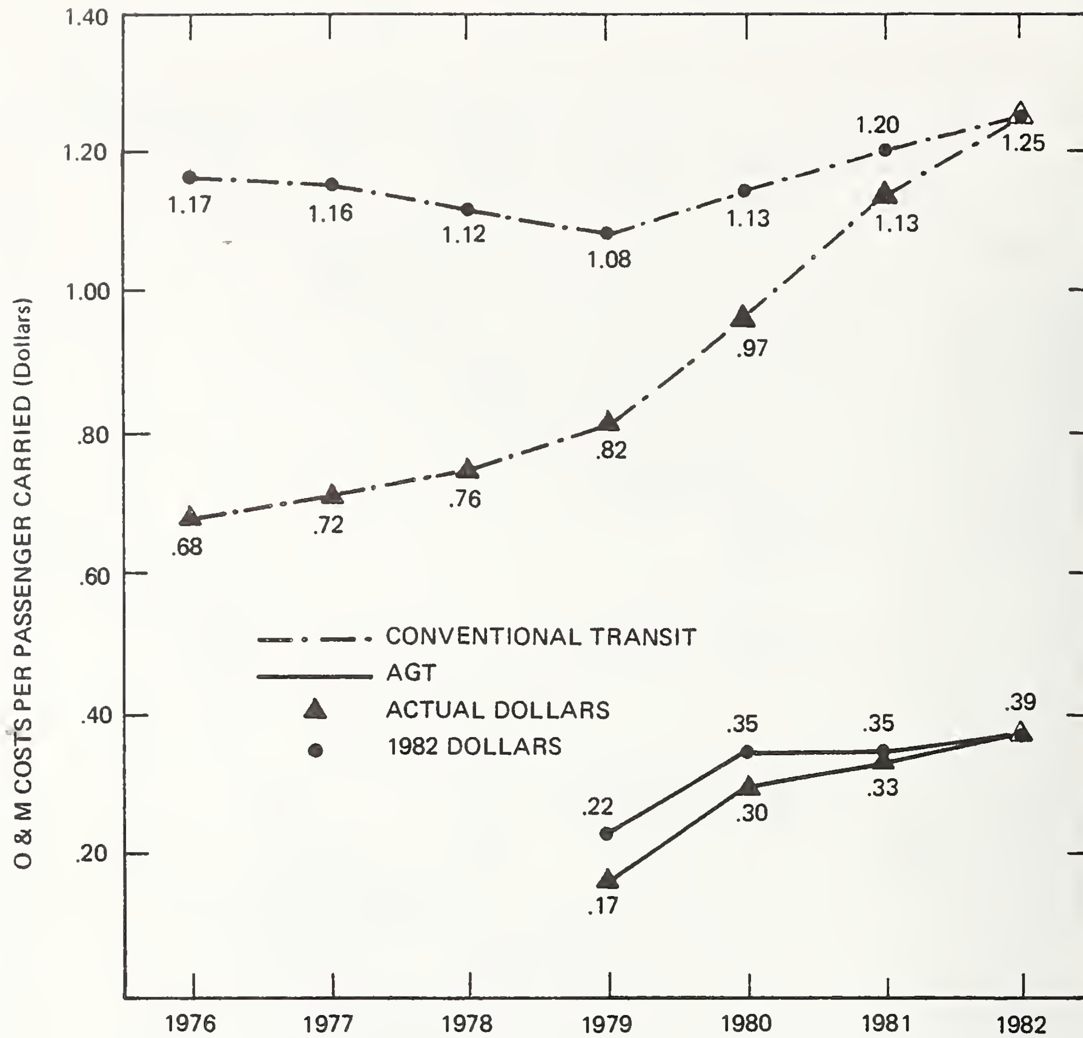


FIGURE 6-5. TREND OF O&M COST PER PASSENGER CARRIED



NOTE: AGT costs are a five system average of Airtrans, Disneyworld, Morgantown, Sea-Tac, and Tampa.

FIGURE 6-6. TREND OF O&M COSTS PER VEHICLE MILE TRAVELED FOR AGT AND CONVENTIONAL TRANSIT SYSTEMS



NOTE: AGT costs are a five system average of Airtrans, Disneyworld, Morgantown, Sea-Tac, and Tampa.

FIGURE 6-7. TREND OF O&M COSTS PER PASSENGER CARRIED FOR AGT AND CONVENTIONAL TRANSIT SYSTEMS

6.4 DISCUSSION OF COST VARIATIONS

The data contained in Table 6-1 was first collected in 1976 for the systems at Airtrans, Disneyworld, Morgantown, Sea-Tac, and Tampa as part of the AGT Assessment Project. Over the past seven years information on eleven additional systems has been obtained. In some instances gaps or inconsistencies in the data has occurred. Some of the variations that may be observed are addressed below.

The number of passengers carried on each system were not recorded prior to 1979. In 1979, O&M costs and statistics for Morgantown were not available because the system was shut down for expansion. Fairlane has declined to submit O&M costs and labor statistics reasoning that they are proprietary information. There has also been several other cases of systems not submitting complete O&M cost data.

The years 1976 through 1979 represent a transition period in which a standard format for collecting and presenting this data was being formulated. As a result, capital costs were not always recorded in the categories shown in Table 6-1. This is most noticeable by the lack of these costs in 1977 and 1978 for the original five systems in this report.

Having decided upon a standard format, capital costs were collected for seven more systems in 1979 with O&M cost data for these systems recorded during the next two years. Although O&M costs for Pearlridge and Duke have been recorded since 1980 and 1981, respectively, capital costs were not obtained until this past year (1982). Costs for maintenance and support capabilities, power and utilities, and one of the stations at Duke were not given since they were included in the cost of the overall facility. An attempt will be made to estimate duplication costs for these categories in next year's report. Only the total construction cost for Pearlridge was able to be obtained since the supplier has subsequently discontinued its transportation services.

It is planned that future reports will include data for new systems as each becomes operational (as was done in the case of Miami Zoo this past year).

As previously stated, capital costs are adjusted annually to present these costs in current year dollars. However, at some systems capital costs may increase by more than the cost index due to the acquisition of new equipment or expansion of facilities. This was the case at the following:

- Morgantown in 1980 after the upgrading and extension of the system was completed,

- Houston in 1980 upon the installation of a new AGT technology, and

- Miami Airport in 1981 and Sea-Tac in 1982 where new vehicles were purchased.

6.5 ANALYSIS OF COST TRENDS

Trend analysis can be useful when evaluating system services as well as determining a system's fiscal viability. However, it is difficult to arrive at steadfast conclusions regarding AGT cost trends because of the lack of long term data for all systems. Furthermore, the type of analysis necessary to pinpoint all reasons for specific trends or fluctuations in the available data is beyond the scope of this report. To illustrate this point, a larger cost per vehicle mile traveled may result even though the systems are operating more efficiently due to an increase in utility rates or a decrease in vehicle miles logged. (Recall the effects of the energy crisis in the 1970's and the air traffic controllers strike in 1981 on the frequency of travel.) Therefore, the financial histories are included in this report mainly to show how the capital and O&M costs change from year to year and to provide a basis for projecting AGT costs in the future. To follow are some general comments highlighting the data presented in the cost exhibits.

Trends in capital costs are not shown since these costs are simply adjusted according to inflation. However, it can be discerned that non-airport systems, excluding Morgantown, average $11 million in total construction costs while airport systems cost over four times as much (an average of $48 million).

Using the five oldest, year-round systems as a baseline, average O&M costs and operating statistics have remained relatively stable. Average cost data for all the systems combined is variable because the operating policies employed at the systems are so diverse. Also, the degree of system maturity will impact the stability of average costs. That is, a new system will usually experience higher O&M costs during start-up than will be found once steady-state operation is achieved. This phenomenon should be evident in following the trends for Houston, Orlando, and Miami Zoo over the next few years.

6.6 COMPARISON OF AGT AND CONVENTIONAL TRANSIT COST TRENDS

As AGT systems become more prominent in urban, downtown settings, comparisons with competing conventional transit modes on the basis of service characteristics and overall economics are inevitable. Despite the limitations of existing data and the need to make further refinements to reflect the influence of design- and site-specific factors, it appears that AGT systems have the potential to compete economically with conventional modes in a variety of situations. Again, an in-depth analysis of AGT costs in relation to conventional transit modes is beyond the scope of this study. However, it is considered appropriate to cite certain cost comparisons.

Trends of O&M costs per vehicle mile traveled and passenger carried for AGT and conventional transit systems are shown in Figures 6-6 and 6-7. O&M costs per vehicle mile traveled for both AGT and conventional transit have risen over the last seven years with conventional transit costs being double that of AGT costs. Since data on passengers carried for AGT systems have only been available for the last four years, no significant trends can be discerned. However, large O&M cost differences per passenger carried can be observed, with AGT costs approximately 70 percent less than conventional transit costs.

APPENDIX A

AGT REFERENCES

AGT SOCIO-ECONOMIC RESEARCH PROGRAM DOCUMENTS

Assessments

Assessment of Operational Automated Guideway Systems -- AIRTRANS (Phase I); Sept. 1976; Transportation Systems Center; UMTA-MA-06-0067-76-1; PB-261339.

Assessment of Operational Automated Guideway Systems -- AIRTRANS (Phase II); Jan. 1980; Transportation Systems Center and Institute de Recherche des Transports; DOT-TSC-UMTA-79-19; UMTA-MA-06-0067-79-1; PB-80-182538.

Assessment of Operational Automated Guideway Systems -- Jetrail; Dec. 1977; Transportation Systems Center; DOT-TSC-UMTA-77-55; UMTA-MA-06-0067-77-1; PB-278521.

Assessment of the Atlanta Airport Automated Transit System; June 1982; N.D. Lea & Associates, Inc.; UMTA-IT-06-0248-82-1; PB-83-145714.

Assessment of the Automatically Controlled Transportation (ACT) System at Fairlane Town Center; Dec. 1977; SRI International; UMTA-IT-06-0135-77-2; PB-286524.

Assessment of the Busch Gardens Automated Anheuser-Busch Shuttle System; Nov. 1979; N.D. Lea & Associates, Inc.; UMTA-IT-06-0188-79-4; PB-80-127384.

Assessment of the Mueller Aerobus System; Sept. 1979; N.D. Lea & Associates, Inc.; UMTA-IT-06-0189-79-2; PB-80-130636.

Assessment of the Passenger Shuttle System (PSS) at Tampa International Airport; Dec. 1977; SRI International; UMTA-IT-06-0135-77-4; PB-285597.

Assessment of the Phase I Morgantown People Mover System; Oct. 1979; N.D. Lea & Associates, Inc. and SNV Studiengesellschaft Nahvenkehr mbH; UMTA-IT-06-0157-79-1; PB-80-177926.

Assessment of the Satellite Transit System (STS) at the Seattle-Tacoma International Airport; Dec. 1977; SRI International; UMTA-IT-06-0135-77-1; PB-281820.

Assessment of the Tunnel Train System at the Houston Intercontinental Airport; Dec. 1977; SRI International; UMTA-IT-06-0135-77-3; PB-286641.

Assessment of the UMI Type II Tourister AGT System at King's Dominion; Dec. 1977; SRI International; UMTA-IT-06-0135-77-6; PB-286513.

Assessment of the WEDway People Mover System at Walt Disney World; Dec. 1977; SRI International; UMTA-IT-06-0135-77-5; PB-286935.

