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Supplement IV Cost Experience of Automated Guideway Transit Systems

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Final Report

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16. Abstract

Automated Guideway Transit (AGT) is an innovative form of public transportation in which automatically controlled vehicles are operated on fixed guideways along an exclusive right-of-way. By the end of 1982, domestic AGT systems will have carried over 500 million passengers since their first commercial operation at the Tampa International Airport in 1971. To keep abreast of the domestic use of AGT systems in the United States, UMTA has sponsored a series of reports on the cost experience of selected domestic AGT systems. Presented in these documents are the capital costs, operations and maintenance (O&M) costs, and system characteristics of selected AGT systems currently operating in the United States. Evaluation of trends over time and comparisons with other transportation modes are also presented.

This report provides cost information about 15 domestic AGT systems. Capital costs, in 1981 dollars, for 13 systems are provided. O&M data for calendar year 1981 is provided for all 15 systems. Additional information about numbers cf passengers, system availability and system characteristics is also provided. The 15 AGT systems examined in this report are: 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; Minnesota Zoological Gardens; Orlando International Airport; Pearlridge Center; Seattle-Tacoma International Airport; Tampa International Airport; Walt Disney World; and Morgantown West Virginia University System.

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PREFACE

This report summarizes the capital and operations and maintenance cost experience and trends of various Automated Guideway Transit (AGT) systems.

This study was sponsored by the U.S. Department of Transportation, Urban Mass Transportation Administration (UMTA) through the Analysis Division of the Office of Methods and Support under the Office of Technical Assistance.

This report has been compiled using data provided as a public service by several institutions. We would like to acknowledge the following personnel at these institutions who contributed to this data collection effort.

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Morgantown People Mover System	R. Bates, Director
Minnesota Zoological Garden	S.A. Iserman, Director, Business Division
Otis Elevator Company Transportation Technology Div.	L. Saunders, General Manager R. Donlon, Manager, Business Development
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Seattle-Tacoma International Airport	M.K. Bitts, Electronics Superintendent
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1.0 EXECUTIVE SUMMARY

1.1 BACKGROUND

By the end of 1982, domestic Automated Guideway Transit (AGT) systems will have carried over 500 million passengers since their first commercial operation at the Tampa International Airport in 1971. To keep abreast of the domestic use of AGT systems in the United States, the Urban Mass Transportation Administration (UMTA) has sponsored a series of reports on the cost experience of selected domestic AGT systems. The present report is the fifth volume in the series.

AGT systems can be classified using the structure developed in the report entitled "Systems Operation Studies for Automated Guideway Transit Systems". In this classification structure, three major categories of AGT were identified on the basis of traveling unit capacity: Personal Rapid Transit (PRT), Group Rapid Transit (GRT), and Automated Rail Transit (ART). GRT is further partitioned into three distinct ranges of traveling unit capacity: Small Vehicle GRT (SVGRT), Intermediate Vehicle GRT (IVGRT), and Large Vehicle GRT (LVGRT). This series of reports on the AGT cost experience deals with GRT systems exclusively.

The fifteen domestic AGT systems for which data are reported herein are listed by system class and initial operation date in Table 1-1. Note that the systems in Houston and Orlando commenced operation in August and September of 1981, respectively. A system name, if applicable, and the abbreviated system identification used in this report are also provided.

1.2 PASSENGER STATISTICS

1.2.1 Fifteen Systems - 1981

In 1981 the fifteen domestic AGT systems queried carried more than 84 million passengers. Figure 1-1 and 1-2 show the distribution of passengers among the systems during 1981. Figure 1-1 is the distribution of passengers on systems located in international airports; Figure 1-2 is the distribution

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

SYSTEM CLASS(1)	INITIAL OPERATION DATE		LOCATION	SYSTEM NAME	ABBREVIATED SYSTEM IDENTIFICATION
SVGRT	JUL	1975	WALT DISNEY WORLD	WEDWAY	DISNEYWORLD (DW)
	SEP	1975	WEST VIRGINIA UNIVERSITY	MORGANTOWN PEOPLE MOVER	MORGANTOWN (M)
	MAR	1976	FAIRLANE SHOPPING CENTER	-	FAIRLANE (F)
	MAY	1980	DUKE UNIVERSITY MEDICAL CENTER	-	DUKE (D)
IVGRT	JAN	1974	DALLAS-FORT WORTH AIRPORT	AIRTRANS	AIRTRANS (A)
	NOV	1977	PEARL RIDGE CENTER	-	PEARLRIDGE (P)
	SEP	1980	HARTSFIELD INTERNATIONAL AIRPORT	-	ATLANTA (AT)
	AUG	1981	HOUSTON INTERCONTINENTAL AIRPORT	WEDWAY PEOPLE MOVER	HOUSTON (H)
LVGRT	APR	1971	TAMPA INTERNATIONAL AIRPORT	PASSENGER SHUTTLE SYSTEM	TAMPA (T)
	FEB	1973	SEATTLE-TACOMA INTERNATIONAL AIRPORT	SATELLITE TRANSIT SYSTEM	SEA-TAC (ST)
	APR	1975	KING'S DOMINION AMUSEMENT PARK	-	KING'S DOMINION (KD)
	MAY	1975	BUSCH GARDENS	-	BUSCH GARDENS (BG)
	AUG	1979	MINNESOTA ZOOLOGICAL GARDEN	-	MINNESOTA ZOO (MZ)
	APR	1980	MIAMI INTERNATIONAL AIRPORT	-	MIAMI (M)
	SEP	1981	ORLANDO INTERNATIONAL AIRPORT	-	ORLANDO (O)

(1) CLASSIFICATION OF SYSTEMS AS USED IN THE "SYSTEMS OPERATIONS STUDIES FOR AUTOMATED GUIDEWAY TRANSIT SYSTEMS".

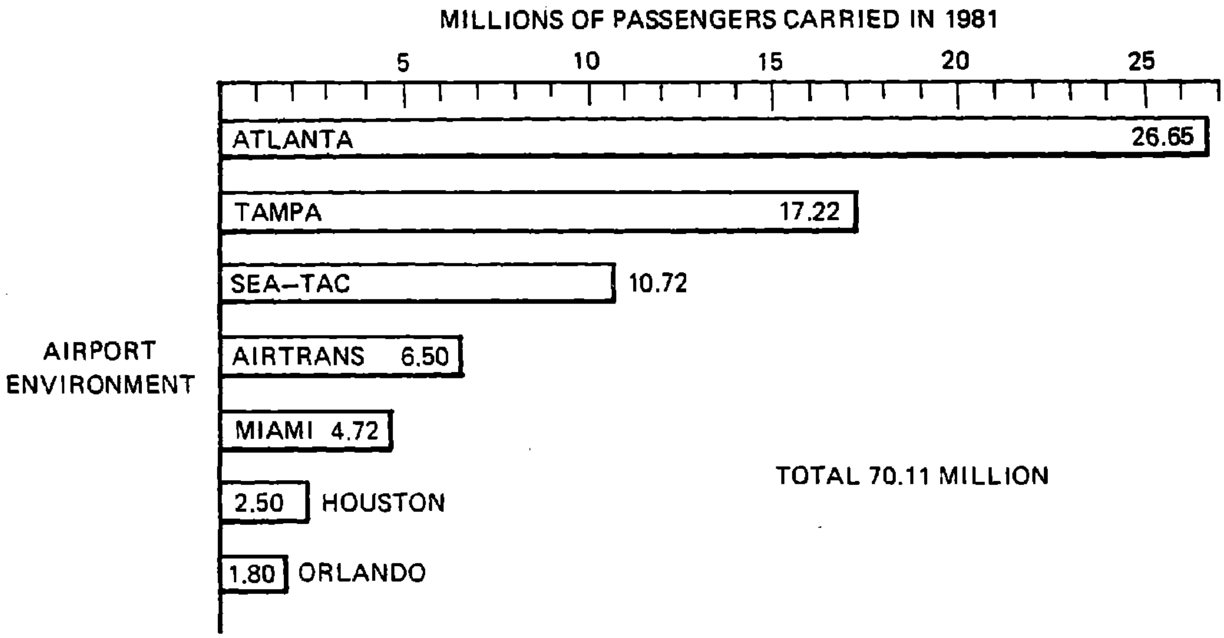


FIGURE 1-1. PASSENGERS CARRIED ON SEVEN AGT SYSTEMS LOCATED IN AN AIRPORT ENVIRONMENT

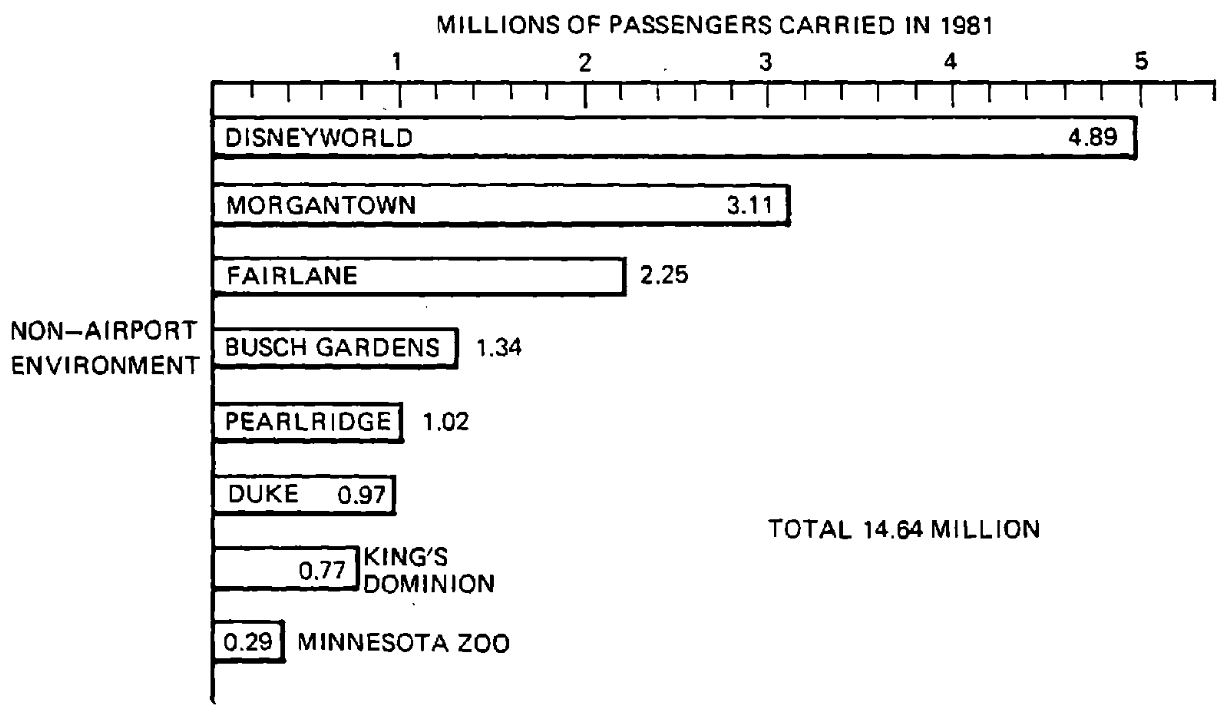


FIGURE 1-2. PASSENGERS CARRIED ON EIGHT AGT SYSTEMS LOCATED IN A NON-AIRPORT ENVIRONMENT

of passengers located in other environments - a medical center, two shopping centers, four theme parks, and a university campus.

Over 80 percent of all passengers were carried on systems located at airports. Almost two-thirds of all passengers were carried by the three systems located at international airports in Atlanta, Seattle-Tacoma, and Tampa. Over 50 percent of the passengers carried in a non-airport environment were carried by the two systems located at Disneyworld and Morgantown.

1.2.2 Nine Systems - 1980/81

Table 1-2 presents a comparison of passenger traffic on nine domestic AGT systems for 1980 and 1981. Passenger traffic decreased on all but two systems, at an overall rate of 6 percent. Since over 80 percent of all passengers were carried on systems located at airports, it is instructive to see how domestic airline traffic changed in the same period. According to data provided in the March 1982 issue of "Air Transport World" (p.88), domestic airline passenger traffic decreased by 5.5 percent between 1980 and 1981. It should be noted that the passenger traffic on the four AGT systems located at international airports (shown in Table 1-2) decreased 6.3 percent between 1980 and 1981. Thus, it seems reasonable to assume that the decrease in passenger traffic on several domestic AGT systems between 1980 and 1981 can be explained, in part, by the decline in domestic airline passenger traffic during the same period.

1.3 OPERATION AND MAINTENANCE COST STATISTICS

1.3.1 Fifteen Systems - 1981

In 1981 the fifteen domestic AGT systems queried carried the 84 million passengers at an average operations and maintenance (O&M) cost of $ 0.19 per passenger. Table 1-3 provides a brief summary. The cost per passenger varied from $ 0.04 at Tampa to $ 0.90 at Minnesota Zoo.