Automated Guideway Transit - An Assessment of PRT and Other New Systems; June 1975; Office of Technology Assessment; PB-244845.

Description and Technical Review of the Duke University Automated People/Cargo Transportation System; Aug. 1979; N.D. Lea & Associates, Inc.; UMTA-IT-06-0188-79-2; PB-80-159734.

Description and Technical Review of the Miami International Airport Satellite Transit Shuttle System; Sept. 1979; N.D. Lea & Associates, Inc.; UMTA-IT-06-0188-79-3.

Description of the VAL Automated Guideway Transit System; March 1978; Transportation Systems Center and Institute de Recherche des Transports; UMTA-TSC-UM836- PM78-7.

Development/Deployment Investigation of the Cabintaxi/Cabinlift Systems; Dec. 1977; Transportation Systems Center and SNV Studiengesellschaft Nahvenkehr mbH; DOT-TSC-UMTA-77-51; UMTA-MA-06-0067-77-2; PB-277184.

Development/Deployment Investigation of the H-Bahn System; Jan. 1981; Transportation System Center and SNV Studiengesellschaft Nahvenkehr mbH; DOT-TSC-UMTA-81-6; UMTA-06-0069-81-1; PB-81-214991.

Interim Assessment of the VAL Automated Guideway Transit System; Nov. 1981; Transportation Systems Center and Institute de Recherche des Transports; DOT-TSC-UMTA-81-34; UMTA-MA-06-0069-81-3; PB-82-163783.

Preliminary Data Base for Existing Automated Guideway Transit Systems; Dec. 1977; MITRE Corporation; UMTA-VA-06-0040-77-1.

Roosevelt Island Tramway System Assessment; Aug. 1979; N.D. Lea & Associates, Inc.; UMTA-IT-06-0189-79-1.

Technical Assessment of the Transette Transit System; Oct. 1981; Transportation System Center; DOT-TSC-UMTA-81-9; UMTA-MA-06-0069-81-4; PB-82-234360.

Transette System Application Study; Jan. 1982; MITRE Corporation; UMTA-VA-06-0056-81-2; PB-82-170226.

Cost Studies

Comparative Costs of Automated Guideway Transit (AGT) Systems; Feb. 1979; Custom Engineering, Inc.

Life-Cycle Cost Model for Comparing AGT and Conventional Transit Alternatives; Feb. 1976; General Research Corporation; UMTA-CA-06-0090-76-1; PB-259529.

Summary of Capital and Operations & Maintenance Cost Experience of Automated Guideway Transit Systems; June 1978; Transportation Systems Center - F.A.F. Cooke, C.P. Elms, T.J. McGean, H.W. Merrit; UMTA-IT-06-0157-78-2; PB-294306.

Supplement I: Summary of Capital and Operations and Maintenance Cost Experience of Automated Guideway Transit Systems Cost and Trends for the Period 1976-1978; March 1979; Transportation Systems Center - T.F. Comparato, T.M. Dooley, F.A.F. Cooke; UMTA-IT-06-0188-79-1; PB-80-146483.

Supplement II: Summary of Capital and Operations & Maintenance Cost Experience of Automated Guideway Transit Systems Costs and Trends for the Period 1976-1979; March 1980; Transportation Systems Center - T.F. Comparato, M.E. von Rosenvinge, D.C. Kendall; UMTA-MA-06-0069-80-1; PB-80-204878.

Supplement III: Cost Experience of Automated Guideway Transit Systems; July 1981; Transportation Systems Center - M.E. von Rosenvinge; UMTA-MA-06-0069-81-2; PB-81-245656.

Supplement IV: Cost Experience of Automated Guideway Transit Systems; Transportation Systems Center - W.I. Thompson III; Dec. 1982; UMTA-MA-06-0126-82-3; PB-83-162792.

Alternatives Analyses

AGT Aesthetics: A Handbook for Planning and Design of Automated Guideway Transit Systems; Feb. 1980; Skidmore, Owings, and Merrill; UMTA-IT-06-0165-79-2; PB-80-173594.

Environmental Impact Issues for Automated Guideway Transit Systems; Aug. 1976; MITRE Corporation; UMTA-VA-06-0025-77-2; PB-263640.

Generic Alternatives Analyses; June 1979; W.V. Rouse & Company, N.D. Lea & Associates, Inc., Kaiser Engineers, and R.J. Harman & Associates;

Vol. 1: Definition of Generic Modes and Application Areas, UMTA-IT-06-0168-80-1;

Vol. 2: Guidelines on Model Applicability, UMTA-IT-06-0168-80-2;

Vol. 3: Guidelines on Analysis Methodology, UMTA-IT-06-0168-80-3.

Guidelines for the Design and Evaluation of Human Factors Aspects of Automated Guideway Transit Systems; March 1979; Transportation Systems Center; DOT-TSC-UMTA-79-12; UMTA-MA-06-0081-79-1; PB-294817.

Guidelines for the Maintenance of Downtown People Mover (DPM) Systems; July 1979; Technology Research and Analysis Corporation; UMTA-VA-06-005580-1; PB-80-159361.

Impact of Advanced Group Rapid Transit Technology; Jan. 1980; Office of Technology Assessment; 052-003-0736-3; PB-80-153323.

Network Analyses of Advanced Group Rapid Transit Systems; April 1979; Johns Hopkins University; UMTA-MD-06-0025-79-2; PB-80-112006.

Review of Local Alternatives Analyses Involving Automated Guideway Transit; Feb. 1978; Urbitran Associates, Inc.; UMTA-NY-06-0057-78-1; PB-291334.

Urban Applications of Advanced Group Rapid Transit: An Alternatives Analysis Study; Sept. 1978; MITRE Corporation; UMTA-IT-06-0176-78-2.

Urban Impacts of AGT: Implications from Existing Transit Systems; July 1979; MITRE Corporation.

Market Research

An Analysis of the U.S. Market for Automated Guideway Transit; Nov. 1980; Cambridge Systematics, Inc. and National Analysts, Inc.;
Vol. 1: National Market Estimates, UMTA-IT-06-0165-79-1, PB-81-228793;
Vol. 2: Urban Area Case Studies, UMTA-IT-06-0165-79-3, PB-82-228801;
Vol. 3: A Case Study of Consumer Attitudes, UMTA-IT-06-0165-79-4, PB-82-228819.

Review of Downtown People Mover Project Proposals: Preliminary Market Implications for Downtown Applications of Automated Guideway Transit; Dec. 1977; MITRE Corporation; UMTA-IT-06-0176-77-1; PB-281068.

<u>Communications</u>

AGT Socio-Economic Research Program Digest; May 1981; Transportation Systems Center; DOT-TSC-UMTA-81-12.

Automated Guideway Transit Socio-Economic Research Program Findings, 1976-1979; Feb. 1980; MITRE Corporation; UMTA-IT-06-0176-80-1; PB-80-184633.

Institute of Transportation Engineers 48th Annual Meeting; Aug. 1978; Technical Paper: "Automated Guideway Transit - Perceptions, Problems, and Prospects".

Proceedings - Advanced Transit Association International Conference; April 1978; "Advanced Transit and Urban Revitalization - An International Dialogue", Vol. I and II.

AGT TECHNOLOGY PROGRAM DOCUMENTS

Systems Operations Studies:

Summary Report; Feb. 1980; General Motors Corporation (GMC); DOT-TSC-UMTA-79-26; UMTA-MA-06-0048-80-2; PB-81-101693.

Classification and Definition of AGT Systems; Feb. 1980; GMC; DOT-TSC-UMTA-79-50; UMTA-MA-06-0048-80-3; PB-80-226509.

Representative Application Areas for AGT; Nov. 80; GMC; DOT-TSC-UMTA-80-30; UMTA-MA-06-0048-80-1; PB-81-154551.

Feeder Systems Model Functional Specification; June 1981; GMC; DOT-TSC-UMTA-81-14; UMTA-MA-06-0048-81-1; PB-81-233496.

System Availability Model User's Manual; June 1981; GMC; DOT-TSC-UMTA-81-12; UMTA-MA-06-0048-81-2; PB-81-233504.

System Availability Model Functional Specification; June 1981; GMC; DOT-TSC-UMTA-81-15; UMTA-MA-06-0048-81-3; PB-81-233512.

System Availability Model Programmer's Manual; June 1981; GMC; DOT-TSC-UMTA-81-13; UMTA-MA-06-0048-81-4; PB-81-233520.

Detailed Station Model Functional Specification; July 1981; GMC; DOT-TSC-UMTA-81-16; UMTA-MA-06-0048-81-5; PB-81-233538.

Quantitative Analysis of Alternative AGT Operational Control Strategies; Oct. 1981; GMC; DOT-TSC-UMTA-81-26; UMTA-MA-06-0048-81-6; PB-81-148958.

Detailed Station Model User's Manual; Oct. 1981; GMC; DOT-TSC-UMTA-81-41; UMTA-MA-06-0048-81-7.

Detailed Station Model Programmer's Manual; Jan. 1982; GMC; DOT-TSC-UMTA-81-44, I; UMTA-MA-06-0048-81-8.

Detailed Station Model Programmer's Manual- Appendix; Jan. 1982; GMC; DOT-TSC-UMTA-81-44, II; UMTA-MA-06-0048-81-9.

Discrete Event Simulation Model Programmer's Manual; June 1982; GMC; UMTA-MA-06-0048-82-1.

Discrete Event Simulation Model User's Manual; June 1982; GMC; UMTA-MA-06-0048-82-2; PB-82-258518.

Feeder System Model User's Manual; Nov. 1982; Transportation Systems Center; UMTA-MA-06-0048-82-3; PB-83-161695.

Extended Systems Operations Studies:

Procedure for the Analysis of Representative AGT Deployments; Dec. 1981; GMC; DOT-TSC-UMTA-81-55; UMTA-MA-06-0048-81-10; PB-82-192246.

Final Report; Feb. 1982; GMC; DOT-TSC-UMTA-81-67; UMTA-MA-06-0048-81-12; PB-82-194119.

Systems Safety and Passenger Security Studies:

Automated Guideway Transit System Passenger Security Guidebook; Jan. 1980; Dunlap and Associates, Inc.; UMTA-MA-06-0048-79-7.

Closed Circuit Television in Transit Stations: Application Guidelines; Aug. 1980; Dunlap and Associates, Inc.; DOT-TSC-UMTA-80-33; PB-81-122913.

Effects of Deceleration and Rate of Deceleration on Live Seated Human Subjects; 1977; Dunlap and Associates, Inc.; DOT-TSC-UMTA-77-44; UMTA-MA-06-0048-77-3; PB-284653.

Evacuation and Rescue in AGT; Dec. 1979; Vought Corporation;

Vol. I: Data Collection, Scenarios, and Evaluation, DOT-TSC-UMTA-79-47-I;PB-80-195761;

Vol. II: Guidebook, DOT-TSC-UMTA-79-47-II, PB-80-195779.

Factors Contributing to the Retention of Seated Passengers During Emergency Stops; March 1980; Dunlap and Associates, Inc.; DOT-TSC-UMTA-79-52; PB-80-195134.

Passenger Safety and Convenience Services in AGT; Dec. 1979; Vought Corporation;

Vol. I: Data Collection, Scenarios, and Evaluation, DOT-TSC-UMTA-79-48-I, PB-80-167059;

Vol. II: Guidebook, DOT-TSC-UMTA-79-48-II, PB-80-167067.