TABLE 1-2. COMPARISON OF PASSENGER TRAFFIC ON NINE DOMESTIC AGT SYSTEMS FOR 1980 AND 1981

SYSTEM	PASSENGERS CARRIED (MILLIONS) 1980	1981	CHANGE (%)
AIRTRANS	7.01	6.50	-7.28
BUSCH GARDENS	1.37	1.34	-2.19
DISNEYWORLD	5.33	4.89	-8.25
MIAMI	4.62	4.72	2.16
MINNESOTA ZOO	0.37	0.29	-21.62
MORGANTOWN	3.01	3.11	3.32
PEARLRIDGE	1.20	1.02	-15.00
SEA-TAC	10.94	10.72	-2.01
TAMPA	19.22	17.22	-10.40
TOTALS	53.07	49.81	-6.14

TABLE 1-3. SUMMARY OF O&M COST PER PASSENGER CARRIED FOR FIFTEEN DOMESTIC AGT SYSTEMS DURING 1981

SYSTEM	TOTAL O&M COST (MILLIONS)	NUMBER OF PASSENGERS CARRIED (MILLIONS)	O&M COST PER PASSENGER CARRIED ($)
AIRTRANS	4.739	6.50	0.73
ATLANTA	3.043	26.65	0.11
BUSCH GARDENS	0.182	1.34	0.14
DISNEYWORLD	0.422	4.89	0.09
DUKE	0.462	0.97	0.48
FAIRLANE	1.372 (est.)	2.25	0.61
HOUSTON(1)	0.340	2.50	0.13
KING'S DOMINION	0.076	0.77	0.10
MIAMI	0.317	4.72	0.07
MINNESOTA ZOO	0.258	0.29	0.90
MORGANTOWN	2.259	3.11	0.73
ORLANDO(2)	0.361	1.80	0.20
PEARLRIDGE	0.315	1.02	0.31
SEA-TAC	0.802	10.72	0.07
TAMPA	0.765	17.22	0.04
TOTALS	15.713	84.75	0.19

(1) APPROXIMATELY FOUR MONTHS OF DATA
(2) APPROXIMATELY THREE MONTHS OF DATA

1.3.2 Seven Systems - 1980/81

Seven systems reported cost data for both 1980 and 1981. Table 1-4 presents the O&M cost data. The seven systems carried 47.1 million passengers in 1980 at an average O&M cost per passenger of $ 0.19. In 1981, the same seven systems carried 43.8 million passengers, a 7 percent decrease, at an average O&M cost per passenger of $ 0.22. This represents a 15.8 percent increase in the O&M cost per passenger. The total expenditures for O&M on these seven systems were $ 8.911 million in 1980 and $ 9.560 million in 1981, representing a 7.3 percent increase. Thus, both the increase in O&M expenditures (7.3 percent) and the decrease in passenger traffic (7 percent) combined to approximate the observed increase (15.8 percent) in O&M cost per passenger between 1980 and 1981.

1.4 DISCUSSION

Domestic AGT systems are providing transportation for an increasing number of persons at an O&M cost which seems to be increasing at about the same rate as inflation.

The acceptability of AGT as a viable mode of transportation is emphasized by the fact that a new domestic AGT system has initiated service every eight months for the past thirteen years; it appears that this trend will continue. Two AGT systems are presently being constructed in the Miami area: one at the Metro Zoo and another in downtown Miami. AGT systems are also being planned for the 1984 Louisiana World Exposition (New Orleans) and another for Detroit, Michigan.

TABLE 1-4. SUMMARY OF O&M COSTS FOR SEVEN DOMESTIC AGT SYSTEMS FOR 1980 AND 1981

SYSTEM	O&M COSTS (MILLIONS)		CHANGE
	1980	1981	(%)
AIRTRANS	4.383	4.739	8.12
DISNEYWORLD	0.384	0.422	9.90
MORGANTOWN	2.154	2.259	4.87
MINNESOTA ZOO	0.255	0.258	1.76
PEARLRIDGE	0.326	0.315	-3.37
SEA-TAC	0.797	0.802	0.01
TAMPA	0.612	0.765	25.00
TOTAL	8.911	9.560	7.28

2.0 INTRODUCTION

Automated Guideway Transit (AGT) is an innovative form of public transportation in which automatically controlled vehicles are operated on fixed guideways along an exclusive right-of-way. This mode of transit has been installed at a number of sites in the United States and abroad. AGT systems have been in operation in this country over the past ten years, demonstrating an ability to serve a variety of public transportation needs.

This effort, under the sponsorship of UMTA's Office of Methods and Support, represents the fifth in a series of reports that began in 1978. These reports are intended to provide transportation decision makers with a comprehensive source for AGT cost information. Presented in these documents are the capital costs, operations and maintenance (O&M) costs, and system characteristics of selected AGT systems currently operating in the United States. Although additional AGT systems exist in foreign countries, primarily in test configurations, the availability and applicability of cost information are limited. Evaluations of trends over time and comparisons with other transportation modes are also presented.

The previous reports are:

- M. E. von Rosenvinge, "Supplement III: Cost Experience of Automated Transit Systems, " Report No. UMTA-MA-06-0069-81-2, Washington DC, July 1981, PB-81-245656.

- T. F. Comparato, M.E. von Rosenvinge, D.C. Kendall, "Supplement II: Summary of Capital and Operations & Maintenance Cost Experience of Automated Guideway Transit Systems Costs and Trends for the Period 1976-1979," Report No. UMTA-MA-06-0069-80-1, Washington DC, March 1980.

- T. F. Comparato, T.M. Dooley, F.A.F. Cooke, et al., "Supplement I: Summary of Capital and Operations and Maintenance Cost Experience of

Automated Guideway Transit Systems Cost and Trends for the Period 1976-1978," Report No. UMTA-IT-06-0188-79-1, Washington DC, March 1979, PB-80-146483.

- F.A.F. Cooke, C.P. Elms, T.J. McGean, H.W. Merrit, "Summary of Capital and Operations & Maintenance Cost Experience of Automated Guideway Transit System," Report No. UMTA-IT-06-0157-78-2, Washington DC, June 1978, PB-294306.

This report supplements the data presented in the above four reports and strives to provide a better understanding of the factors which affect the cost of building and operating an AGT system. The format and content are consistent with previous reports, however, new correlations and more extensive system descriptions have been included. In order to provide the reader with more information and insight into important cost variations, O&M cost data have been obtained and analyzed for ten additional systems.

3.0 OVERVIEW OF AGT SYSTEMS

3.1 EXISTING SYSTEMS

Fifteen domestic AGT systems, all currently in operation, are examined in this report. These systems carried more than 84 million passengers in 1981 and served a variety of transportation needs such as people/goods movement at airports; multi-purpose trips at medical centers, shopping centers, and universities; and attractive, enjoyable rides at recreation centers. Figure 3-1 presents these systems and shows the timing of their construction and operation. Also included in this figure are four systems (Detroit, Miami Downtown, Miami Zoo, and New Orleans) presently being constructed or planned for construction.

AGT systems are being utilized extensively as the primary source of public transportation in many activity center applications. These systems represent a significant range of technology options, site conditions, and performance characteristics. This range of applications results in a diversity of site characteristics and system sizes and configurations varying from the expansive, multi-loop Airtrans system at the Dallas-Fort Worth Airport to the simple shuttle system at the Fairlane Shopping Center in Dearborn, Michigan. Table 3-1 illustrates the variability in system size, configuration, and vehicle capacity between the various systems by presenting the more prominent characteristics of each system. Appendix A contains a more detailed system description by subsystem.

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. Because of this relationship to site conditions and the fact that the AGT deployments have been primarily in activity centers, the transferability of documented cost information and operating experience to other application areas is limited. The following section briefly discusses these limitations.

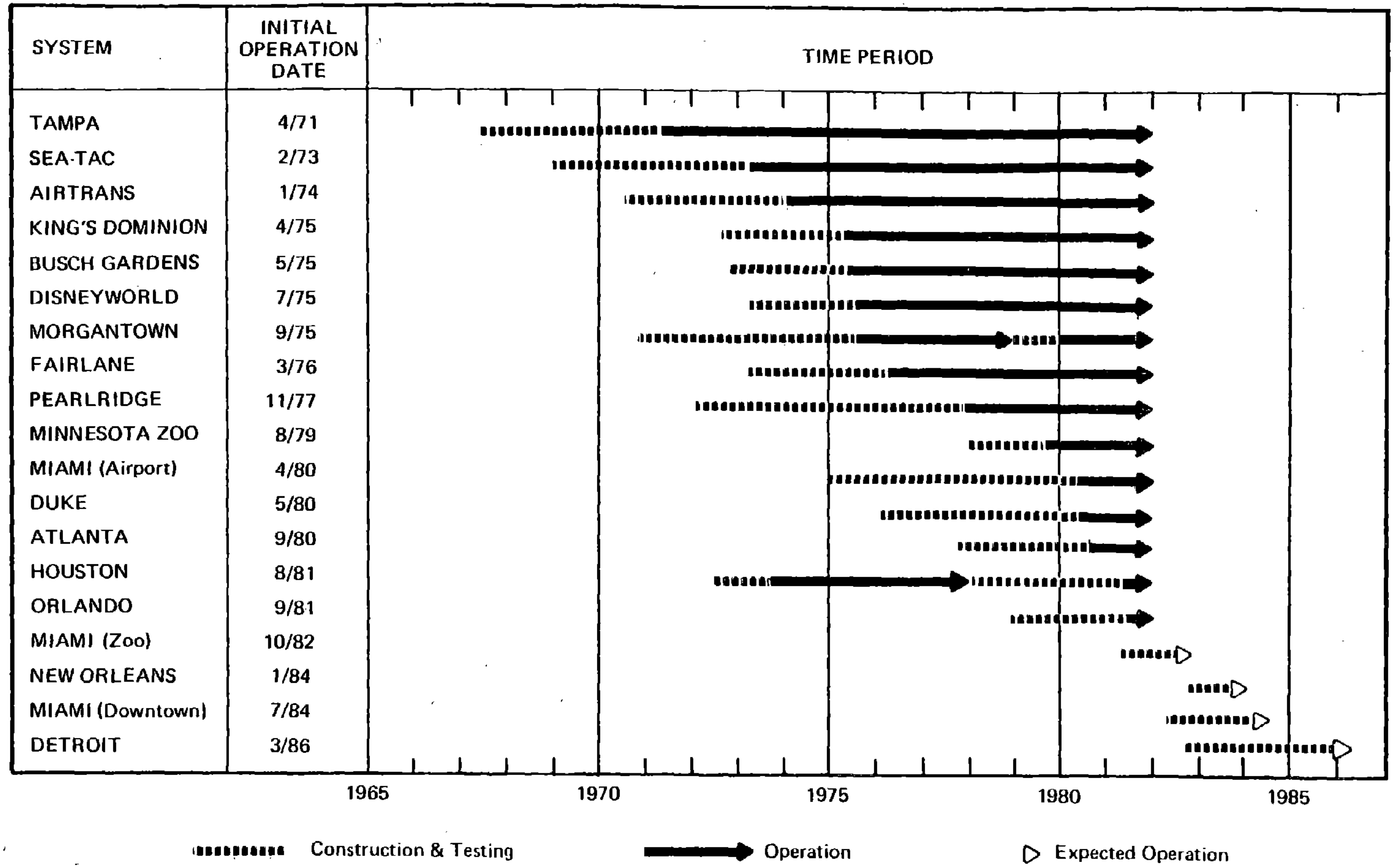


FIGURE 3-1. DOMESTIC AGT DEPLOYMENTS

TABLE 3-1. SYSTEM CHARACTERISTICS

SYSTEM	LOCATION	SUPPLIER	SITE DESCRIPTION	SYSTEM CONFIGURATION	GUIDEWAY ELEVATION	GUIDEWAY LENGTH LANE MILES/ EQUIVALENT ELEVATED LANE MILES (1)	NUMBER OF STATIONS	NUMBER OF VEHICLES	VEHICLE CAPACITY/EQUIVALENT PASSENGER PLACES (2)	PERIOD OF OPERATION
AIRTRANS	DALLAS, TX	VOUGHT	AIRPORT	SINGLE-LANE MULTI-LOOPS	ELEVATED/ AT-GRADE	12.8/6.66	28	51	40/37	24 HRS/DAY
ATLANTA	ATLANTA, GA	WESTINGHOUSE	AIRPORT	DUAL-LANE SHUTTLE WITH BYPASS	UNDERGROUND	2.29/6.87	10	17	80/91	21 HRS/DAY
BUSCH GARDENS	WILLIAMSBURG, VA	WESTINGHOUSE	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED/ AT-GRADE	1.33/0.84	2	2	96/89	11 HRS/DAY (MAR.-OCT.)
DISNEYWORLD	ORLANDO, FL	WED TRANS. SYSTEM, INC.	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED	0.87/0.87	1	30 (5 car train)	20/48	13 HRS/DAY*
DUKE	DURHAM, NC	OTIS/TTD	MEDICAL CENTER	DOUBLE-LANE AND SINGLE-LANE SHUTTLE	ELEVATED/ AT-GRADE/ UNDERGROUND	0.56/0.61	3	4	22/51	24 HRS/DAY
FAIRLANE	DEARBORN, MI	FORD	SHOPPING CENTER	SINGLE-LANE SHUTTLE WITH BYPASS	ELEVATED	0.61/0.61	2	2	24/41	12.0 HRS/DAY 6.0 HRS SUN.
HOUSTON	HOUSTON, TX	WED TRANS. SYSTEM, INC.	AIRPORT	SINGLE-LANE LOOP	UNDERGROUND	1.48/4.43	9	6 (3 car train)	36/17	24 HRS/DAY
KING'S DOMINION	DOSWELL, VA	UNIVERSAL MOBILITY	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED/ AT-GRADE	2.06/0.88	1	6 (9 car train)	96/168	11 HRS/DAY (APR.-OCT.)
MIAMI	MIAMI, FL	WESTINGHOUSE	AIRPORT	DUAL-LANE SHUTTLE	ELEVATED	0.51/0.51	2	6	99/88	24 HRS/DAY
MINNESOTA ZOO	APPLE VALLEY, MN	UNIVERSAL MOBILITY	RECREATION CENTER	SINGLE-LANE LOOP	ELEVATED/ AT-GRADE	1.36/1.28	1	3 (6 car train)	94/123	10 HRS/DAY*
MORGANTOWN	MORGANTOWN, WV	BOEING	UNIVERSITY	DUAL-LANE WITH OFF-LINE STATIONS	EVEVATED/ AT-GRADE	8.60/6.79	5	71	21/26	76 HRS/WK
ORLANDO	ORLANDO, FL	WESTINGHOUSE	AIRPORT	2 DUAL-LANE SHUTTLES	ELEVATED	1.48/1.48	8	8	100/88	24 HRS/DAY
PEARLRIDGE	AIEA, HI	ROHR	SHOPPING CENTER	SINGLE-LANE SHUTTLE	ELEVATED/ AT-GRADE	0.23/0.21	2	1 (4 car train)	64/60	69 HRS/WK
SEA-TAC	SEATTLE, WA	WESTINGHOUSE	AIRPORT	2 SINGLE-LANE LOOPS WITH SHUTTLE CONNECTION	UNDERGROUND	1.71/5.13	8	12	102/86	20-24 HRS/DAY
TAMPA	TAMPA, FL	WESTINGHOUSE	AIRPORT	4 DUAL-LANE SHUTTLES	ELEVATED	1.35/1.35	8	8	100/84	18

* Annual Average

(1) 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.

(2) Equivalent Passenger Places per vehicle have been calculated on an allocation of 4 square feet per passenger, based on the gross area (length x width) of the vehicles for each system.

3.2 APPLICABILITY OF EXISTING AGT COST AND SERVICE INFORMATION TO ALTERNATIVE SETTINGS

Domestic AGT systems are currently serving airports; medical, recreation, and shopping centers; and a university. Only the Morgantown system, connecting downtown Morgantown with the West Virginia University campus, 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 center. These are very different environments from an urban area. Consequently, the capital costs associated with these systems do not include a number of major components that would be included in the cost of an urban deployment.

The decision to deploy AGT systems in urban settings would be based on the mobility requirements of the area in conjunction with land use patterns and population densities. These 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. Vehicle size and system throughput 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 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 soil conditions and topography, utility relocation, street modifications, traffic control, site accessibility, labor rates, local codes, etc. Costs associated with construction in urban areas include integrating AGT stations 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 did 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.

While there are constraints and complexities associated with 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 the total capital costs reported herein are not directly transferable because of site-specific factors in urban areas that impact costs and schedules.

4.0 CAPITAL COSTS

4.1 INTRODUCTION

This section presents capital cost data compiled for thirteen AGT systems. Data for the systems located at Duke University Medical Center and Pearl Ridge Center are not available.

Capital cost information was obtained primarily through responses by systems and suppliers and site surveys performed as part of UMTA-sponsored assessments. Where available, actual capital acquisition costs have been used and adjusted to average 1981 dollars. However, analysis of available data shows that the various AGT systems maintained their cost records in different formats. Also, in many cases the AGT system is an integral part of a larger facility and the costs have not always been recorded separately. Due to these facts, engineering estimates were used to duplicate the subject systems and have been adjusted to average 1981 dollars. These duplication costs generally do not consider the specific location of the system being examined, but rather are estimates based on up-to-date construction costs for equivalent generic systems.

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

- o Guideway - The vehicle roadway including site preparation, foundations, supporting structures, pedestrian walkways, running and guidance surfaces, wayside switching equipment, and special facilities for melting snow and ice if required.

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

- Maintenance and Support - Maintenance and storage facilities including special vehicles and equipment.

- Power and Utilities - Electric power transformers, feeders, switchgear, wayside power rails, and normal housekeeping power equipment.

- Vehicles - The rolling stock.

- Command and Control - Wayside and central control and communications equipment including operational software and voice and video communication systems.

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

4.2 COST ADJUSTMENTS

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 1981 price level. In order to remain consistent with past reports, the same indices for cost adjustments have been used and are explained below:

- CPI: The Consumer Price Index for urban wage earners and clerical workers (U.S. cities average) is used to adjust all costs for engineering and project management.

- PPI: The Producer Price Index for machinery and motive products (previously called the Wholesale Price Index) is used to adjust all hardware costs.

- ENR: The Engineering News Record 20-city construction cost index is used to adjust the cost of all fixed facility construction.

All three indices have a base of 100 for 1967. Listed below are the indices used and their yearly averages. These yearly averages have been used to adjust system capital costs when applicable. For other systems, the starting point for adjusting capital costs has been either the midpoint of construction or date of procurement.

YEARS	CPI	PPI	ENR
1975	161.2	156.2	206.0
1976	170.3	165.8	223.0
1977	181.5	176.6	240.0
1978	195.4	190.4	258.0
1979	217.4	206.9	279.5
1980	246.8	225.8	301.5
1981	272.4	256.7	329.0

Research and development costs and right-of-way acquisition costs have been removed from the data as much as possible since capital cost estimates for future AGT systems will not include them.

4.3 CAPITAL COST EXHIBITS

Capital cost data for thirteen AGT systems are summarized in Table 4-1. This table delineates the total system cost for each AGT system by cost category and presents each subsystem cost in terms of percentage of total system cost. This allows the subsystem costs of both large and small systems to be evaluated on a normalized basis.

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

TABLE 4-1. AGT CAPITAL COST SUMMARY
(THOUSANDS OF 1981 DOLLARS)

	AIRTRANS	ATLANTA	BUSCH GARDENS	DISNEY-WORLD	FAIRLANE	HOUSTON	KING'S DOMINION	MIAMI	MINNESOTA ZOO	MORGAN-TOWN	ORLANDO	SEA-TAC	TAMPA
GUIDEWAY													
TOTAL COST	18,982	20,613	2,530	2,899	3,061	8,579	1,589	3,618	3,232	39,708	5,668	18,247	5,077
% OF TOTAL SYSTEM COST	.21	.30	.36	.15	.33	.36	.19	.25	.34	.25	.20	.35	.23
STATIONS													
TOTAL COST	10,242	10,835	192	2,370	614	5,188	265	3,975	385	7,246	4,532	8,152	3,311
% OF TOTAL SYSTEM COST	.11	.16	.03	.13	.07	.22	.03	.27	.04	.05	.16	.15	.15
MAINTENANCE & SUPPORT													
TOTAL COST	5,663	4,004	338	885	175	377	305	1,099	803	6,233	2,357	4,238	1,346
% OF TOTAL SYSTEM COST	.06	.06	.05	.05	.02	.02	.03	.07	.08	.04	.08	.08	.06
POWER & UTILITIES													
TOTAL COST	7,680	3,902	586	1,224	1,447	613	496	620	919	10,004	1,057	2,506	3,293
% OF TOTAL SYSTEM COST	.08	.06	.08	.06	.15	.03	.06	.04	.10	.07	.04	.05	.15
VEHICLES													
TOTAL COST	18,950	13,908	1,279	4,956	1,137	1,264	3,495	1,696	2,924	20,876	5,643	7,689	4,194
% OF TOTAL SYSTEM COST	.20	.20	.18	.27	.12	.05	.41	.12	.31	.13	.20	.15	.20
COMMAND & CONTROL													
TOTAL COST	10,034	5,124	788	5,001	1,138	2,660	54	1,229	433	30,327	6,284	3,158	2,143
% OF TOTAL SYSTEM COST	.11	.07	.11	.27	.12	.11	.01	.08	.04	.19	.22	.06	.10
ENGINEERING & PROJECT MGT.													
TOTAL COST	21,161	10,039	1,342	1,302	1,734	5,070	2,259	2,536	862	42,694	2,860	8,241	2,340
% OF TOTAL SYSTEM COST	.23	.15	.19	.07	.19	.21	.27	.17	.09	.27	.10	.16	.11
TOTAL SYSTEM COST	92,712	68,425	7,055	18,637	9,306	23,751	8,463	14,773	9,558	157,088	28,401	52,231	21,704

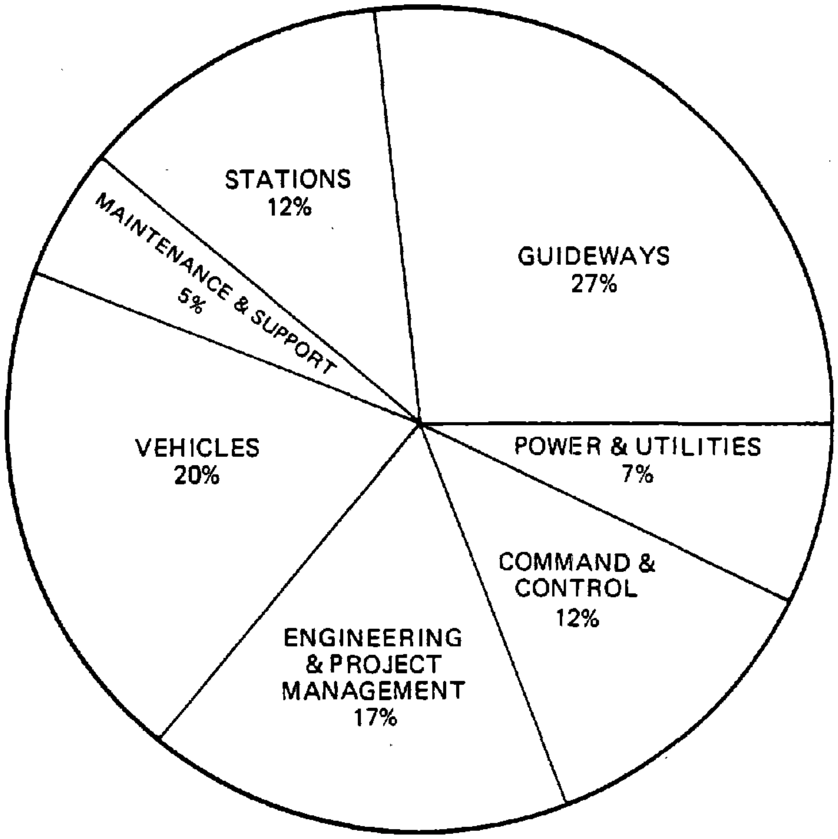


FIGURE 4-1. AVERAGE DISTRIBUTION OF CAPITAL COSTS FOR THIRTEEN AGT SYSTEMS

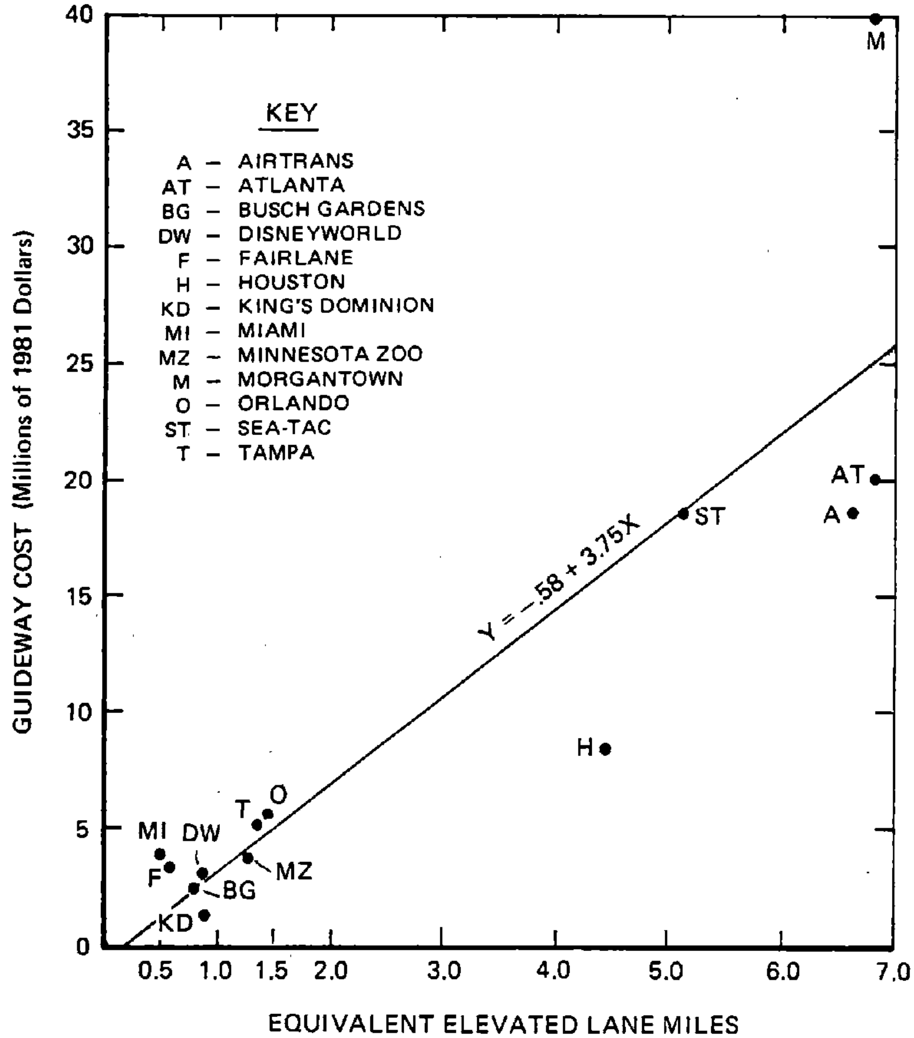
Differences in system size makes cost comparisons difficult. Figures 4-2 and 4-3 take into account system size differences when comparing subsystem costs. In these figures, correlations between guideway costs and equivalent elevated lane miles, and unit vehicle cost and equivalent passenger places are displayed graphically. A linear regression analysis has been used to correlate these costs as a function of the independent variables. (The specific routine used was the Stepwise Multi-Variate Linear Regression Procedure in the Statistical Package for the Social Sciences (SPSS)). The resulting regression curves, which represent the scattered data points, are shown on the appropriate figures where Y represents the abscissa and X represents the ordinate.

4.4 DISCUSSION OF CAPITAL COST VARIATIONS

One of the primary reasons for the variations in total system costs is the difference in system size, ranging from one-half mile at Miami to almost thirteen miles at Airtrans. Some effects of size differentials are removed by normalizing the cost data around size-related parameters; however, economies of scale inherent in the larger systems must still be considered.