Passenger Value Structure Model; July 1980; Dunlap and Associates, Inc.; DOT-TSC-UMTA-80-23; PB-81-120815.

Vehicle Lateral Control and Switching Studies:

Vehicle Lateral Control and Switching; Otis Elevator Company;

Vol. I: Project Summary, March 1980, UMTA-IT-06-0156-79-1, PB-80-199722;

Vol. II: Parts A and B - Design and Analysis, March 1980, UMTA-IT-06-0156-79-2/3, PB-80-199730;

Vol. III: Detailed Hardware Studies, March 1980, UMTA-IT-06-0156-79-4, PB-80-199755;

Vol. IV: Test Program, March 1980, UMTA-IT-06-0156-79-5, PB-80-199763;

Vol. V: Data Base, Feb. 1979, UMTA-IT-06-0156-79-6, PB-80-199771;

Vol. VI: Software Manual, March 1980, UMTA-IT-06-0156-79-7, PB-80-199787.

Vehicle Longitudinal Control and Reliability Studies:

Vehicle Longitudinal Control and Reliability; Otis Elevator Company;

Vol. I: Project Summary, June 1979, UMTA-IT-06-0148-79-10, PB-81-218406;

Vol. II: Part A - A Review of AGT Control and Measurement System Technology, June 1979, Part B - A Review of AGT Communication System Technology, July 1979, Part C - A Review of AGT Propulsion, Power Conditioning, Braking, and Power Distribution Technology, Part D - A Review of Entrainment Technology, Feb. 1979, UMTA-IT-06-0148-79-4,3,2,1;

Vol. III: Part A - Longitudinal Control Analysis and Design, SLT and GRT Systems, May 1979, UMTA-IT-06-0148-79-7, PB-298766, Part B - Longitudinal Control Analysis and Design, PRT Systems, May 1979, UMTA-IT-06-0148-79-8, PB-298767;

Vol. IV: Reliability Enhancement Analysis and Design, May 1979, UMTA-IT-06-0148-79-9;

Vol. V: Parts A and B - Entrainment and Platooning Analysis and Design, Feb. 1979, UMTA-IT-06-0148-79-5, PB-299798, Appendix - TRAINSIM User's Guide, Feb. 1979, UMTA-IT-06-0148-79-6, PB-297129;

Vol. VI: VLCR Cost and Weight Models, UMTA-IT-06-0148-79-11,

Vol. VII: Experimental Program Methodology and Test Results, Dec. 1979, UMTA-IT-06-0148-79-12, PB-81-218133;

Vol. VIII:VLCR Data Base, Sept. 1979, UMTA-IT-06-0148-79-13.

Guideway and Station Technology Studies:

AGT Guideway and Station Technology; DeLeuw, Cather, and Company;

Vol. I: Executive Summary, July 1979, UMTA-IT-06-0152-79-8, PB-299553;

Vol. II: Weather Protection Review, March 1979, UMTA-IT-06-0152-79-1, PB-281632;

Vol. III: Guideway and Station Review, Sept. 1979, UMTA-IT-06-0152-79-2, PB-287522;

Vol. IV: Design Guidelines, March 1979, UMTA-IT-06-0152-79-3, PB-295613;
Vol. V: Evaluation Models, June 1979, UMTA-IT-06-0152-79-4, PB-299034;
Vol. VI: Dynamic Model, July 1979, UMTA-IT-06-0152-79-5, PB-299153;
Vol. VII: Guideway and Station Concepts, July 1979, UMTA-IT-06-0152-79-6; PB-299411;
Vol. VIII: Weather Protection Concepts, Aug. 1979, UMTA-IT-06-0152-79-7; PB-299746.

Cold Weather Transit Technology; University of Notre Dame;
Vol. I: Executive Summary, Sept. 1981, UMTA-IN-06-0009-82-1, PB-83-178533;
Vol. II: Physics of Ice and Snow at the Interface with Transitway Surfaces, Sept. 1981, UMTA-IN-06-0009-82-2, PB-83-162438;
Vol. III: Characteristics of Ice and Snow at the Interface with Transit Vehicle Surfaces, Sept. 1981, UMTA-IN-06-0009-82-3, PB-83-159871;
Vol. IV: Advanced Countermeasures for Combatting Ice and Snow Problems, Sept 1981, UMTA-IN-06-0009-82-4, PB-83-162099;
Vol. V: Transitway Design Concepts for Improving System Performance Under Cold Weather Conditions, Sept. 1981, UMTA-IN-06-0009-82-5, PB-83-128736;
Vol. VI: Planning for a National CWTT Research Center, Sept. 1981, UMTA-IN-06-0009-82-6, PB-83-134684;
Vol. VII: Lightweight Transit Vehicle Traction Performance on Ice and Snow, April 1982, UMTA-IN-06-0009-82-7, PB-82-256488;
Vol. VIII: Development of Transitway Countermeasures for Combatting Ice and Snow Problems, April 1982 UMTA-IN-06-0009-82-8, PB-82-256496;
Vol. IX: Development of Vehicle Countermeasures for Combatting Ice and Snow Problems, April 1982, UMTA-IN-06-0009-82-9, PB-82-257287.

Associated/Supporting Studies:

AMTV Headway Sensor and Safety Design; Jan. 1980; Jet Propulsion Laboratory; UMTA-CA-06-0088-80-1; PB-80-179039.

Automated Mixed Traffic Vehicle System Design AMTV II; Jan. 1982; Jet Propulsion Laboratory; UMTA-CA-06-0088-82-1.

Independent Study of Personal Rapid Transit; Dec. 1977; Aerospace Corporation; UMTA-CA-06-0090-77-1; PB-287869.

Operation of Automated Guideway Transit Vehicles in Dynamically Reconfigured Trains and Platoons; Massachusetts Institute of Technology;
Extended Summary, April 1979, UMTA-MA-06-0085-79-1, PB-300513;
Vol I: Part I - Applications Analysis, Part II - Vehicle Dynamics, July 1979, UMTA-MA-06-0085-79-2, PB-80-142862;
Vol II: Part III - Systems Operations Analysis, Oct. 1979, UMTA-MA-06-0085-79-3, PB-80-198856.

Point-Follower Automatic Vehicle Control: A Generic Analysis; May 1977; Johns Hopkins University; UMTA-MD-06-0022-77-1; PB-270354.

Safety and Reliability of Automated Guideway Transit Systems; March 1982; Battelle Columbus Laboratories; UMTA-OH-06-0028-82-1; PB-82-202375.

Study of Hydrostatic Drives for Small AGT Vehicles; Oct. 1978; Mobility Systems and Equipment Company; UMTA-CA-06-0089-78-1; PB-298805.

The Development of Measures of Service Availability; June 1978; Battelle Columbus Laboratories;
Vol. I: Summary Report, UMTA-MA-06-0048-78-2, PB-294804;
Vol. II: Task Technical Reports, UMTA-MA-06-0048-78-3, PB-294805;
Vol. III: Application Guideline Manual, UMTA-MA-06-0048-78-4, PB-294806.

Vehicle Data Acquisition System; 1979; Port of Seattle; UMTA-WA-06-0009-79-1.

Vehicle-Follower Controls for Short Headway AGT Systems - Functional Analysis and Conceptual Designs; Dec. 1976; Johns Hopkins University; UMTA-MD-06-0018-76-4, PB-266272.

Vehicle Operating Strategies for Small Automated Guideway Transit Network; Aug. 1976; MITRE Corporation; UMTA-VA-06-0025-77-1; PB-262480.

Program Summaries:

Automated Guideway Transit Technical Data; April 1979; MITRE Corporation; UMTA-VA-06-0041-79-4; PB-295095.

Automated Guideway Transit Technology Overview; Feb. 1978; MITRE Corporation; UMTA-VA-06-0041-78-1.

Workshops/Conferences:

Automated Guideway Transit Service Availability Workshop; Feb. 1978; Transportation Systems Center; DOT-TSC-UMTA-77-46; UMTA-MA-06-0048-77-4; PB-282295.

Automated Guideway Transit Workshop on Performance Measures, Evaluation Techniques, and Goals; Aug. 1976; Johns Hopkins University; UMTA-MD-06-0022-77-4; PB-277046.

Proceedings - Conference on Automated Guideway Transit Technology Development; April 1978; Transportation Systems Center; DOT-TSC-UMTA-78-28; UMTA-MA-06-0048-78-1; PB-287864.

Proceedings of the UMTA R&D Priorities Conference (3rd); Nov. 1978; American Public Transit Association; UMTA-DC-06-0157-79-3; PB-300988.

Proceedings of Workshop on Methodology for Evaluating the Effectiveness of Transit Crime Reduction Measures in Automated Guideway Transit Systems; July 1977; Transportation Systems Center; DOT-TSC-UMTA-77-27; UMTA-MA-06-0048-77-1; PB-273695.

OTHER DOCUMENTS

Characteristics of Urban Transportation Systems; June 1979; DeLeuw, Cather & Company; UMTA-IT-06-0049-79-1.*

Evaluation of Rail Rapid Transit and Express Bus Service in the Urban Commuter Market; Oct. 1983; Institute for Defense Analyses; DOT-P-6520.1.*

Guidelines for the Estimation of Transit Costs; Nov. 1980; The Urban Institute.*

Intergration of AGT Systems with Other Transportation Modes; Dec. 1981; UMTA-WV-11-0003-82-2; PB-82-255621.

Rail Transit System Cost Study; March 1977; T.K. Dyer, Inc.; UMTA-MA-06-0025-77-12; PB-266918.*

Survey of Public Reaction to TRANSPO '72 Personal Rapid Transit Systems and UMTA-Sponsored Bus and Rail Exhibits; Nov. 1972; Century Research Corporation; UMTA-IT-06-0037-72-1; PB-214819.

Urban Rail in America: An Exploration of Criteria for Fixed Guideway Transit; Nov. 1980; Regional Planning Assocation, Inc.; UMTA-NY-06-0061-80-1; PB-82-106907.*

---

* Contain information pertaining to transit system construction and operation costs.