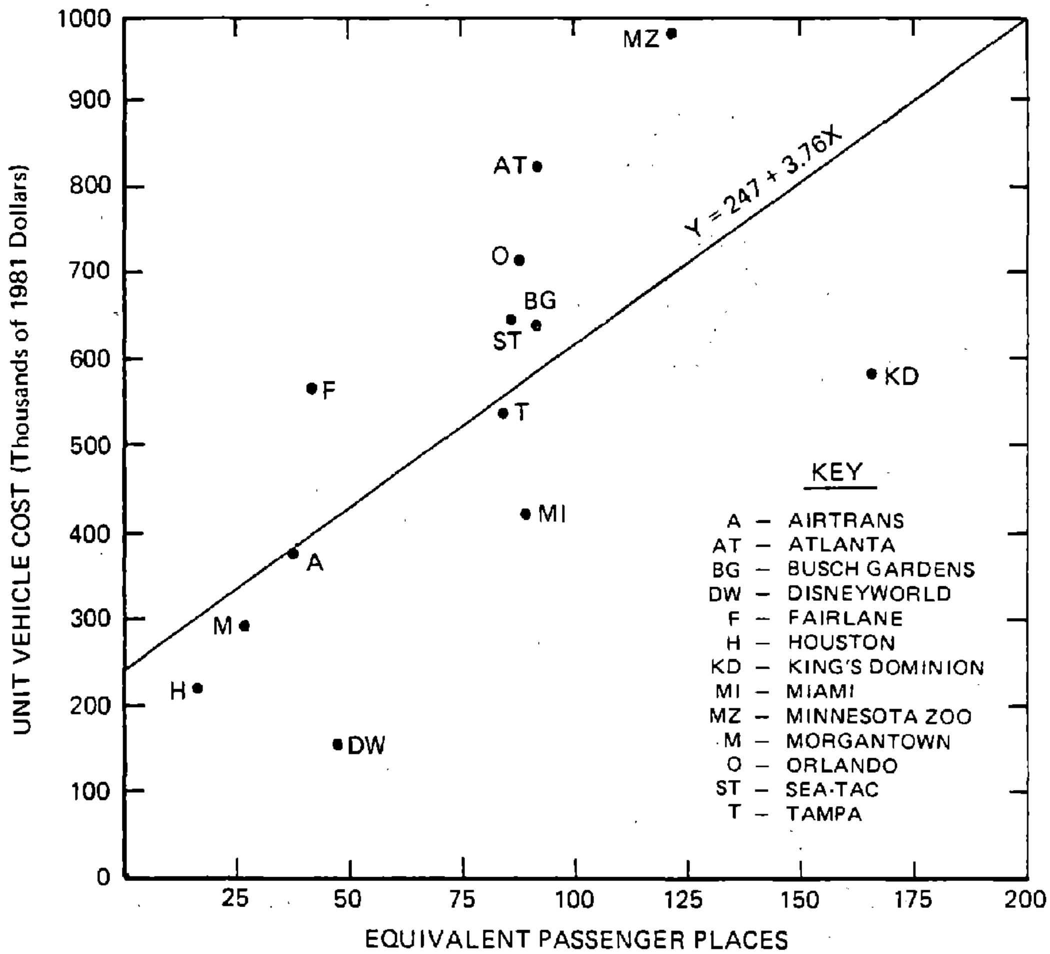
In addition to economies of scale, major cost variations are attributable to other general characteristics of the systems. These characteristics include site description, site location, technology employed, bid competitiveness, and degree of regulation. Site descriptions vary from airports and a university to medical, recreation, and shopping centers. The differing design factors for each system (e.g., an airport system requiring almost 100 percent availability, 24 hours per day, 365 days per year or a recreation center system needing 80 percent availability, 12 hours per day, 140 days per year) impact total system costs.

Locations vary from sites located 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



NOTE: The Resulting Curve Is Based On All Points And Has A Correlation Coefficient Of 0.88.

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



NOTE: The Resulting Curve Is Based On All Points And Has A Correlation Coefficient Of 0.67.

FIGURE 4-3. REGRESSION OF UNIT VEHICLE COST ON EQUIVALENT PASSENGER PLACES 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 technology employed will also vary costs. Aside from basic differences in the technical sophistication of the control system, performance requirements such as capacity, safety, and reliability can also influence the cost between various systems.

Another factor contributing to cost variations is the competitiveness of supplier bids. As a general rule, sole source contracts may be expected to have higher costs than systems bid by three or four suppliers.

Finally, the extensiveness of regulations, local code requirements, and technical and performance specifications that must be met by the supplier may weigh heavily on total project costs.

The following sections provide a brief discussion of factors and considerations that may result in cost variations of the seven major capital cost categories for each of the AGT systems. Appendix A contains a more detailed description of the subsystem characteristics of these systems.

4.4.1 Guideway

The construction and installation costs associated with the guideway element of an AGT system are functions of many factors, both design-specific and site-specific, that may result in widely varying unit cost ranges. Unit guideway costs are based on equivalent elevated lane miles and range from $ 1,806,000 per lane mile at King's Dominion to $ 7,094,000 at Miami; the average cost is approximately $ 3,500,000 per lane mile. The distribution of guideway costs vary from 15 percent of total system costs at Disneyworld to 36 percent at Busch Gardens and Houston.

Among the factors resulting in cost variations are:

- o Beam shape, width, and span length.
- o Single- or dual-lane construction.
- o Guideway materials and construction techniques.
- o Guideway load capacity.
- o Guideway curvature and column height.
- o Emergency egress provisions.
- o Climate and all-weather provisions.
- o Percent of guideway elevated, at-grade, and underground.
- o Number and type of switches, crossovers, and turntables.
- o Guideway aesthetics and environmental considerations.
- o Local topographical and soil conditions.
- o Local labor and material rates.
- o Degree of utility and street relocations.

4.4.2 Stations

Station costs, like guideway costs, may vary significantly due to both design-specific and site-specific factors. The distribution of station costs range from 3 percent of total system costs at Busch Gardens and King's Dominion to 27 percent at Miami.

Among the factors resulting in cost variations are:

- o Size and number of stations.
- o Station materials and construction techniques.
- o Number of stations elevated, at-grade, and underground.
- o Station design (open vs. enclosed; freestanding vs. contiguous vs. joint use).
- o Platform design (sides or island).
- o Climate control and amenities.
- o Station aesthetics and environmental considerations.
- o Amount and type of graphics.
- o Amount and type of fare collection equipment.

- Amount and type of bi-parting doors or separations.
- Amount and type of elevators and escalators.
- Local topographical and soil conditions.
- Local labor and material rates.

4.4.3 Maintenance and Support

Maintenance and support facilities costs, impacted by many of the same factors affecting station costs, result in variations from one deployment to the next. The distribution of costs range from 2 percent of total system costs at Fairlane and Houston to 8 percent at Minnesota Zoo, Orlando, and Sea-Tac.

Among the factors resulting in cost variations are:

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

4.4.4 Power and Utilities

Power and utility costs also vary from system-to-system. The distribution of costs range from 3 percent of total system costs at Houston to 15 percent at Fairlane and Tampa.

Among the factors resulting in cost variations are:

- Type of power supply available.
- Type of power system (basic or redundant).
- Total length of system.
- Single- or dual-lane construction.

4.4.5 Vehicles

Vehicle costs, even among vehicles provided by the same suppliers, vary considerably due to design characteristics. Individual vehicle costs are based on equivalent passenger places and range from \$ 3,400 per passenger place at Disneyworld to \$ 13,900 at Fairlane; the average cost is approximately \$ 7,500 per passenger place. The distribution of vehicle costs vary from 5 percent of total system costs at Houston to 41 percent at King's Dominion.

Among the factors resulting in cost variations are:

- Vehicle size and weight.
- Vehicle propulsion systems.
- Vehicle control systems.
- Type of operation (independent units vs. trains).
- Type of vehicle (active vs. passive).
- Climate control and interior design.
- Vehicle switching capabilities.
- Emergency and failure requirements.
- Performance requirements.
- Size of vehicle order.
- Competitiveness of vehicle bids.

4.4.6 Command and Control

Command and control costs will vary from system-to-system based on the operating strategies and requirements at each deployment. The distribution of cost range from 1 percent of total system costs at King's Dominion to 27 percent at Disneyworld.

Among the factors resulting in cost variations are:

- Number of vehicles.
- Number of lane miles.

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

4.4.7 Engineering and Project Management

Engineering and project management costs vary among deployments due to differences in construction techniques and management strategies. The distribution of costs range from 7 percent of total system costs at Disneyworld to 27 percent at King's Dominion and Morgantown.

Among the factors resulting in cost variations are:

- Size of system.
- Length of construction schedule.
- Degree of regulatory requirements.
- Amount of systems testing required.
- Size of project management staff and number of consultants.

5.0 OPERATIONS AND MAINTENANCE COSTS

5.1 INTRODUCTION

This section presents cost and performance information on the operation and maintenance of selected AGT systems. Data have been compiled and analyzed for fifteen AGT systems in the United States. Included for the first time are operations and maintenance (O&M) costs for systems in Houston and Orlando which opened for service in August and September of 1981.

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

- Labor - Costs associated with the personnel for system administration and engineering, operation, and maintenance.
- Utilities - Costs of electricity, natural gas, etc.
- Materials and Services - Costs for spare parts and materials as well as contract services.
- General and Administrative - Any pro rata share of the general management costs as well as other overhead costs.

When comparing the actual 1981 O&M costs for AGT systems with the data for both AGT and conventional transit, the Consumer Price Index (CPI) for urban wage earners and clerical workers in the United States (defined in Section 4.2) was used to adjust the costs to average 1981 dollars. O&M cost information for conventional transit was obtained from the Transit Fact Book 1981 published by the American Public Transit Association. Costs for conventional transit (i.e., bus and rail) 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.

Conventional transit O&M cost data for 1981 were not yet available at the time of report publication. Because of the time required to compile the data for the Transit Fact Book, totals for 1980 are subject to change. Changes in totals for years prior to 1980 result from subsequently available data.

5.2 O&M COST EXHIBITS

A detailed accounting of 1981 O&M costs for each system is shown in Table 5-1 along with other pertinent operating information. The operational statistics include: vehicle miles traveled, equivalent place miles, passengers carried, and system operating hours.

A breakdown of O&M cost measures is shown in Table 5-2. In this table, O&M costs for each system are normalized by the operating parameters recorded in Table 5-1.

O&M cost data for the fifteen AGT systems are summarized in Table 5-3. This table delineates the total system cost for each AGT system by cost category and presents each category in terms of percentage of total O&M cost.

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.

Figures 5-2 through 5-5 present the total O&M cost for each system versus the vehicle miles traveled, equivalent place miles, passengers carried, and system operating hours. These figures are furnished in order to provide average cost data so that O&M cost projections for future systems can be extrapolated based on proposed operating characteristics. A linear regression analysis has been used to correlate this cost as a function of the independent variables. (The specific routine used was the Stepwise Multi-Variate Linear Regression Procedure in the Statistical Package for the Social Sciences (SPSS)). The resulting regression curves, which represent the scattered data points, are shown on the appropriate figures where Y represents the abscissa and X represents the ordinate.

TABLE 5-1. AGT OPERATIONAL STATISTICS AND OPERATIONS AND MAINTENANCE COST BREAKDOWN

	AIRTRANS	ATLANTA	BUSCH GARDENS	DISNEYWORLD	DUKE	FAIRLANE	HOUSTON	KING'S DOMINION	MIAMI	MINNESOTA ZOO (1)	MORGANTOWN	ORLANDO	PEARLRIDGE	SEA-TAC	TAMPA
OPERATIONAL STATISTICS															
VEHICLE MILES TRAVELED	2,982,533	767,913	23,222	577,896	69,216	73,391	75,852	50,568	232,703	6,532	994,555	183,700	12,211	574,425	555,897
EQUIVALENT PLACE MILES(2)	110,353,721	69,880,083	2,066,758	27,739,008	3,530,016	3,009,031	1,289,484	8,495,424	20,477,864	803,436	25,858,430	16,165,600	732,660	49,400,550	29,895,348
PASSENGERS CARRIED	6,499,407	26,652,000	1,342,256	4,885,042	968,040	2,249,684	2,500,000	770,000	4,724,631	287,800	3,113,528	1,804,000	1,020,596	10,721,825	17,223,145
SYSTEM OPERATING HOURS	8,615	7,665	1,565	4,114	8,760	3,874	2,688	1,364	8,760	2,720	5,722	2,472	3,665	8,030	5,385
O&M COSTS (1981 DOLLARS)															
LABOR		2,447,212												637,360	
ADMINISTRATIVE & ENGINEERING	317,628	-	8,000	0	29,442	N/A		0		0	280,291	2,000	60,700	-	15,373
OPERATIONS	346,534	-	46,000	156,200	67,073	N/A	Provided	30,000	Provided	78,864	248,669	18,180	43,748	-	5,666
MAINTENANCE	2,071,153	-	57,500	74,879	291,667	N/A	Under Contract	0	Under Contract	125,100	570,616	286,900	117,038	-	9,707
OTHER	682,308	-	0	41,000	0	N/A		0		0	0	0	0	-	0
UTILITIES															
ELECTRICITY	341,908	113,622	14,000	68,420	13,560	N/A	8,754	38,833	60,146	28,849	223,168	37,187	9,612	21,541	88,947
GAS	0	0	0	0	0	N/A	0	0	0	1,509	179,917	0	0	0	0
TELEPHONE	0	0	0	0	0	N/A	0	0	0	0	0	0	1,243	0	0
MATERIALS & SERVICES															
SPARE PARTS & MATERIALS	685,302	43,417	23,500	50,063	60,000	N/A	0	8,000	0	12,231	327,663	0	12,569	113,000	94,356
CONTRACT SERVICES	202,980	188,752	33,000	0	0	N/A	328,404	0	256,364	3,062	263,184	13,991	2,280	30,000	534,684
GENERAL & ADMINISTRATIVE	91,238	249,996	0	31,240	0	N/A	0	0	0	8,497	165,449	3,000	67,912	0	16,500
TOTAL O&M COST	4,739,051	3,042,999	182,000	421,802	461,742	1,372,307 (est.)	337,158	76,833	316,510	258,112	2,258,957	361,258	315,102	801,901	765,233

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

N/A Not Available

(1) Totals affected by employee strike from 7/20/81 - 8/12/81.

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

TABLE 5-2. AGT OPERATIONS AND MAINTENANCE COST MEASURES (1981 DOLLARS)

SYSTEM	O&M COST PER VEHICLE MILE TRAVELED	O&M COST PER EQUIVALENT PLACE MILE	O&M COST PER PASSENGER CARRIED	O&M COST PER SYSTEM OPERATING HOUR
AIRTRANS	1.59	0.043	0.73	550.00
ATLANTA	3.96	0.044	0.11	397.00
BUSCH GARDENS	7.84	0.088	0.14	116.00
DISNEYWORLD	0.73	0.015	0.09	103.00
DUKE	6.67	0.131	0.48	53.00
FAIRLANE	18.70	0.456	0.61	354.00
HOUSTON(1)	4.44	0.261	0.13	125.00
KING'S DOMINION	1.52	0.009	0.10	56.00
MIAMI	1.36	0.015	0.07	36.00
MINNESOTA ZOO	39.52	0.321	0.90	95.00
MORGANTOWN	2.27	0.087	0.73	395.00
ORLANDO(2)	1.97	0.022	0.20	146.00
PEARLRIDGE	25.80	0.430	0.31	86.00
SEA-TAC	1.40	0.016	0.07	100.00
TAMPA	2.15	0.026	0.04	142.00

(1) APPROXIMATELY FOUR MONTHS OF DATA.
(2) APPROXIMATELY THREE MONTHS OF DATA.

TABLE 5-3. AGT OPERATIONS AND MAINTENANCE COST SUMMARY (1981 DOLLARS)

	AIRTRANS	ATLANTA	BUSCH GARDENS	DISNEYWORLD	DUKE	FAIRLANE	HOUSTON	KING'S DOMINION	MIAMI	MINNESOTA ZOO	MORGANTOWN	ORLANDO	PEARLRIDGE	SEA-TAC	TAMPA
LABOR															
TOTAL COST	3,417,623	2,447,212	111,500	272,079	388,182	N/A	0	30,000	0	203,964	1,099,576	307,080	221,486	637,360	30,746
$ OF TOTAL O&M COST	.72	.80	.61	.65	.84	N/A	0	.39	0	.79	.49	.85	.70	.79	.04
UTILITIES															
TOTAL COST	341,098	113,622	1,0040	68,420	13,560	N/A	8,754	38,835	60,146	30,358	403,085	37,187	10,855	21,541	88,947
$ OF TOTAL O&M COST	.07	.04	.08	.16	.03	N/A	.03	.51	.19	.12	.18	.10	.03	.03	.12
MATERIALS & SERVICES															
TOTAL COST	888,282	232,169	5,5060	50,063	60,000	N/A	328,404	8,000	256,364	15,293	590,847	13,991	14,849	143,000	629,040
$ OF TOTAL O&M COST	.19	.08	.31	.12	.13	N/A	.97	.10	.81	.06	.26	.04	.05	.18	.82
GENERAL & ADMINISTRATIVE															
TOTAL COST	91,238	249,996	0	31,240	0	N/A	0	0	0	8,497	165,449	3,000	67,912	0	16,500
$ OF TOTAL O&M COST	.02	.08	0	.07	0	N/A	0	0	0	.03	.07	.01	.22	0	.02
TOTAL O&M COST	4,739,051	3,042,999	182,000	421,802	461,742	1,372,307 (est.)	337,158	76,885	316,310	258,112	2,258,957	361,258	315,102	801,901	765,233

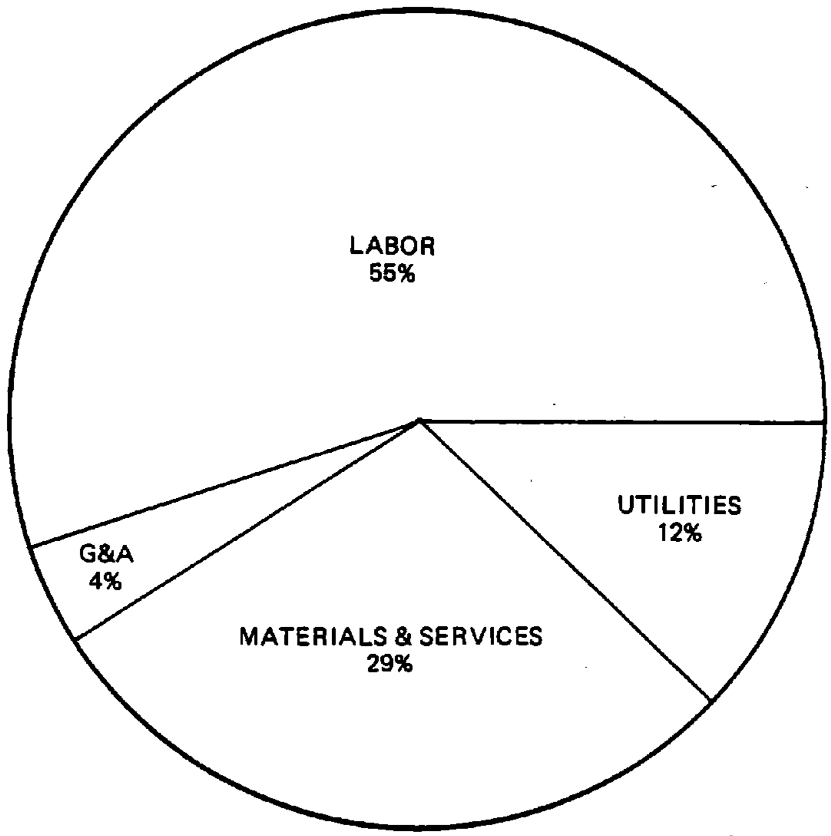
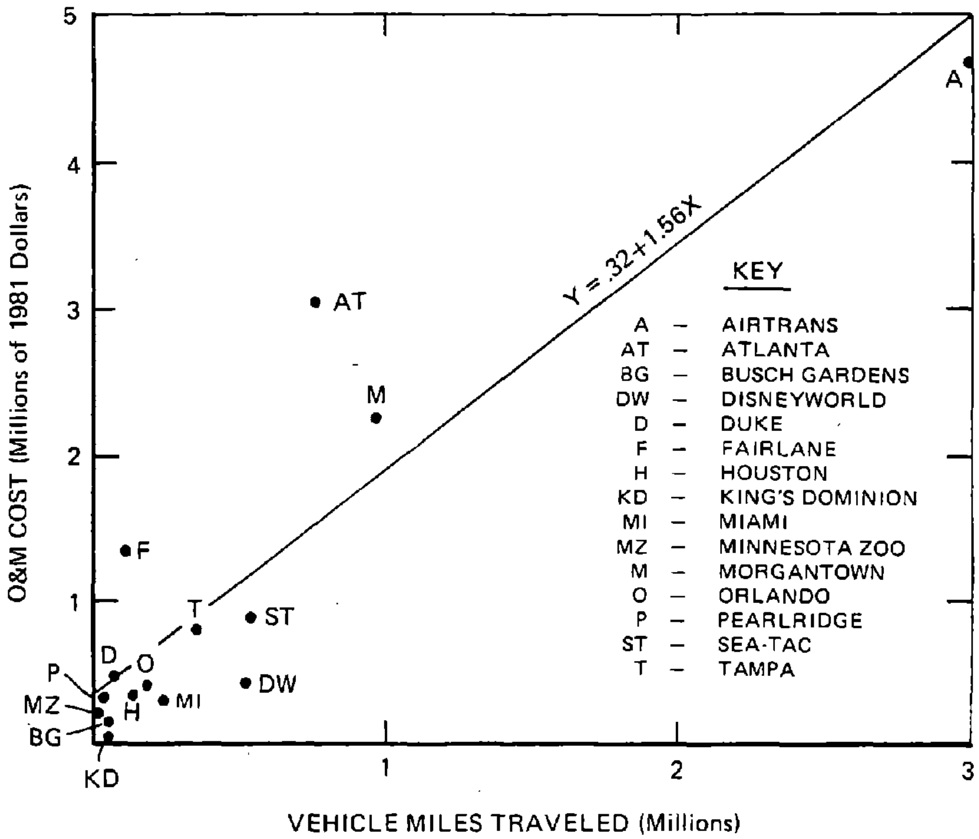
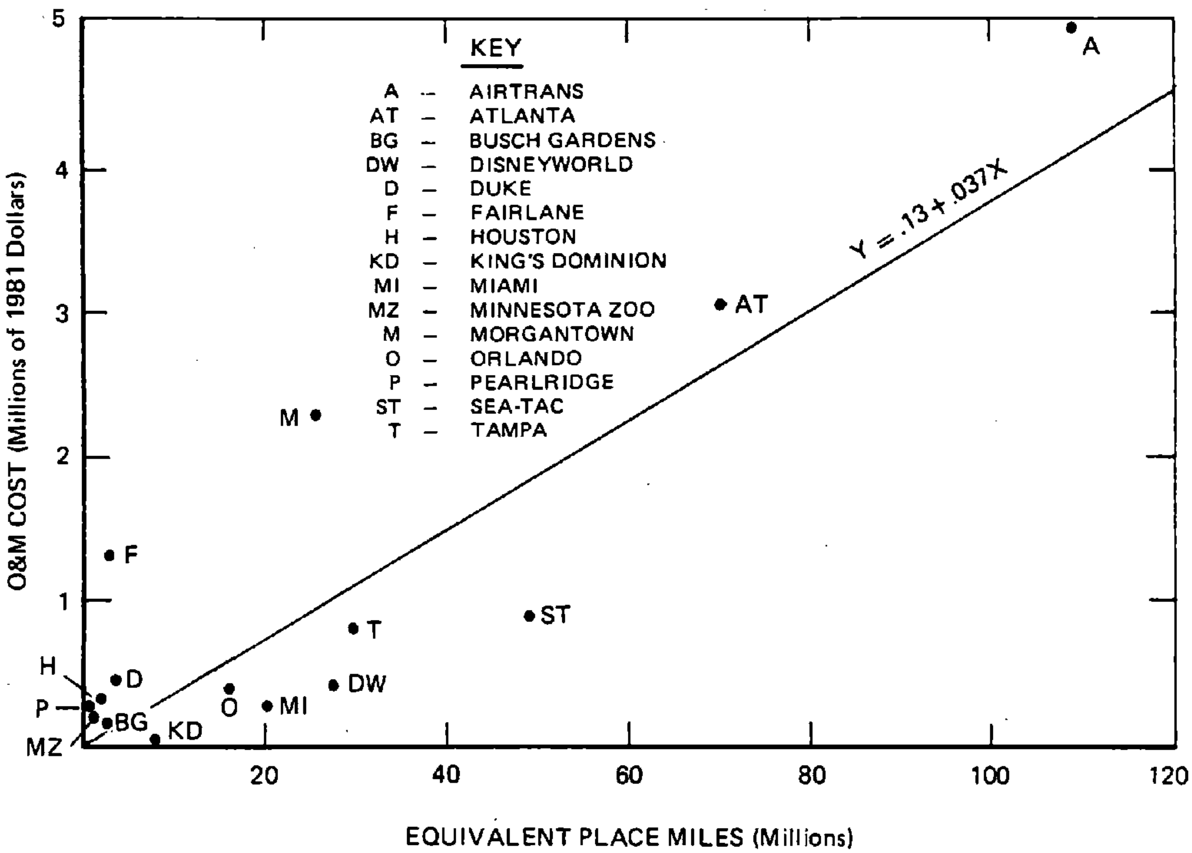


FIGURE 5-1. AVERAGE DISTRIBUTION OF O&M COSTS FOR FIFTEEN AGT SYSTEMS



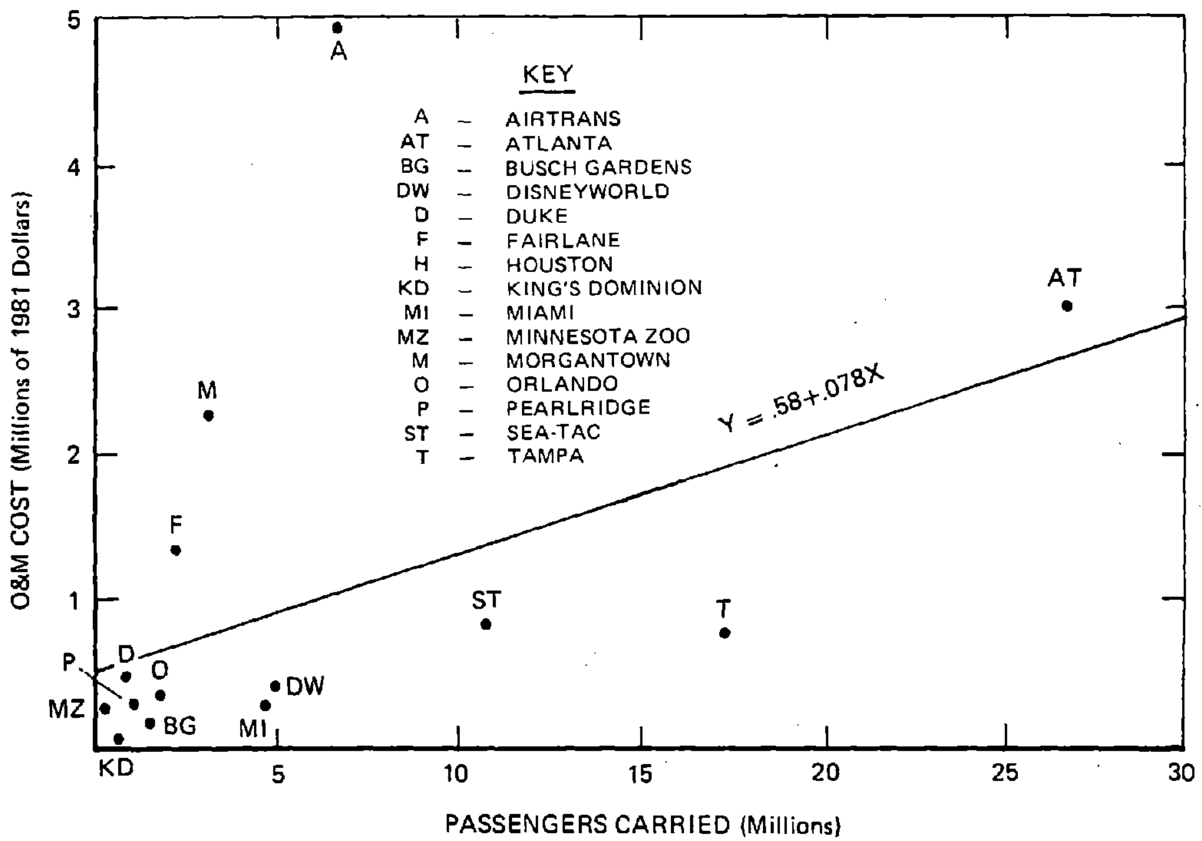
NOTE: The Resulting Curve Is Based On All Points And Has A Correlation Coefficient Of 0.90.