APPENDIX B

OTHER AGT SYSTEMS

OTHER DOMESTIC SYSTEMS

Location	Initial Construction	Initial Operation	Supplier
California Exposition and State Fair - Sacramento, CA	'67	5/68	UMI
Hershey Amusement Park - Hershey, PA	'67	7/69	UMI
Magic Mountain - Valencia, CA	'70	5/71	UMI
Carowinds - Charlotte, NC	'72	6/73	UMI
King's Island - Kings Mill, OH	'72	5/74	UMI
Bronx Zoo - New York, NY	'75	'77	Rohr
Louisiana World Exposition - New Orleans, LA	9/82	3/84	UMI
Metro-Dade DCM - Miami, FL	8/82	7/84	Westinghouse
McCarran International Airport - Las Vegas, NV	'83	1/86	Westinghouse
Central Automated Transit System - Detroit, MI	9/82	3/86	UTDC

OTHER FOREIGN SYSTEMS

Location	Initial Construction	Initial Operation	Supplier
Kobe Portliner - Kobe, Japan	5/78	5/81	Kawasaki, Mitsubishi, Kobe Steel
New Tram - Osaka, Japan	'77	'81	Niigata, Sumitomo, Toyo
VONA One - Yukarigaoka, Japan	'69	11/82	Mitsui, Nippon
VAL - Lille, France	'72	4/83	Engins MATRA
Gatwick Airport - London, England		4/83	Westinghouse
Birmingham Airport - England	'82	4/84	British Rail
Kokura Line - Kita Kyushu, Japan	'83	'84	Hitachi
M-Bahn - Berlin, Germany	'81	'85	Magnetbahn
Tokadai, Japan		'85	
Chiba, Japan		'86	

APPENDIX C

SYSTEM OVERVIEWS

AIRTRANS

SYSTEM CONTACT: D. Leftwich, Director of Transporation, 214-574-6000
R. McKeig, Manager

Dallas/Fort Worth Airport
P.O. Drawer DFW
Dallas/Fort Worth Airport, TX 75261

SYSTEM SUPPLIER: Vought Corporation
P.O. Box 225907
Dallas, TX 75222
214-266-2011

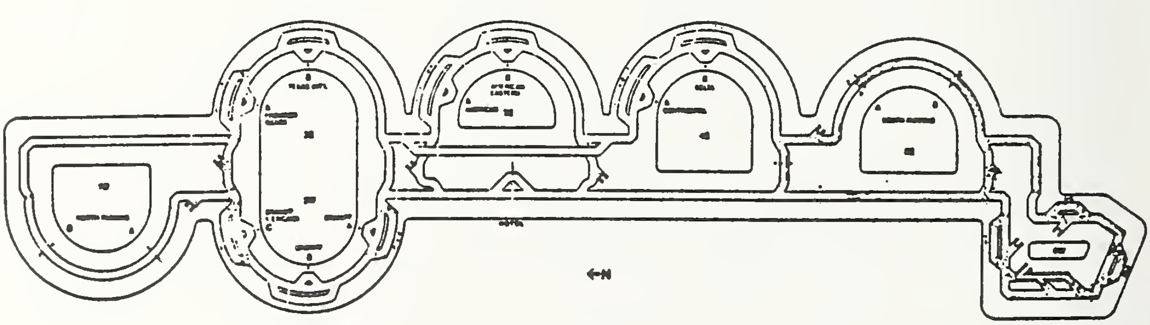
SYSTEM DESCRIPTION:

Airtrans, consisting of nearly 13 miles of guideway, is the most extensive AGT system in the United States. It was the first fully automated transit system to be established at an airport. Airtrans was designed to provide intra-airport transportation service for passengers and cargo between four main passenger terminals, two remote parking lots, a hotel, and maintenance and supply areas on a total of ten interconnecting routes.

As of January 1, 1983, over 48 million riders had been transported on the Airtrans system. The fifty-two passenger vehicles that serve the system can be run independently or coupled together in two-car trains.

In case of emergency or scheduled shutdowns, backup bus service will be supplied.

SYSTEM SCHEMATIC:



ATLANTA

SYSTEM CONTACT: M.W. Walker, Director of Planning and Development, 404-503-6600
K. Malone

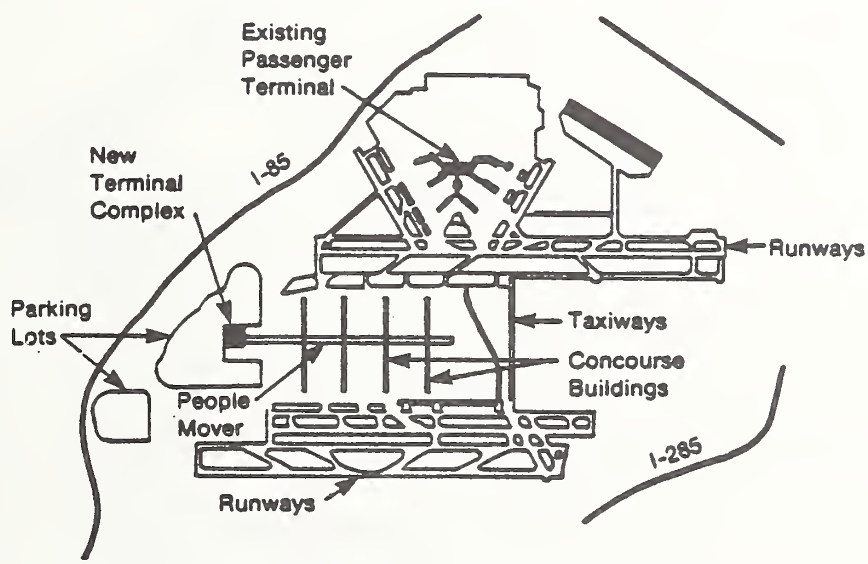
Hartsfield International Airport
Department of Aviation
Atlanta, GA 30320

SYSTEM SUPPLIER: Westinghouse Electric Corporation
Transportation Division
2001 Lebanon Road
West Mifflin, PA 15122
412-256-7000

SYSTEM DESCRIPTION:

The AGT system at Atlanta provides an automatic, underground connection between the new terminal complex and the four airside concourse buildings. The two parallel guideways, separated by a pedestrian walkway, are linked by a crossover at each end. A bypass is available on each lane in the middle of the system to allow two-way shuttle service when necessary.

SYSTEM SCHEMATIC:



BUSCH GARDENS

SYSTEM CONTACT: D. Potter, Operations Manager, 804-253-3200

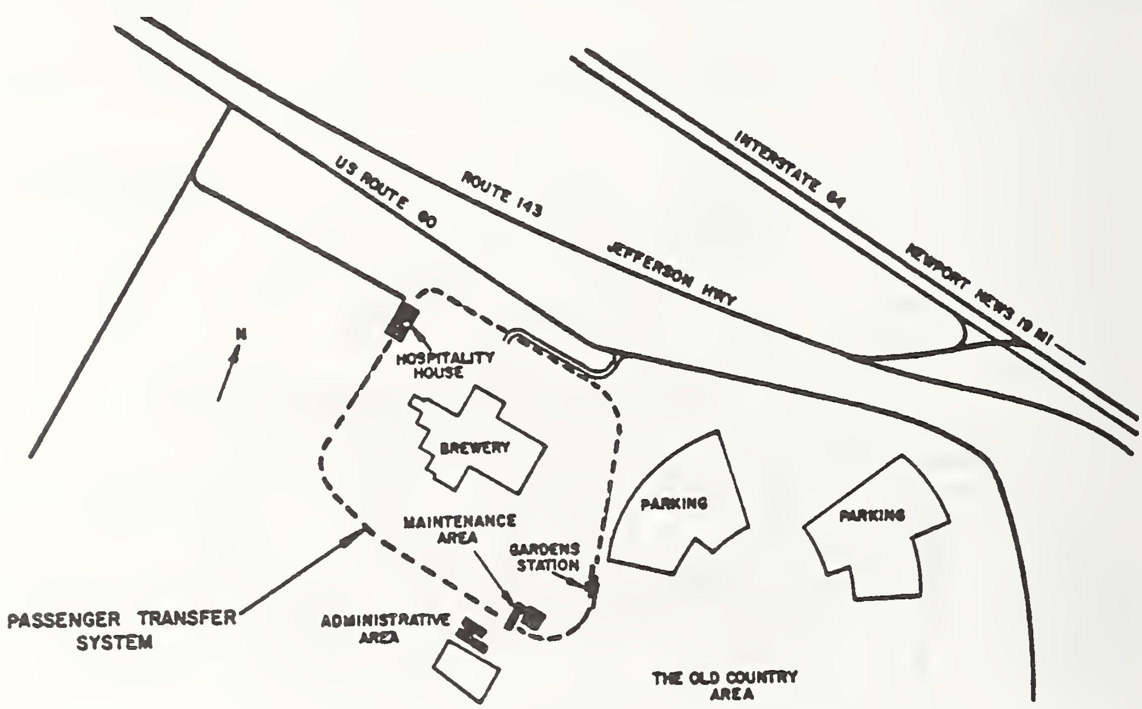
Busch Gardens
P.O. Drawer FC
Williamsburg, VA 23185

SYSTEM SUPPLIER: Westinghouse Electric Corporation
Transportation Division
2001 Lebanon Road
West Mifflin, PA 15122
412-256-7000

SYSTEM DESCRIPTION:

The Anheuser-Busch Shuttle System provides the sole means of transport for those visiting Busch Gardens who also want to tour the brewery adjacent to the amusement park. This single loop system is capable of operating in either the clockwise or counterclockwise direction.

SYSTEM SCHEMATIC:



DISNEYWORLD

SYSTEM CONTACT: R. Weidenbeck, General Manager, 305-824-5050
D. Welsh, Manager of Engineering

WED Transportation System, Inc.
P.O. Box 40
Lake Buena Vista, FL 32830

SYSTEM SUPPLIER: WED Transportation System, Inc.
P.O. Box 40
Lake Buena Vista, FL 32830
305-824-5050

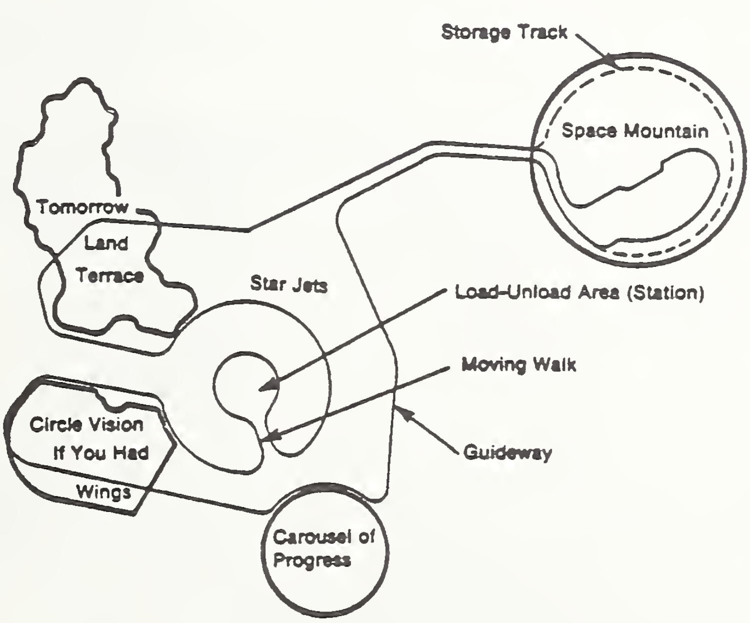
SYSTEM DESCRIPTION:

The WEDway People Mover is one of the major attractions at the Magic Kingdom theme park within Walt Disney World. It is designed to transport riders past a series of displays that preview life in the future.

A unique feature of this closed loop system is dynamic boarding; that is, the vehicles never stop. Passengers load and unload by stepping onto a rotating station platform which is synchronized with the speed of the vehicle. This system also represents a major advance in AGT technology by being the first system to use a linear induction motor propulsion system.

The first WEDway People Mover system was demonstrated at the New York World's Fair in 1964.