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



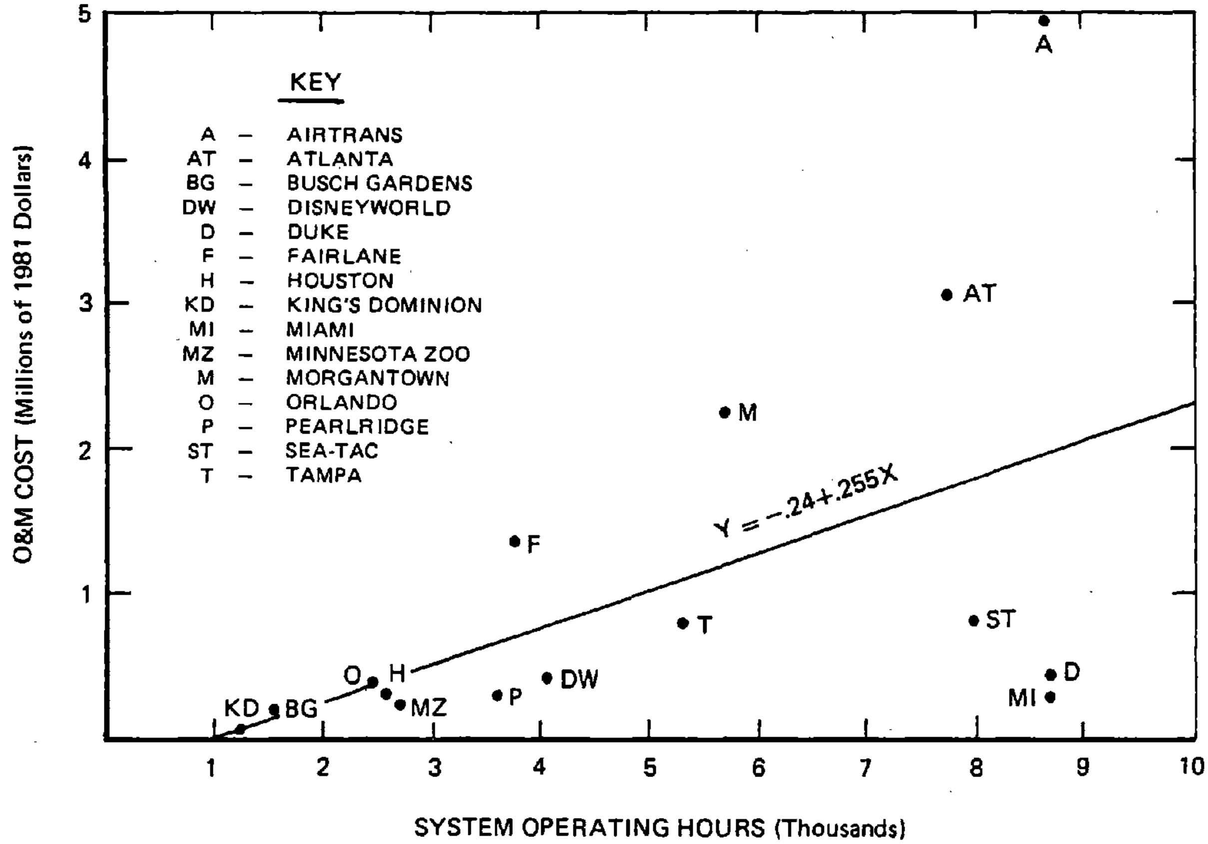
NOTE: The Resulting Curve Is Based On All Points And Has A Correlation Coefficient Of 0.87.

FIGURE 5-3. REGRESSION OF O&M COST ON EQUIVALENT PLACE MILES



NOTE: The Resulting Curve Is Based On All Points And Has A Correlation Coeffieient Of 0.43.

FIGURE 5-4. REGRESSION OF O&M COST ON PASSENGERS CARRIED



NOTE: The Resulting Curve Is Based On All Points And Has A Correlation Coefficient Of 0.52.

FIGURE 5-5. REGRESSION OF O&M COST ON SYSTEM OPERATING HOURS

Figures 5-6 through 5-12 present O&M trends for the five oldest, year-round operating systems (i.e., Airtrans, Disneyworld, Morgantown, Sea-Tac, and Tampa). These figures depict trends over the last six years for O&M costs, pertinent operational statistics, and associated cost measures. Data on the passengers carried were not available prior to 1979. O&M information was not available for Morgantown in 1979 because it was closed for construction of Phase II.

Figures 5-13 through 5-15 exhibit O&M cost trends for AGT in relation to conventional transit. These figures display trends over the last six years for average O&M costs per vehicle mile traveled, equivalent place mile, and passenger carried. Once again it should be noted that data on the passengers carried prior to 1979, and 1979 O&M information for Morgantown were not available.

Figure 5-16 compares average O&M cost per vehicle mile traveled for the following types of transit systems: AGT, Bus, Trolley Coach Bus, and Heavy and Light Rail.

5.3 DISCUSSION OF O&M COST VARIATIONS

The breakdown of O&M costs by specific categories may not be comparable due to the lack of uniformity in the reporting of O&M costs at the various systems. However, the totals are reasonably accurate. To follow is an assessment of the information contained in the O&M cost exhibits.

5.3.1 Cost Analysis

When analyzing O&M costs it should be understood that certain components vary as a function of the number of miles accumulated on the vehicles, while other components represent fixed costs that are independent of vehicle mileage. Cost components that vary with vehicle mileage are related primarily to maintenance of the system (i.e., maintenance labor, spare parts, and

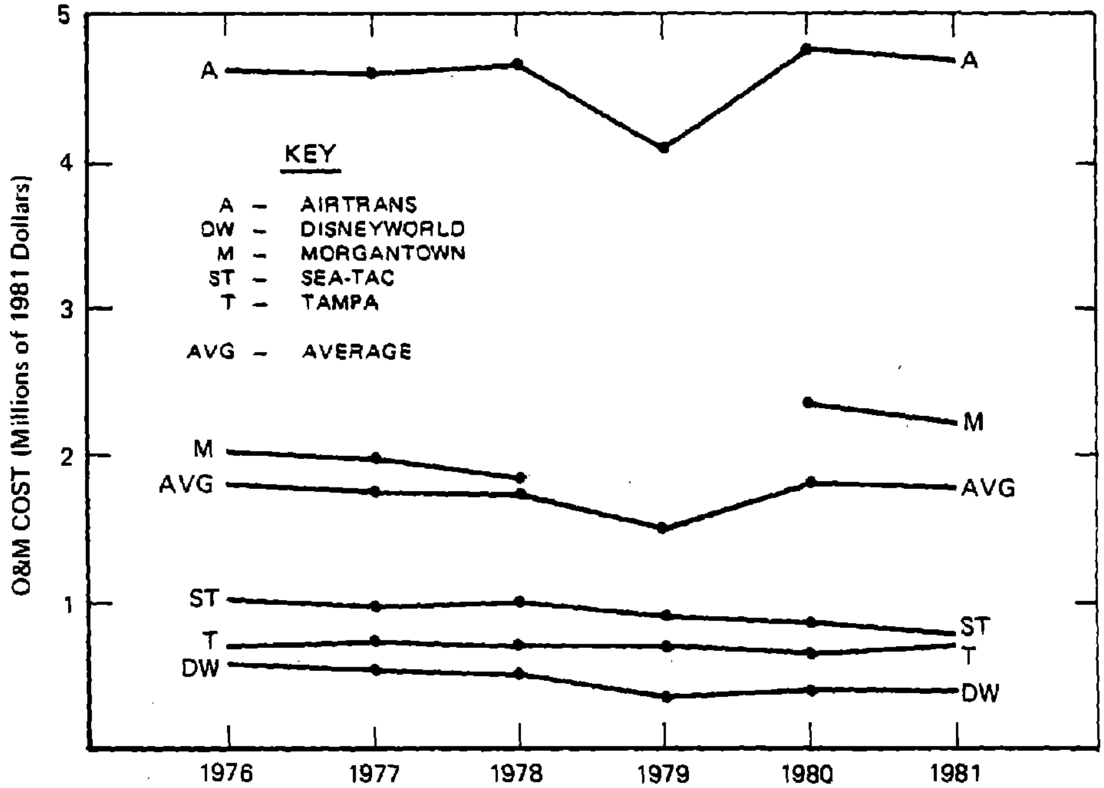


FIGURE 5-6. TREND OF O&M COSTS FOR FIVE AGT SYSTEMS

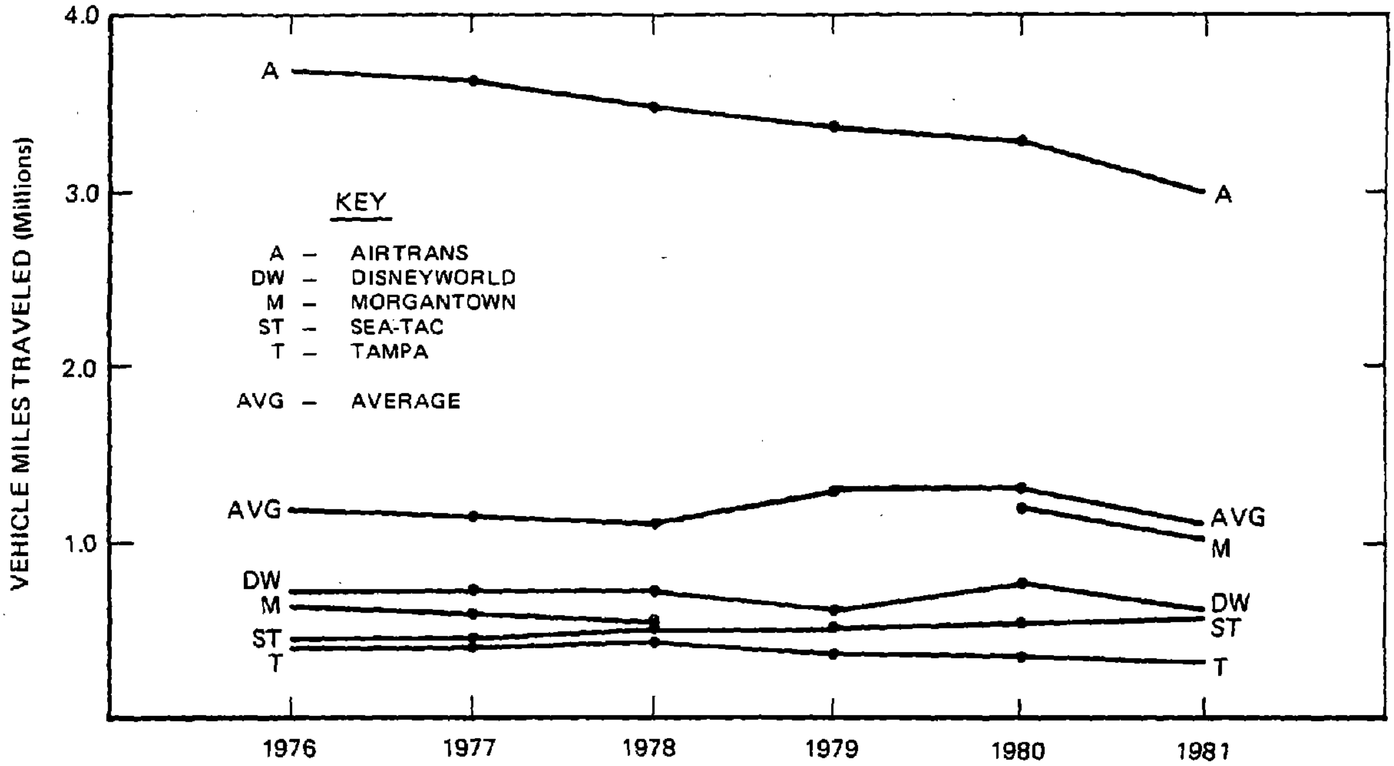


FIGURE 5-7. TREND OF VEHICLE MILES TRAVELED FOR FIVE AGT SYSTEMS

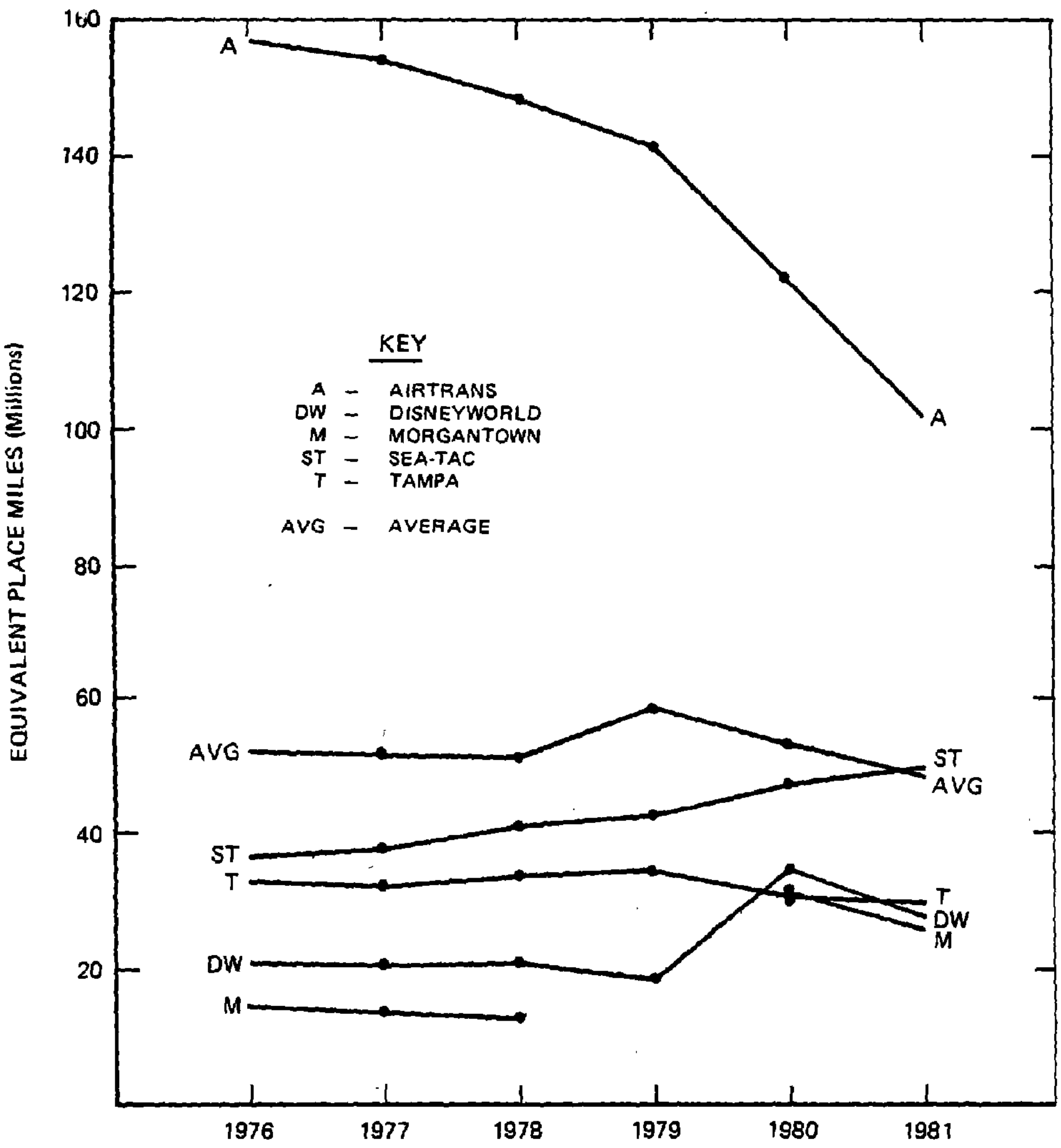


FIGURE 5-8. TREND OF EQUIVALENT PLACE MILES FOR FIVE AGT SYSTEMS

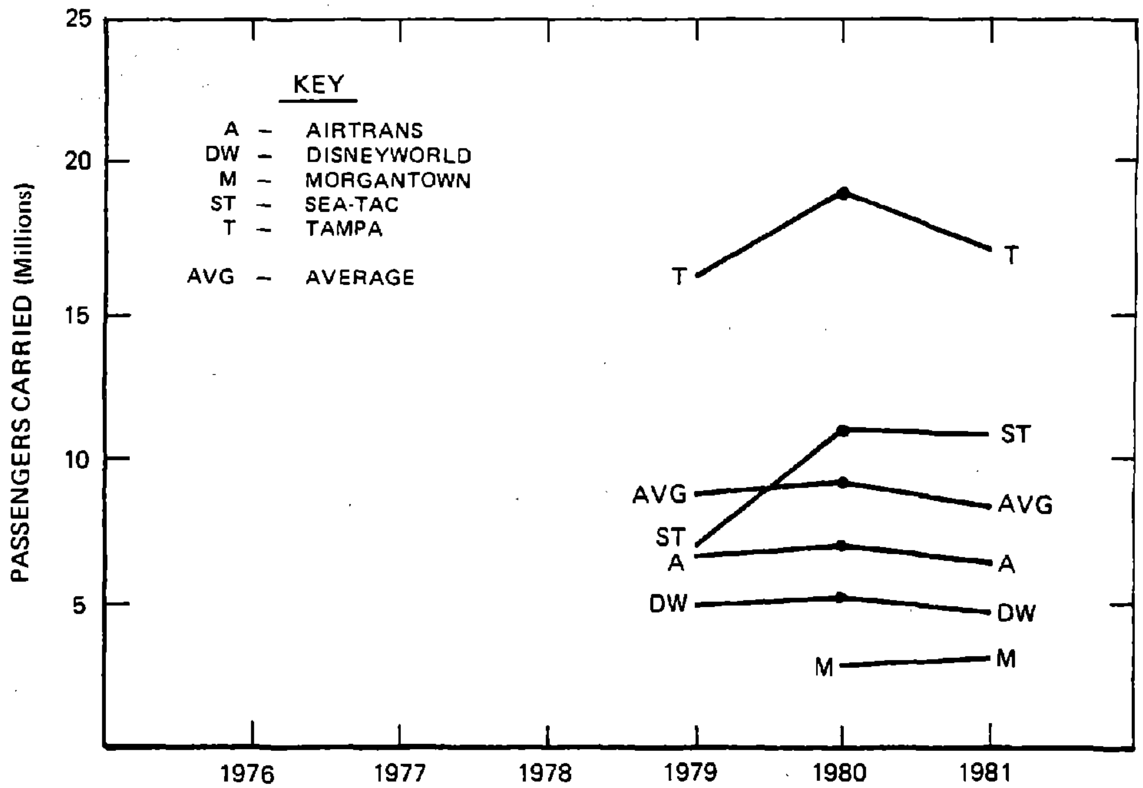


FIGURE 5-9. TREND OF PASSENGERS CARRIED FOR FIVE AGT SYSTEMS

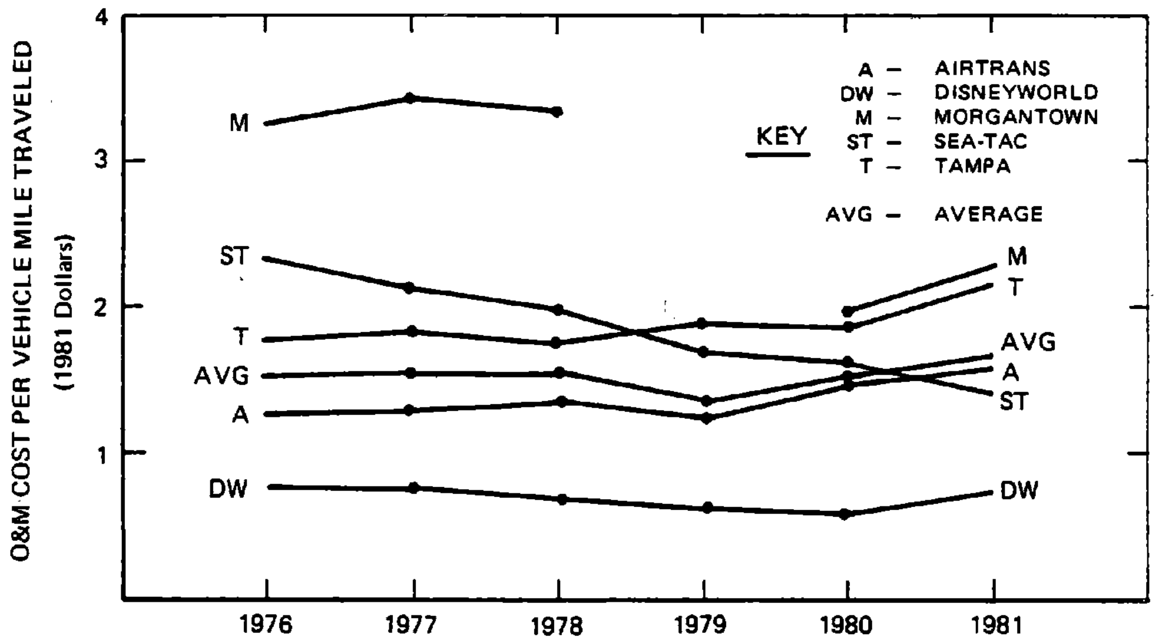


FIGURE 5-10. TREND OF O&M COST PER VEHICLE MILE TRAVELED FOR FIVE AGT SYSTEMS

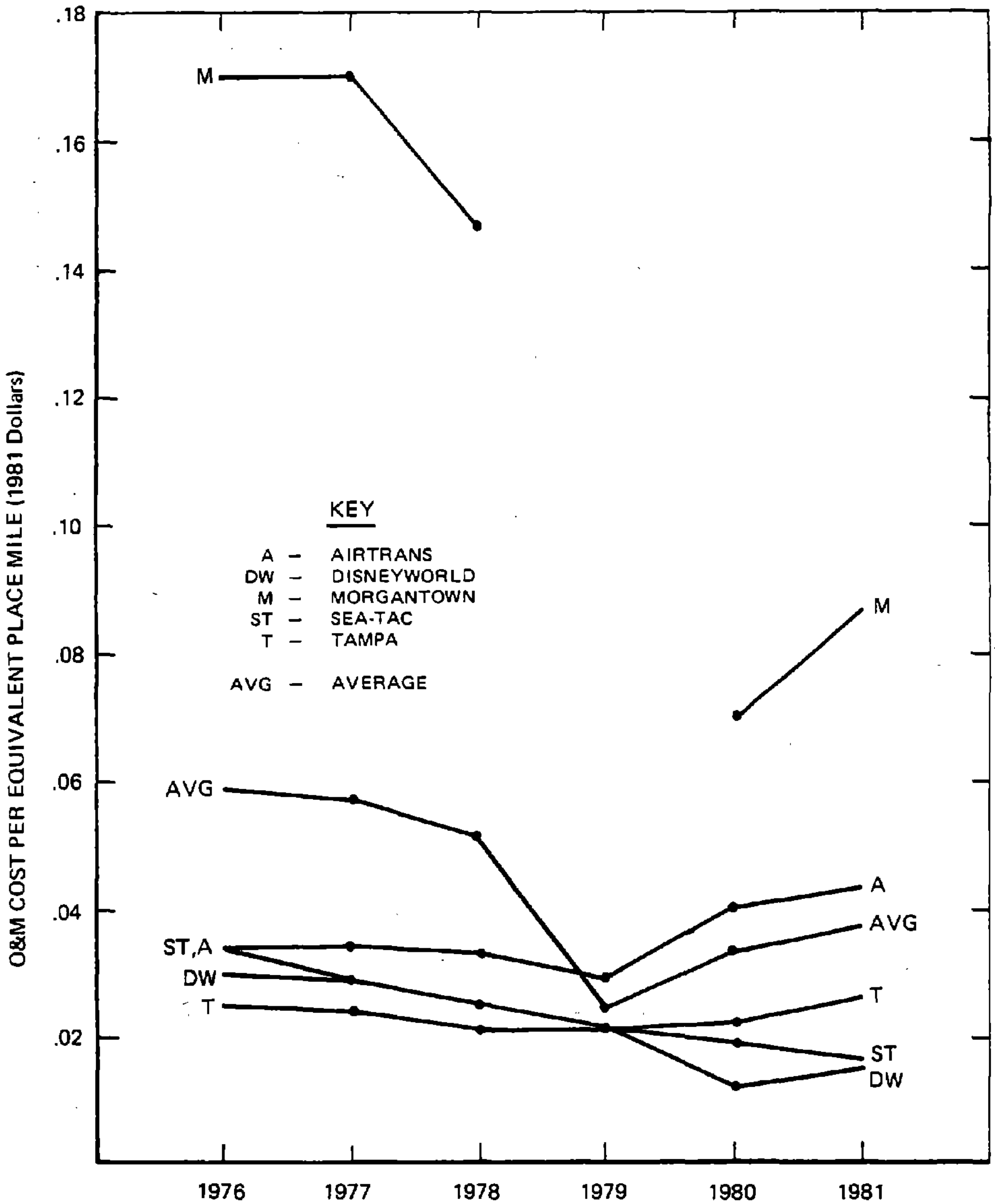


FIGURE 5-11. TREND OF O&M COST PER EQUIVALENT PLACE MILE FOR FIVE AGT SYSTEMS