SYSTEM SCHEMATIC:



DUKE

SYSTEM CONTACT: A.E. Blalock, Maintenance Engineer, 919-681-4192
L.A. Bergen, Medical Planning Architect, 919-684-2578

Duke University Medical Center
P.O. Box 3901
Durham, NC 27710

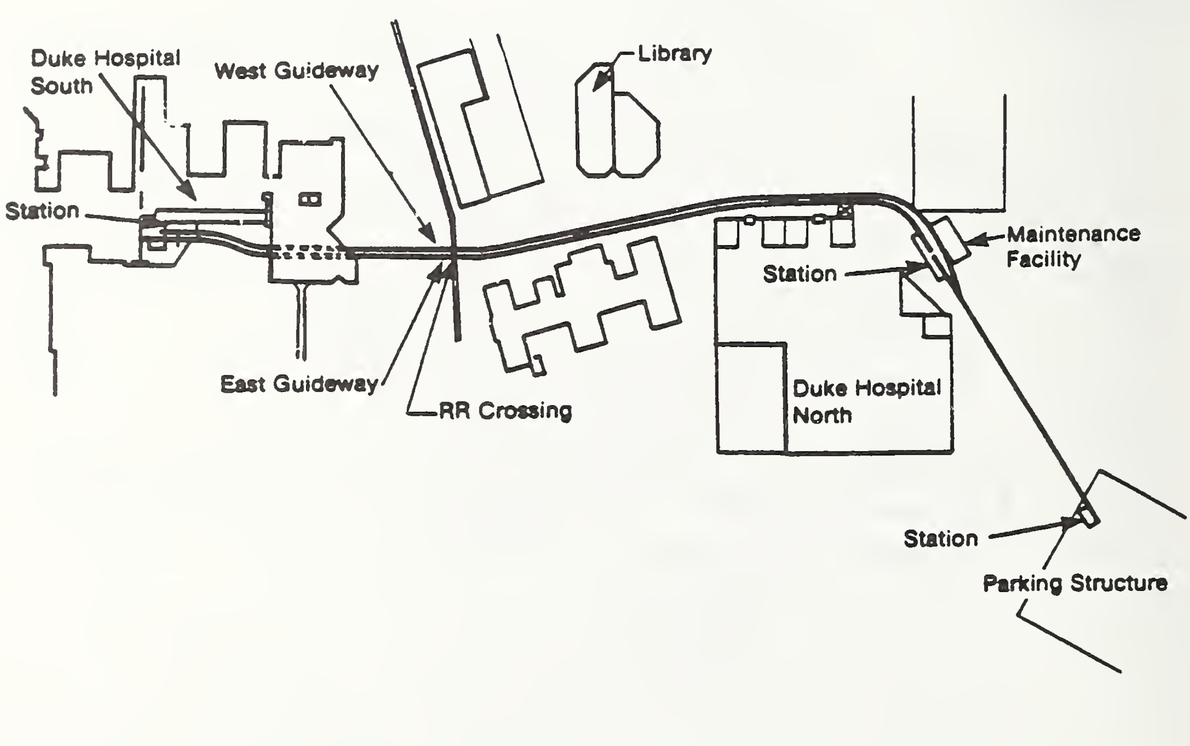
SYSTEM SUPPLIER: Otis Elevator Company
Transportation Technology Division
11380 Smith Road
P.O. Box 7293
Denver, CO 80207
303-343-8780

SYSTEM DESCRIPTION:

The AGT system at Duke University Medical Center provides shuttle transportation for both passengers and cargo between the hospital's North and South Buildings. An underground leg connecting the North Building and a remote parking area has been constructed and tested, but is inactive at this time.

The predominant technological characteristic of this system is that it was the first to be put into service with vehicles that utilized an air cushion suspension system in conjunction with a linear induction motor.

SYSTEM SCHEMATIC:



FAIRLANE

SYSTEM CONTACT: R. G. Reed, Supervisor - ACT System, 313-322-6348

Ford Aerospace & Communications Corporation
2015 Bailey Street
Dearborn, MI 48121

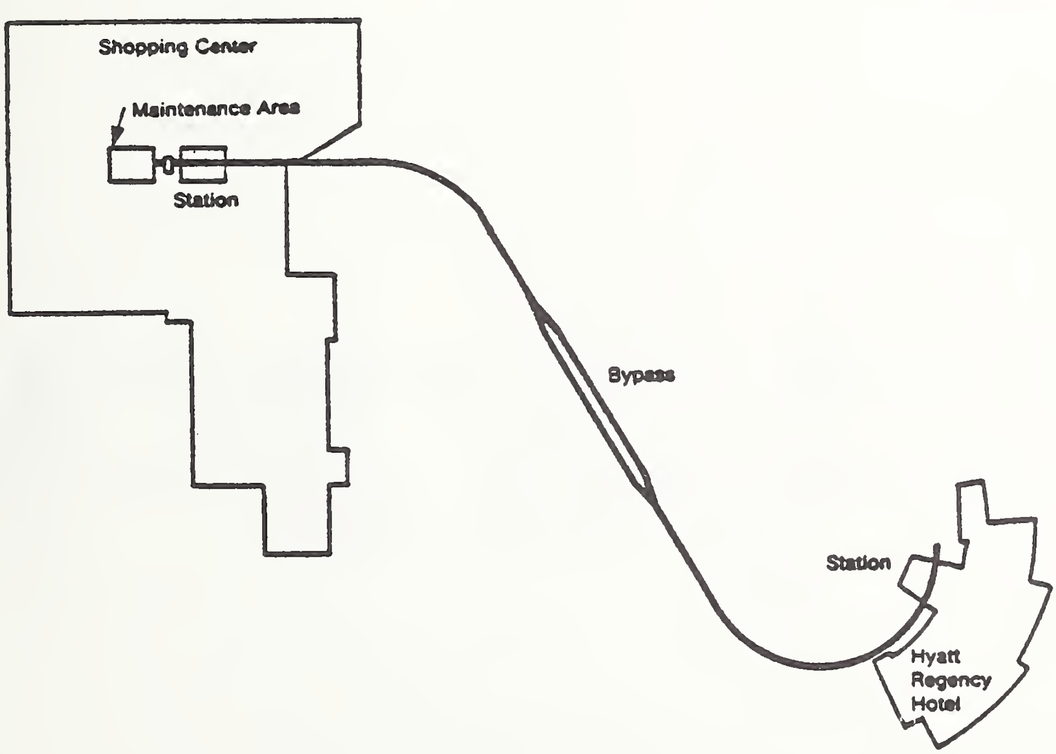
SYSTEM SUPPLIER: Ford Motor Company
World Headquarters
American Road
Dearborn, MI
313-322-3000

SYSTEM DESCRIPTION:

The Automatically Controlled Transportation (ACT) System offers transportation service for multi-purpose trips between the Fairlane Shopping Center and the Hyatt Regency Hotel. While this shuttle system with bypass is the focal point of the Fairlane Town Center complex, it is not essential to the functions of the mall or hotel. During shopping hours the vehicles are dispatched automatically, but when the stores are closed the system operates on demand.

The Ford Motor Company demonstrated its first ACT system at TRANSPO '72.

SYSTEM SCHEMATIC:



HOUSTON

SYSTEM CONTACT: R. Weidenbeck, General Manager, 305-824-5050
D. Welsh, Manager of Engineering

WED Transportation System, Inc.
P.O. Box 40
Lake Buena Vista, FL 32380

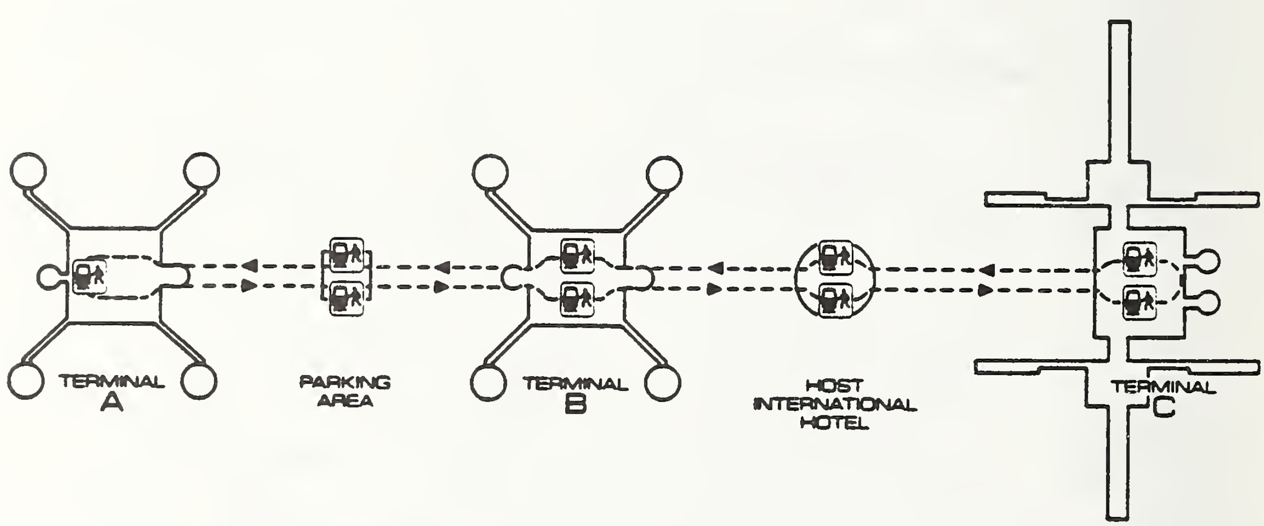
SYSTEM SUPPLIER: WED Transportation System, Inc.
P.O. Box 40
Lake Buena Vista, FL 32380
305-824-5050

SYSTEM DESCRIPTION:

The original battery-powered tug system supplied by Barrett encountered many design problems resulting from underdeveloped AGT technology. It was subsequently replaced in 1972 by a Tunnel Train System purchased from the Westinghouse Air Brake Company and later sold to Rohr Industries.

The current system opened for service in 1981 and is the first public application of the WEDway People Mover developed at Walt Disney World. It provides underground, automated shuttle service for passengers between three airline terminals, a hotel, and remote parking areas.

SYSTEM SCHEMATIC:



KING'S DOMINION

SYSTEM CONTACT: A. Ryland, Rides Manager, 804-876-5000
D. Jeffers, 804-876-5260

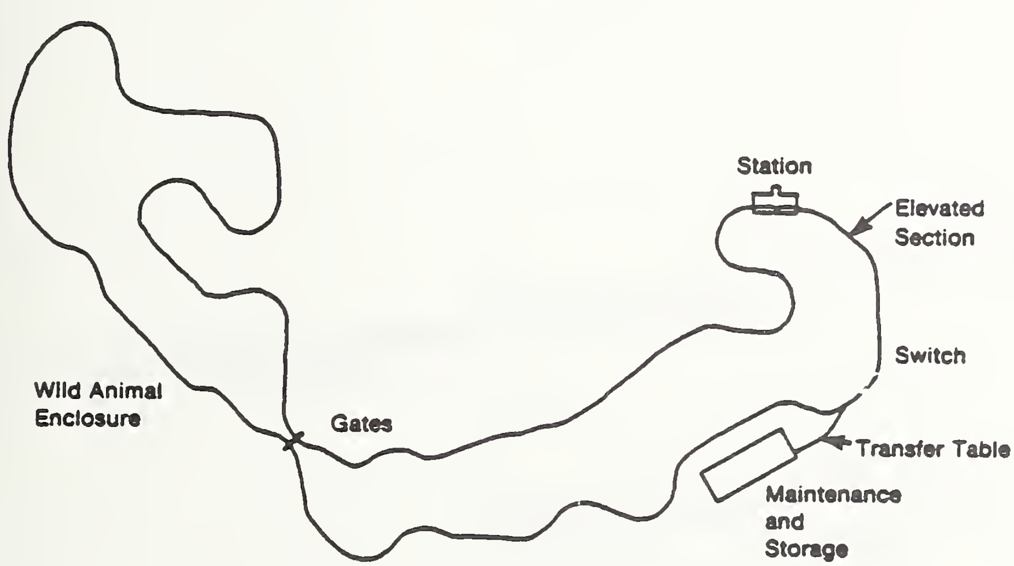
King's Dominion Amusement Park
P.O. Box 166
Doswell, VA 23219

SYSTEM SUPPLIER: Universal Mobility, Inc.
2040 East 4800 South Street
Salt Lake City, UT 84117
801-278-4421

SYSTEM DESCRIPTION:

The AGT system is one of the many rides and attractions in the Safari Village theme park at King's Dominion. The loop system was designed specifically to ferry passengers through an enclosed area where wild animals are allowed to roam freely.

SYSTEM SCHEMATIC:



MIAMI AIRPORT

SYSTEM CONTACT: R. Kemmink, Construction Manager, 305-526-2017

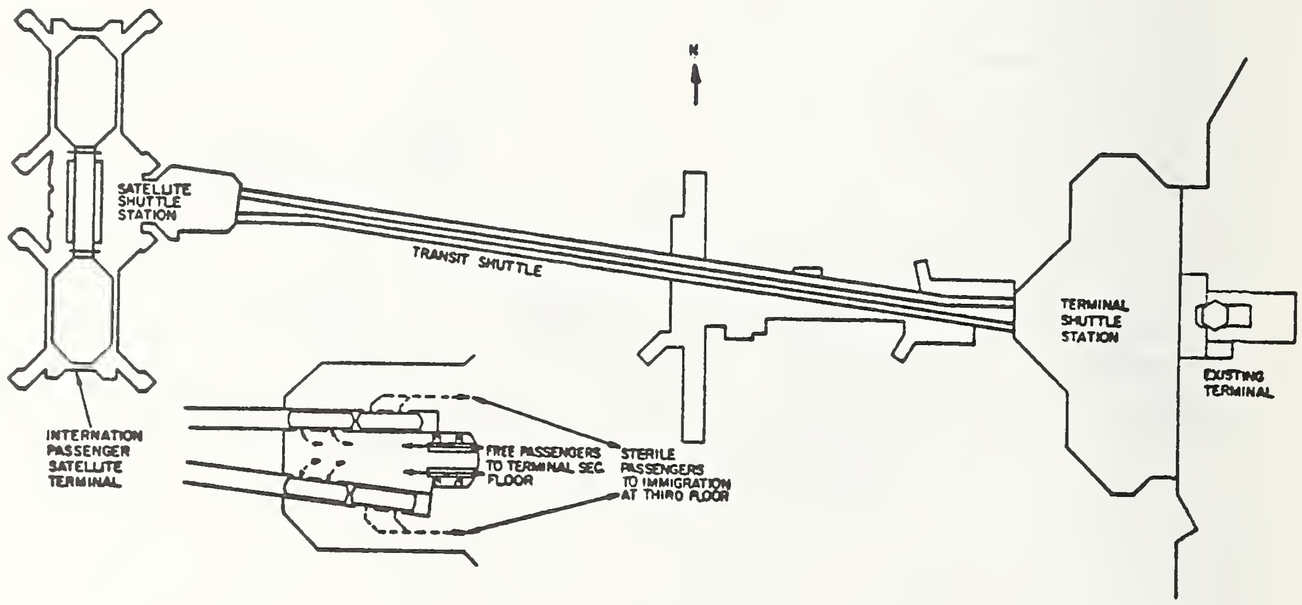
Miami International Airport
Dade County Aviation Department
P.O. Box 590275
Miami, FL 33159

SYSTEM SUPPLIER: Westinghouse Electric Corporation
Transportation Division
2001 Lebanon Road
West Mifflin, PA 15122
412-256-7000

SYSTEM DESCRIPTION:

The Satellite Transit Shuttle System operates between the main terminal and the international satellites. The shuttle system not only facilitates travel between the two terminals, which are beyond acceptable walking distance, but also aids in separating passengers who are required to pass through Customs and Immigration Services from those who are not.

SYSTEM SCHEMATIC:



MIAMI ZOO

SYSTEM CONTACT: H. Pater, President, 801-278-4421
R. Janzen

Universal Mobility, Inc.
2040 East 4800 South Street
Salt Lake City, UT 84117

SYSTEM SUPPLIER: Universal Mobility, Inc.
2040 East 4800 South Street
Salt Lake City, UT 84117
801-278-4421

SYSTEM DESCRIPTION:

The AGT system at the Miami Zoo provides visitors with a transit alternative to walking which allows them to ride through the park to view the animals.

SYSTEM SCHEMATIC:

Not Available

MINNESOTA ZOO

SYSTEM CONTACT: S.A. Iserman, Administrative Officer, 612-432-9010
D. Rickabaugh, 612-432-9010 Ext. 303

Minnesota Zoological Garden
12101 Jonny Cake Road
Apple Valley, MN 55124

SYSTEM SUPPLIER: Universal Mobility, Inc.
2040 East 4800 South Street
Salt Lake City, UT 84117
801-278-4421

SYSTEM DESCRIPTION:

The AGT system at the Minnesota Zoo provides alternative transportation around the outdoor animal exhibits.

SYSTEM SCHEMATIC:

Not Available

MORGANTOWN

SYSTEM CONTACT: R. Bates, Director, 304-293-5011

Morgantown People Mover System
99 8th Street
Morgantown, WV 26506

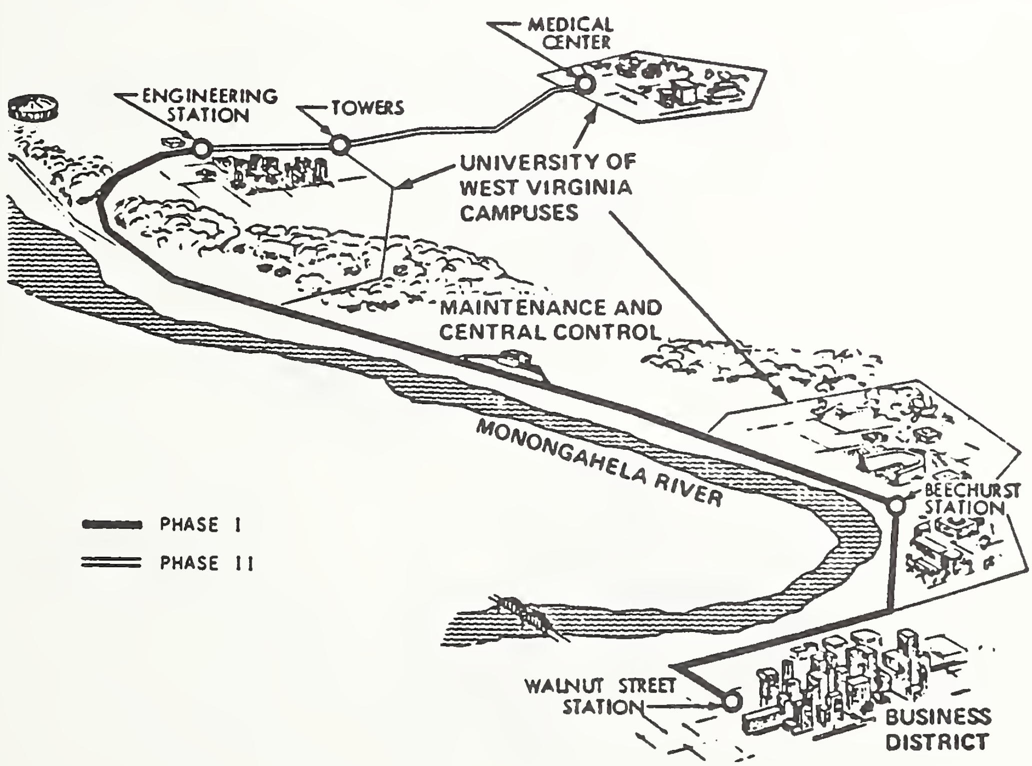
SYSTEM SUPPLIER: Boeing Aerospace Company
P.O. Box 3999
Seattle, WA 98124
206-655-1131

SYSTEM DESCRIPTION:

The Morgantown People Mover provides rapid transit service for students, employees, and community residents between the central business district and the three campuses of West Virginia University. It is the most sophisticated AGT system in regular passenger service as evidenced by its non-stop, origin-to-destination operation in the scheduled mode (during peak hours), on-demand mode (during off-peak hours), and circulation mode (during special events).

The present system was built in two time periods. Phase I consisted of 3 stations, 45 vehicles, and 5.4 miles of guideway. Phase II upgraded the Phase I facilities and expanded the system by 2 stations, 28 vehicles, and 3.3 miles of guideway.

SYSTEM SCHEMATIC:



ORLANDO

SYSTEM CONTACT: G.W. Seel, Director of Facilities, 305-826-2016
L. Hannon

Orlando International Airport
Greater Orlando Aviation Authority
P.O. Box 30004
Orlando, FL 32862

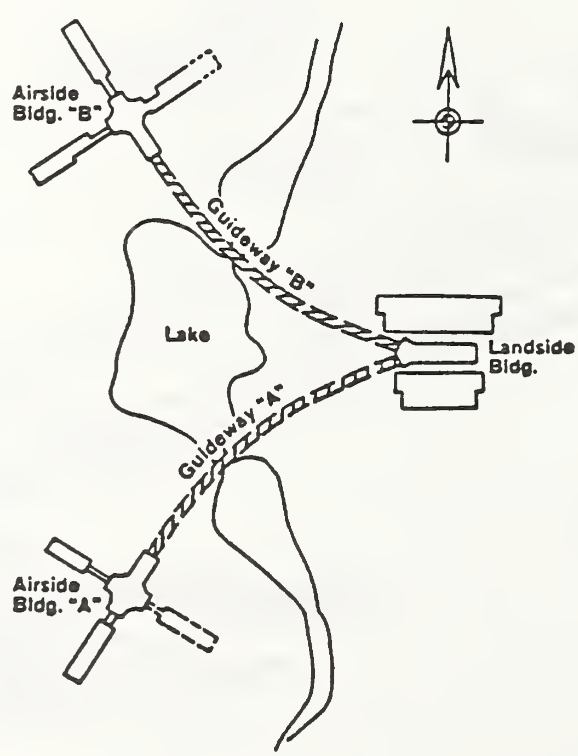
SYSTEM SUPPLIER: Westinghouse Electric Corporation
Transportation Division
2001 Lebanon Road
West Mifflin, PA 15122
412-256-7000

SYSTEM DESCRIPTION:

The Automated Transit System forms a critical passenger link between the main landside terminal and the two remote airside boarding satellites. This shuttle concept provides scheduled service during peak periods and on-demand service during off-peak hours.

The system represents the most recent operational deployment of the Westinghouse vehicle technology, the Transit Expressway, which was first demonstrated in 1965 at South Park in Allegheny County, PA.

SYSTEM SCHEMATIC:



PEARLRIDGE

SYSTEM CONTACT: W.R. Bricker, President, 808-488-1928

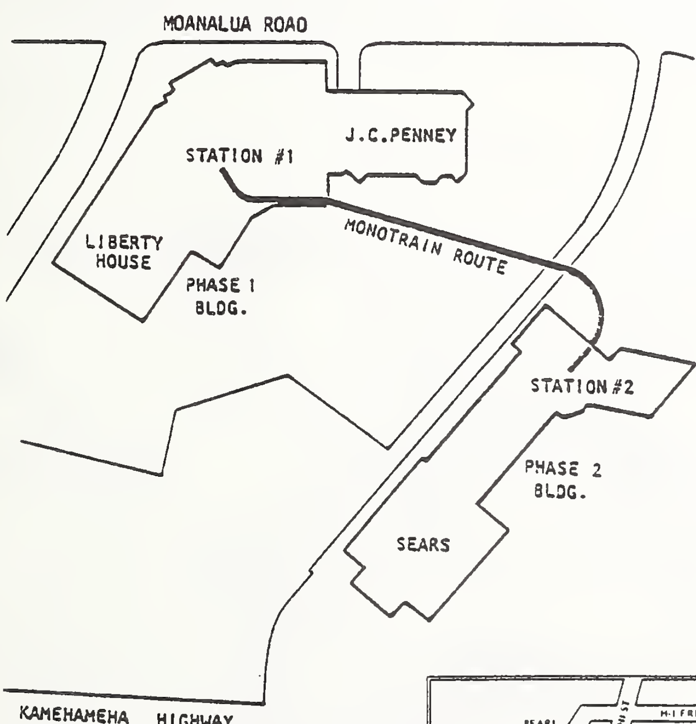
P.M. Hawaii, Inc.
300 Pearlridge Center
98-1005 Moanalua Road
Aiea, HI 96701

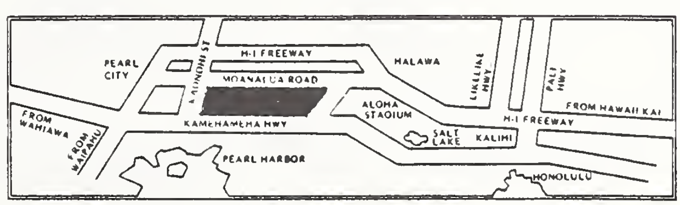
SYSTEM SUPPLIER: Rohr Industries, Inc.
P.O. Box 878
Chula Vista, CA 92012
619-691-4111

SYSTEM DESCRIPTION:

The Pali Momi Express connects two of the shopping malls at the Pearlridge Center and provides a shuttle service for shoppers and employees traveling between these areas.

SYSTEM SCHEMATIC:





SYSTEM CONTACT:

M.K. Bitts, Electronic Superintendent, 206-433-5407
T. Watson, Transit System Specialist

Seattle-Tacoma International Airport
Port of Seattle
P.O. Box 68727
Seattle, WA 98188

SYSTEM SUPPLIER:

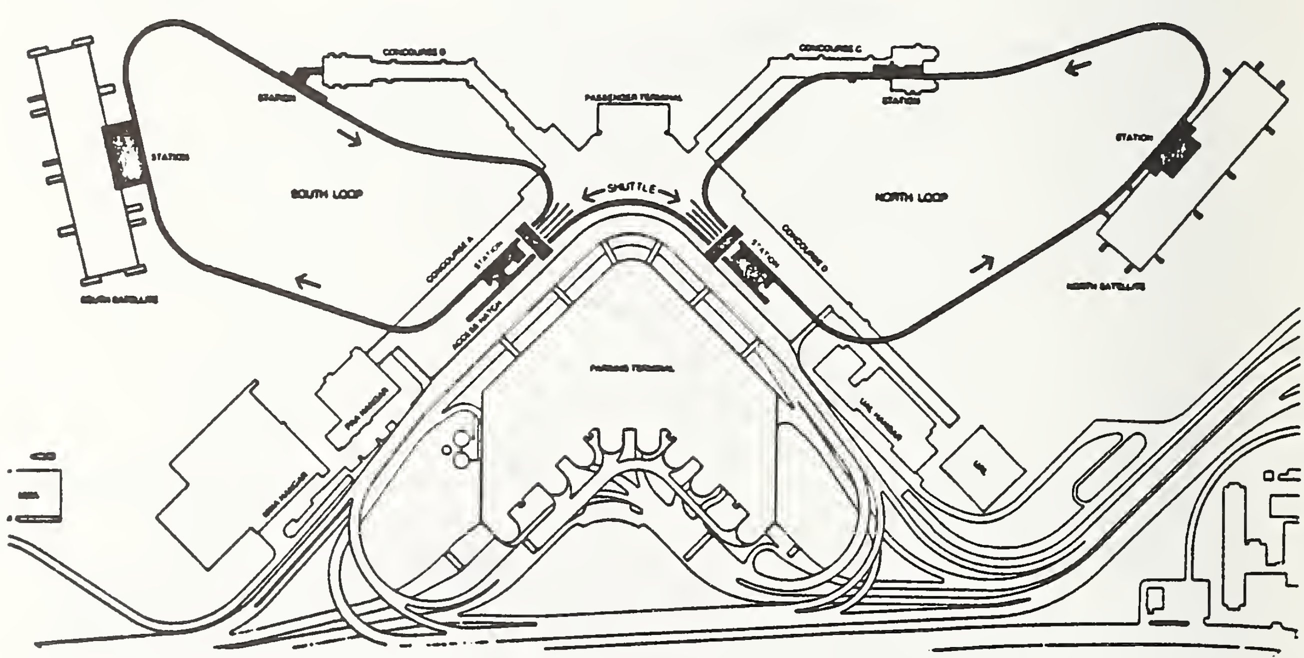
Westinghouse Electric Corporation
Transportation Division
2001 Lebanon Road
West Mifflin, PA 15122
412-256-7000

SYSTEM DESCRIPTION:

The Satellite Transit System provides the sole means of passenger access between the main terminal and the two satellite terminals. This fully automated, underground AGT system is designed to operate bi-directionally on fixed routes consisting of two separate loops linked by a shuttle path.

Since the system is the sole means of passenger transport within the airport, Sea-Tac employs one of the most comprehensive preventative maintenance programs of any AGT system. An emergency walkway has been provided for those periods when AGT service is not available.

SYSTEM SCHEMATIC:



TAMPA

SYSTEM CONTACT: T.W. Leslie, Assistant Director of Facilities, 813-883-3400

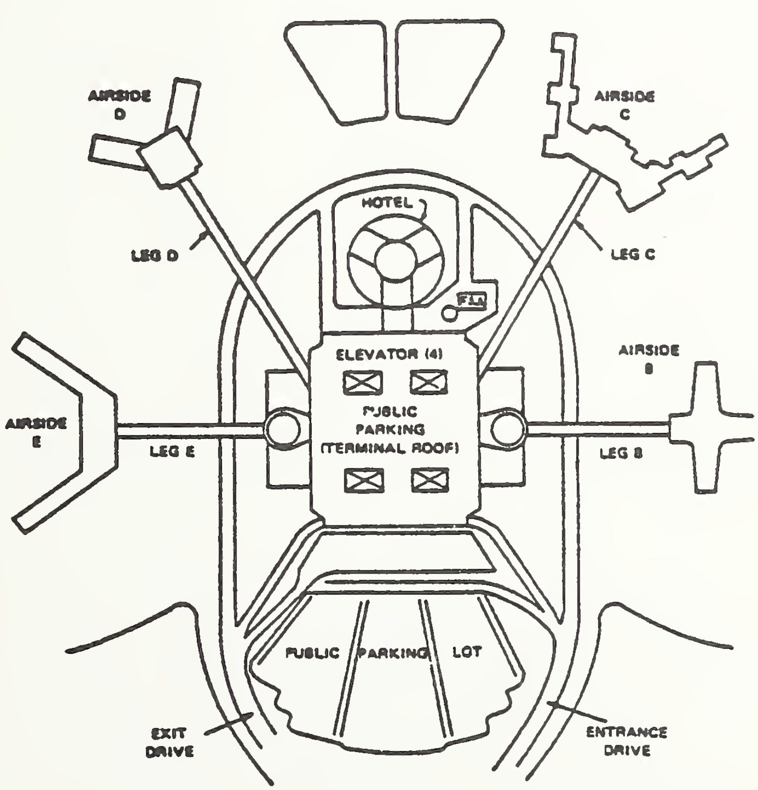
Tampa International Airport
Hillsborough County Aviation Authority
P.O. Box 22287
Tampa, FL 33622

SYSTEM SUPPLIER: Westinghouse Electric Corporation
Transportation Division
2001 Lebanon Road
West Mifflin, PA 15122
412-256-7000

SYSTEM DESCRIPTION:

This Passenger Shuttle Service connects the four remote terminals with the main terminal and serves to limit the passengers walktime between them. A pedestrian walkway has, however, been included between the dual lanes on each leg to permit access to the terminals. Because of this, the system is not critical to intra-airport transportation and is therefore capable of operating under less stringent maintenance requirements than are found at other sites.

SYSTEM SCHEMATIC:



APPENDIX D

SUBSYSTEM CHARACTERISTICS

TABLE D-1. GUIDEWAY CHARACTERISTICS

SYSTEM	GUIDEWAY LENGTH (MI.) SINGLE LANE/ DOUBLE LANE	GUIDEWAY ELEVATION (%) ELEVATED/AT-GRADE/ UNDERGROUND	MAXIMUM GRADE (%)	GUIDEWAY POWER	GUIDEWAY SWITCHES #/TYPE	SNOW/ICE REMOVAL PROVISIONS
AIRTRANS	12.80/0	20/80/0	8	480 VAC, 60 Hz, 3 Phase	71/MBE	UTILITY VEHICLE
ATLANTA	1.89/0.20	0/0/100	LEVEL	600 VAC, 60 Hz, 3 Phase	13/HPG	NONE (UNDERGROUND)
BUSCH GARDENS	1.33/0	40/60/0	10	480 VAC, 60 Hz, 3 Phase	0/TT	NONE (SEASONAL)
DISNEYWORLD	0.87/0	100/0/0	LEVEL	240 VAC, 60 Hz, 3 Phase	2/RT	NONE (COVERED/ENCLOSED)
DUKE	0.11/0.23	20/45/35	6	480 VAC, 60 Hz, 3 Phase	2/LDM	UTILITY VEHICLES
FAIRLANE	0.38/0.11	100/0/0	2.5	480 VAC, 60 Hz, 3 Phase	2/SWA	ELECTRIC HEATING CABLES
HOUSTON	1.48/0	0/0/100	LEVEL	240 VAC, 60 Hz, 3 Phase	NONE	NONE (UNDERGROUND)
KING'S DOMINION	2.06/0	5/95/0	8	480 VAC, 60 Hz, 3 Phase	1/HSS	NONE (SEASONAL)
MIAMI AIRPORT	0/0.26	100/0/0	4	480 VAC, 60 Hz, 3 Phase	NONE	NONE
MIAMI ZOO	1.97/0	96/4/0	10	480 VAC, 60 Hz, 3 Phase	1/SER	NONE
MINNESOTA ZOO	1.25/0	90/10/0	3	440 VAC, 60 Hz, 3 Phase	1/HSS	ELECTRIC HEATED RAILS
MORGANTOWN	0/4.30	60/40/0	10	575 VAC, 60 Hz, 3 Phase	57/OBS	HEATED PIPES
ORLANDO	0/0.74	100/0/0	1	600 VAC, 60 Hz, 3 Phase	NONE	NONE
PEARLRIDGE	0.23/0	100/0/0	4.5	480 VAC, 60 Hz, 3 Phase	NONE	NONE
SEA-TAC	1.71/0	0/0/100	4.5	600 VAC, 60 Hz, 3 Phase	0/TT	NONE (UNDERGROUND)
TAMPA	0/0.68	100/0/0	LEVEL	480 VAC, 60 Hz, 3 Phase	NONE	NONE

GUIDEWAY SWITCHES:

HPG - HYDRAULIC PIVOTING GUIDEBEAMS
HSS - HYDRAULIC SEGMENT SUBSTITUTION
LDM - LATERAL DOCKING MECHANISM
MBE - MOVABLE BLADE AND ENTRAPPING RAIL
MSS - MANUAL SEGMENT SUBSTITUTION

OBS - ON-BOARD SWITCHING
RT - RAILWAY-TYPE
SER - SINGLE ELEMENT ROTATING
SWA - SWITCH WHEEL TO GUIDE RAIL ARM
TT - TRANSFER TABLE FOR VEHICLE MOVEMENT

TABLE D-1. GUIDEWAY CHARACTERISTICS (Concluded)

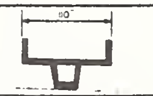
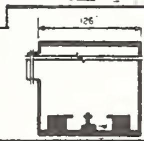
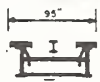
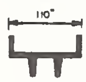
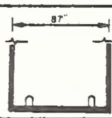
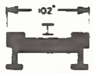
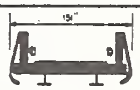
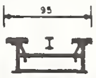
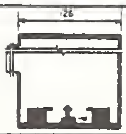
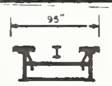
SYSTEM	PRIMARY MATERIAL(S)	CONSTRUCTION TECHNIQUE	COLUMN TYPE	TYPICAL SPAN LENGTH (FT)	BEAM SHAPE	
AIRTRANS	CONCRETE	PLANT PRECAST & PRESTRESSED, FIELD POST-TENSIONED	TAPERED, RECTANGULAR, PRECAST CONCRETE	90	U	
ATLANTA	CONCRETE	RECTANGULAR, CAST-IN-PLACE CONCRETE RUNNING SURFACES	NOT APPLICABLE (TUNNEL)	NOT APPLICABLE (TUNNEL)	BOX	
BUSCH GARDENS	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	RECTANGULAR, CAST-IN-PLACE CONCRETE	73	I	
DISNEYWORLD	STEEL AND CONCRETE	CAST-IN-PLACE. CONCRETE	STRUCTURAL STEEL	50	V	
DUKE	CONCRETE	CAST-IN-PLACE, REINF. CONCRETE, PRECAST/PRESTRESSED CONCRETE	CIRCULAR, CAST-IN-PLACE REINF. CONCRETE	56	U	
FAIRLANE	CONCRETE	PLANT PRECAST & PRESTRESSED, FIELD POST-TENSIONED	TAPERED, RECTANGULAR W/ ROUNDED CORNERS, PRECAST CONCRETE	60	U	
HOUSTON	STEEL AND CONCRETE	PREFABRICATED STEEL TUBES, WELDED END TO END, ANCHORED TO CONCRETE	NOT APPLICABLE (TUNNEL)	24 TUBE SECTIONS	RAIL	
KING'S DOMINION	STEEL	PREFABRICATED, FIELD WELDED	STRUCTURAL STEEL	27-60	BOX	
MIAMI AIRPORT	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	TEE-HEAD, CAST-IN-PLACE CONCRETE	50-110	I	
MIAMI ZOO	STEEL	PREFABRICATED	RECTANGULAR, WIDE FLANGE	68-75	BOX	NOT AVAILABLE
MINNESOTA ZOO	STEEL	PREFABRICATED, FIELD WELDED	STRUCTURAL STEEL	73	BOX	
MORGANTOWN	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	WINE-GLASS SHAPE, CAST-IN-PLACE CONCRETE	66	U	
ORLANDO	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	NOT AVAILABLE	NOT AVAILABLE	I	
PEARLRIDGE	STEEL AND CONCRETE	PREFABRICATED STEEL BEAM	TAPERED, RECTANGULAR, PRECAST CONCRETE, TUBULAR STEEL	50-128	BOX	
SEA-TAC	CONCRETE	RECTANGULAR, CAST-IN-PLACE CONCRETE RUNNING SURFACES	NOT APPLICABLE (TUNNEL)	NOT APPLICABLE (TUNNEL)	BOX	
TAMPA	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	TEE-HEAD, CAST-IN-PLACE CONCRETE	58	I	

TABLE D-2. STATION CHARACTERISTICS

SYSTEM	NUMBER OF STATIONS	STATIONS ON-LINE/ OFF-LINE	STATIONS ELEVATED/AT-GRADE/ UNDERGROUND	TYPE OF CONSTRUCTION	FARE COLLECTION	ELEVATORS/ ESCALATORS	PLATFORM CONFIGURATION
AIRTRANS	14	4/10	1/13/0	5 FREESTANDING 9 CONTIGUOUS	YES	YES/YES	SINGLE-SIDE
ATLANTA	10	10/0	0/0/10	JOINT USE	NO	YES/YES	ISLAND
BUSCH GARDENS	2	2/0	1/1/0	1 FREESTANDING 1 CONTIGUOUS	NO	YES/NO	DUAL-SIDE
DISNEYWORLD	1	1/0	1/0/0	FREESTANDING	YES	NO/YES	SINGLE-SIDE
DUKE	3	2/1	0/2/1	1 CONTIGUOUS 2 JOINT USE	NO	YES/NO	SINGLE-SIDE
FAIRLANE	2	2/0	2/0/0	1 CONTIGUOUS 1 JOINT USE	NO	NO/YES	SINGLE-SIDE AND DUAL-SIDE
HOUSTON		9/0	0/0/9	JOINT USE	NO	YES/YES	ISLAND AND SINGLE-SIDE
KING'S DOMINION	1	1/0	0/1/0	FREESTANDING	NO	NO/NO	DUAL-SIDE
MIAMI AIRPORT	2	2/0	2/0/0	JOINT USE	NO	NO/NO	ISLAND AND DUAL-SIDE
MIAMI ZOO	4	4/0	4/0/0	FREESTANDING	YES	NO/NO	DUAL-SIDE
MINNESOTA ZOO	1	1/0	1/0/0	CONTIGUOUS	YES	NO/NO	SINGLE-SIDE
MORGANTOWN	5	0/5	2/3/0	FREESTANDING	YES	YES/NO	ISLAND AND SINGLE-SIDE
ORLANDO	4	4/0	4/0/0	JOINT USE	NO	NO/NO	ISLAND
PEARLRIDGE	2	2/0	2/0/0	CONTIGUOUS	YES	YES/YES	SINGLE-SIDE
SEA-TAC	6	6/0	0/0/6	JOINT USE	NO	YES/YES	ISLAND AND SINGLE-SIDE
TAMPA	8	8/0	8/0/0	JOINT USE	NO	NO/NO	ISLAND AND DUAL-SIDE

TABLE D-3. FLEET CHARACTERISTICS

SYSTEM	FLEET SIZE	SINGLE VEHICLE DIMENSIONS (FT) LENGTH/WIDTH/HEIGHT	VEHICLE WEIGHT (LBS) EMPTY/GROSS	VEHICLE CAPACITY SEATED/ STANDING	VEHICLE SPEED (MPH) MAXIMUM/AVERAGE	VEHICLE SUSPENSION	VEHICLE STEERING	VEHICLE PROPULSION	VEHICLE CONTROL
AIRTRANS	52	21.0/7.0/10.0	14,000/20,700	16/24	17/10	RTOC, SPDR	SGW	DCTM	PF, FB
ATLANTA	17	39.0/9.3/11.0	27,500/42,100	16/24	27/13	RTOC, SPDR	CGB	DCTM	PF, FB
BUSCH GARDENS	1 (2 CAR TRAIN)	36.7/9.3/11.0	53,000/83,800	16/176	30/11	RTOC, SPDR	CGB	OCTM	PF, FB
DISNEYWORLD	30 (5 CAR TRAIN)	8.3/4.8/3.5	4,700/7,700	20/0	14/5	SWOS, SPDR	SGW	SLIM	VF, FB
DUKE	4	17.0/7.4/10.0	10,200/16,500	4/18	28/14	AC	SGW	SLIM	PF, FB
FAIRLANE	2	24.7/6.7/8.7	12,500/17,000	10/14	30/10	RTOC, SPOR	SGW	OCTM	PF, FB
HOUSTON	6 (3 CAR TRAIN)	13.6/5.2/7.7	7,200/13,200	18/18	15/6	SWOS, SPOR	SGW	SLIM	VF, FB
KING'S DOMINION	6 (9 CAR TRAIN)*	12.2/6.0/7.4	17,100/45,100	96/0	18/6	RTOS, SPMR	SGW	DCTM	VF, FB
MIAMI AIRPORT	2 (3 CAR TRAIN)	36.7/9.3/11.0	77,400/131,400	6/291	30/11	RTOC, SPDR	CGB	DCTM	PF, FB
MIAMI ZOO	3 (10 CAR TRAIN)	15.0/6.5/8.9	31,500/53,900	149/0	10/8	AC	CGB	DCTM	PF, FB
MINNESOTA ZOO	3 (6 CAR TRAIN)	11.7/7.0/7.4	47,800/65,000	94/0	8/7	RTOS, SPMR	SGW	DCTM	VF, FB
MORGANTOWN	73	15.5/6.7/8.8	8,600/11,700	8/12	30/17	RTOC, SPDR	SWF	DCTM	PF, FB
ORLANDO	4 (2 CAR TRAIN)	39.0/9.3/11.0	51,200/92,000	0/200	28/14	RTOC, SPDR	CGB	DCTM	PF, FB
PEARLRIDGE	1 (4 CAR TRAIN)	15.0/6.7/8.5	29,200/40,800	32/32	8/7	RTOS, SPDR	CGB	DCTM	PF, FB
SEA-TAC	24	37.0/9.3/11.0	25,500/46,700	12/90	26/12	RTOC, SPDR	CGB	DCTM	PF, FB
TAMPA	8	36.3/9.3/11.0	21,500/40,200	0/100	30/9	RTOC, SPDR	CGB	DCTM	PF, FB

* Includes non-passenger lead car.

VEHICLE SUSPENSION:
AC - AIR CUSHION
RTOC - RUBBER TIRE ON CONCRETE
RTOS - RUBBER TIRE ON STEEL
SPDR - SUPPORTED DUAL-RAIL
SPMR - SUPPORTED MONORAIL
SWOS - STEEL WHEEL ON STEEL

VEHICLE STEERING (ALL HAVE RUBBER GUIDE WHEEL):
CGB - CENTER GUIDE BEAM
SGW - SIDE GUIDANCE SURFACE
SWF - SIDE WALL FOLLOW/ON-BOARD SWITCH

VEHICLE PROPULSION:
DCTM - Direct Current Traction Motor
SLIM - Single-sided Linear Induction Motor

VEHICLE CONTROL:
FB - Fixed Block
PF - Point Follower
VF - Vehicle Follower

100 copies

☆ U. S. GOVERNMENT PRINTING OFFICE: 1984--701-684--400

)epartment
ansportation
earch and
cial Programs
ninistration
ll Square
idge, Massachusetts 02142