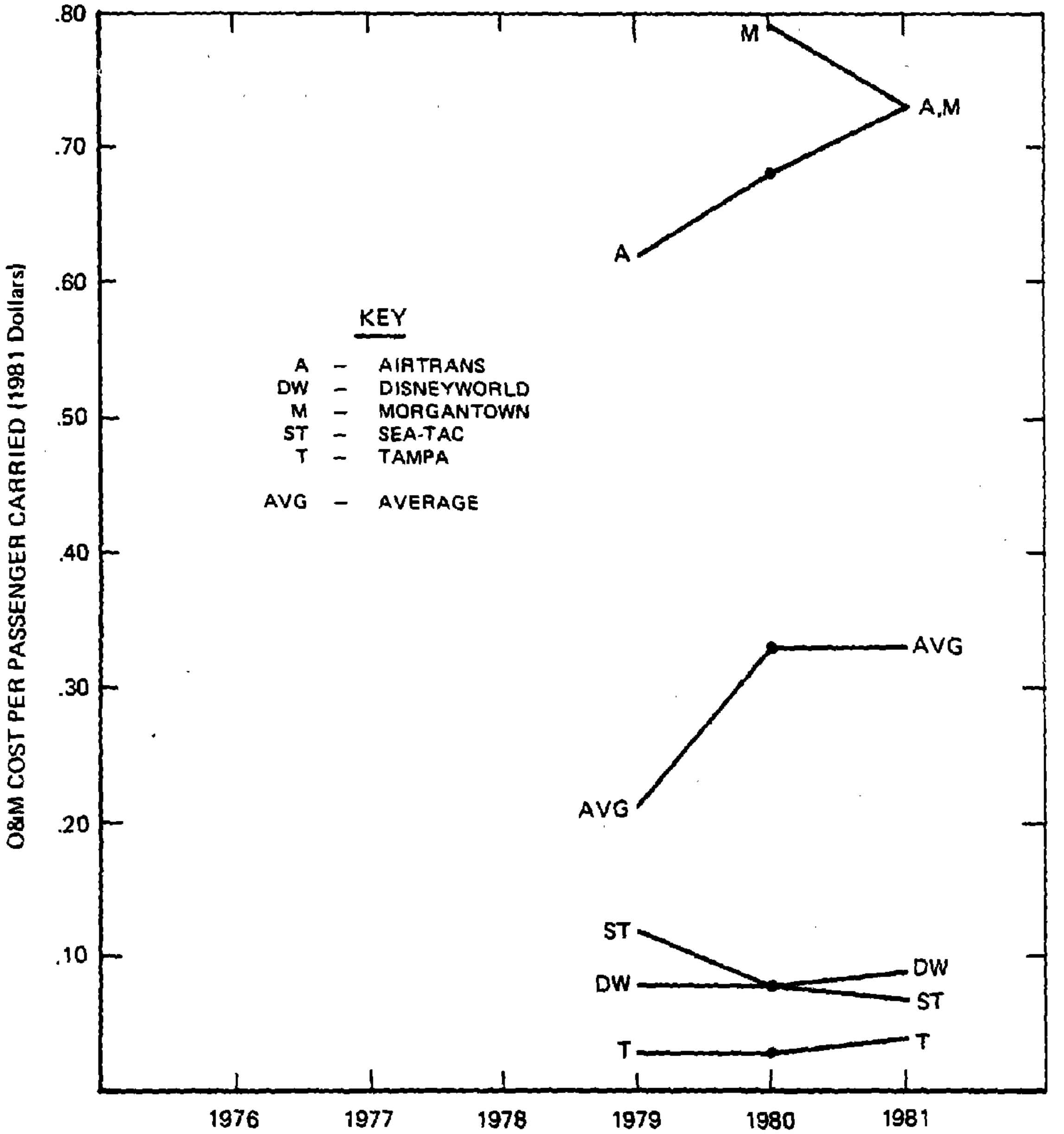


FIGURE 5-12. TREND OF O&M COST PER PASSENGER CARRIED FOR FIVE AGT SYSTEMS

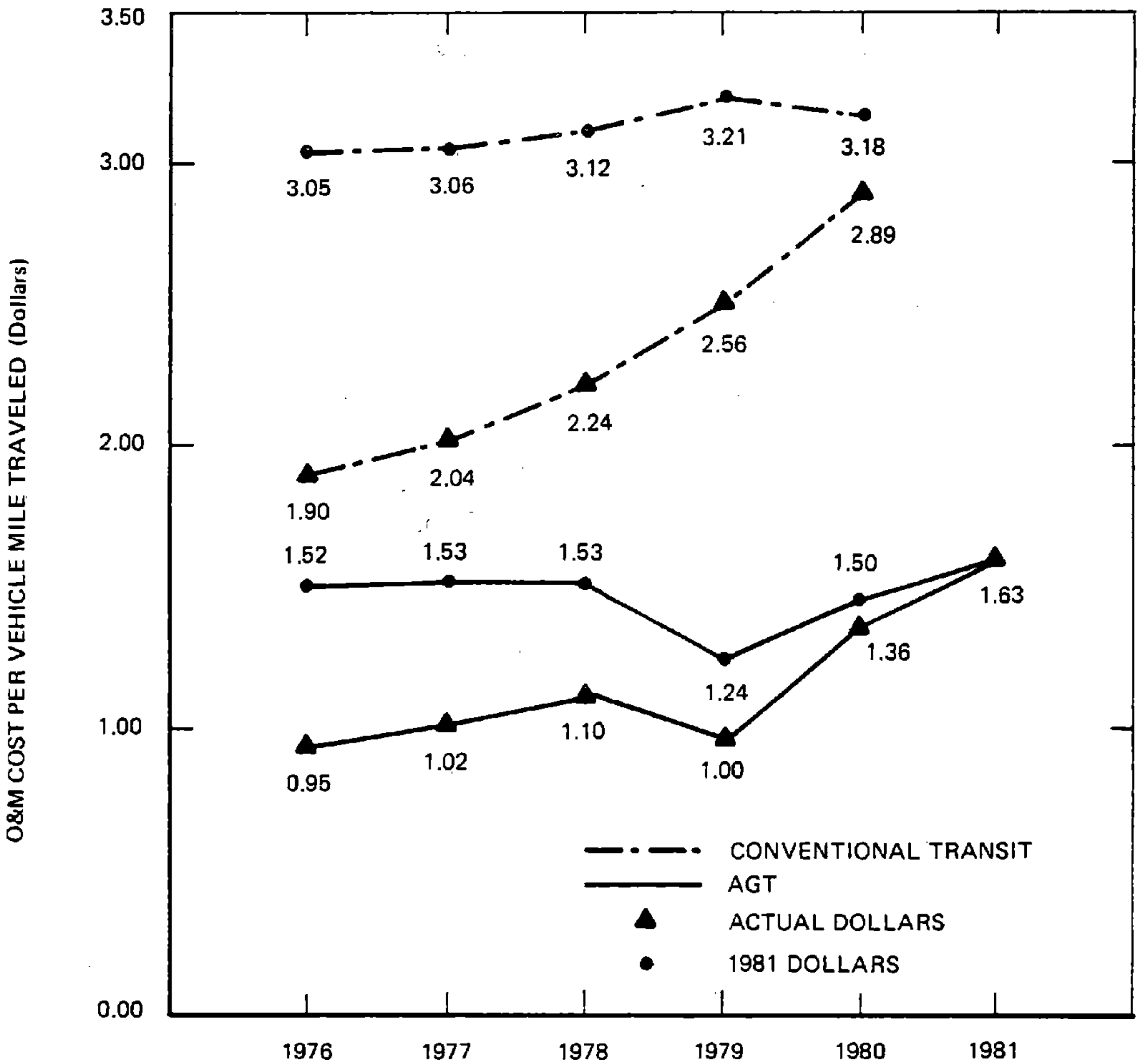
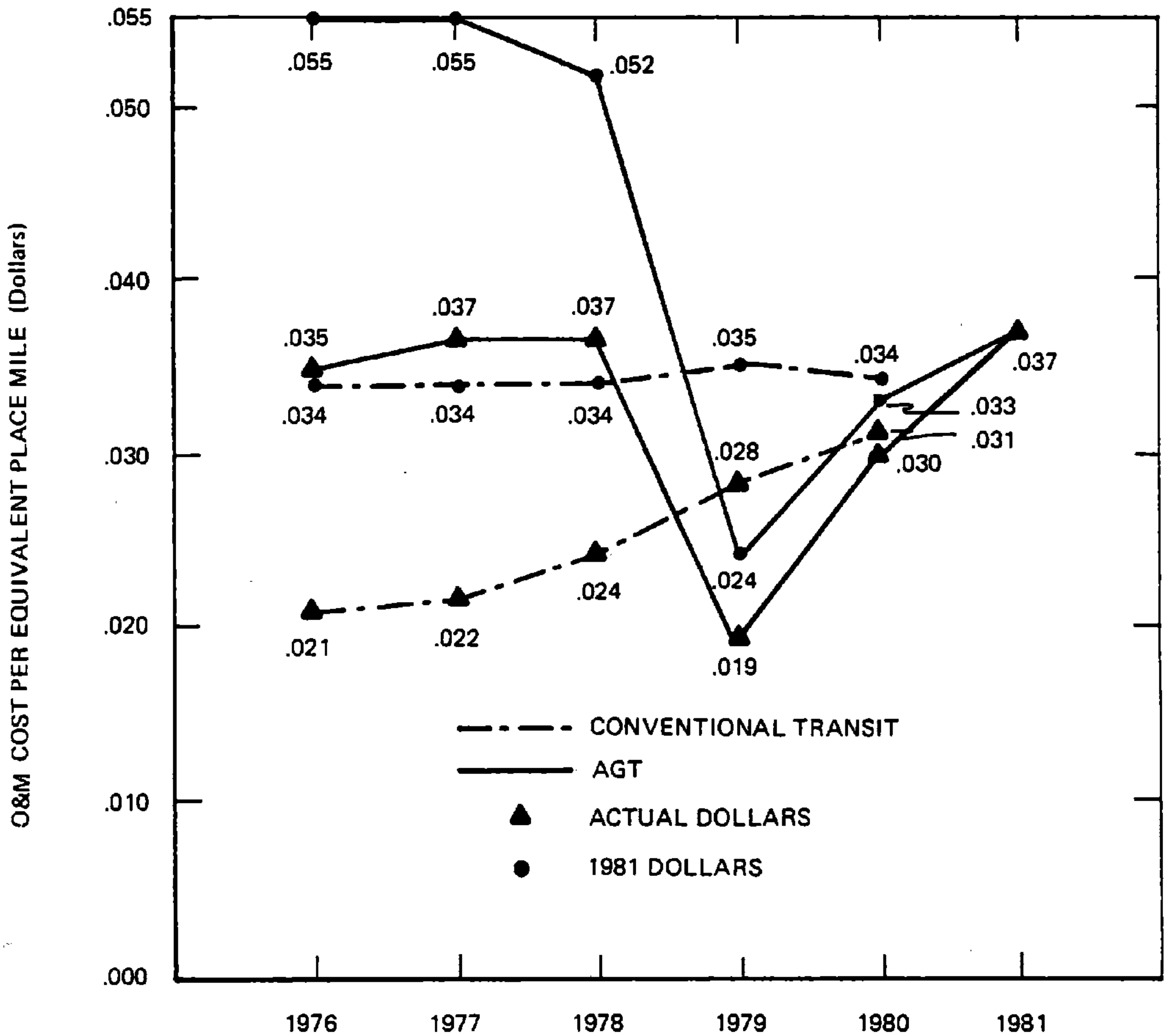


FIGURE 5-13. TREND OF O&M COSTS PER VEHICLE MILE TRAVELED FOR FIVE AGT SYSTEMS AND CONVENTIONAL TRANSIT



NOTE: Equivalent Passenger Places For Conventional Transit Was Derived From Previous Year Data. An Average Of 92 Places Was Computed.

FIGURE 5-14. TREND OF O&M COSTS PER EQUIVALENT PLACE MILE FOR FIVE AGT SYSTEMS AND CONVENTIONAL TRANSIT

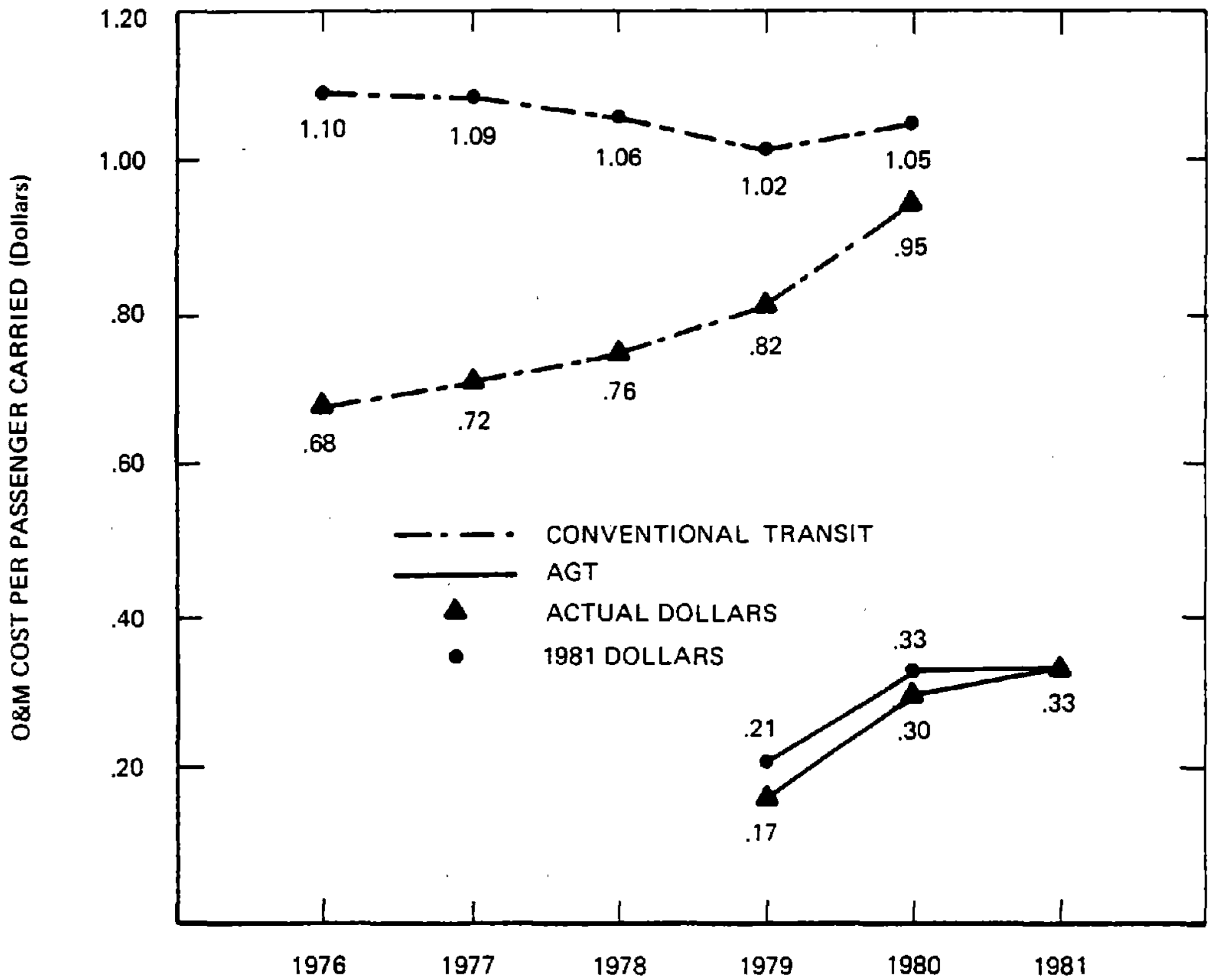


FIGURE 5-15. TREND OF O&M COSTS PER PASSENGER CARRIED FOR FIVE AGT SYSTEMS AND CONVENTIONAL TRANSIT

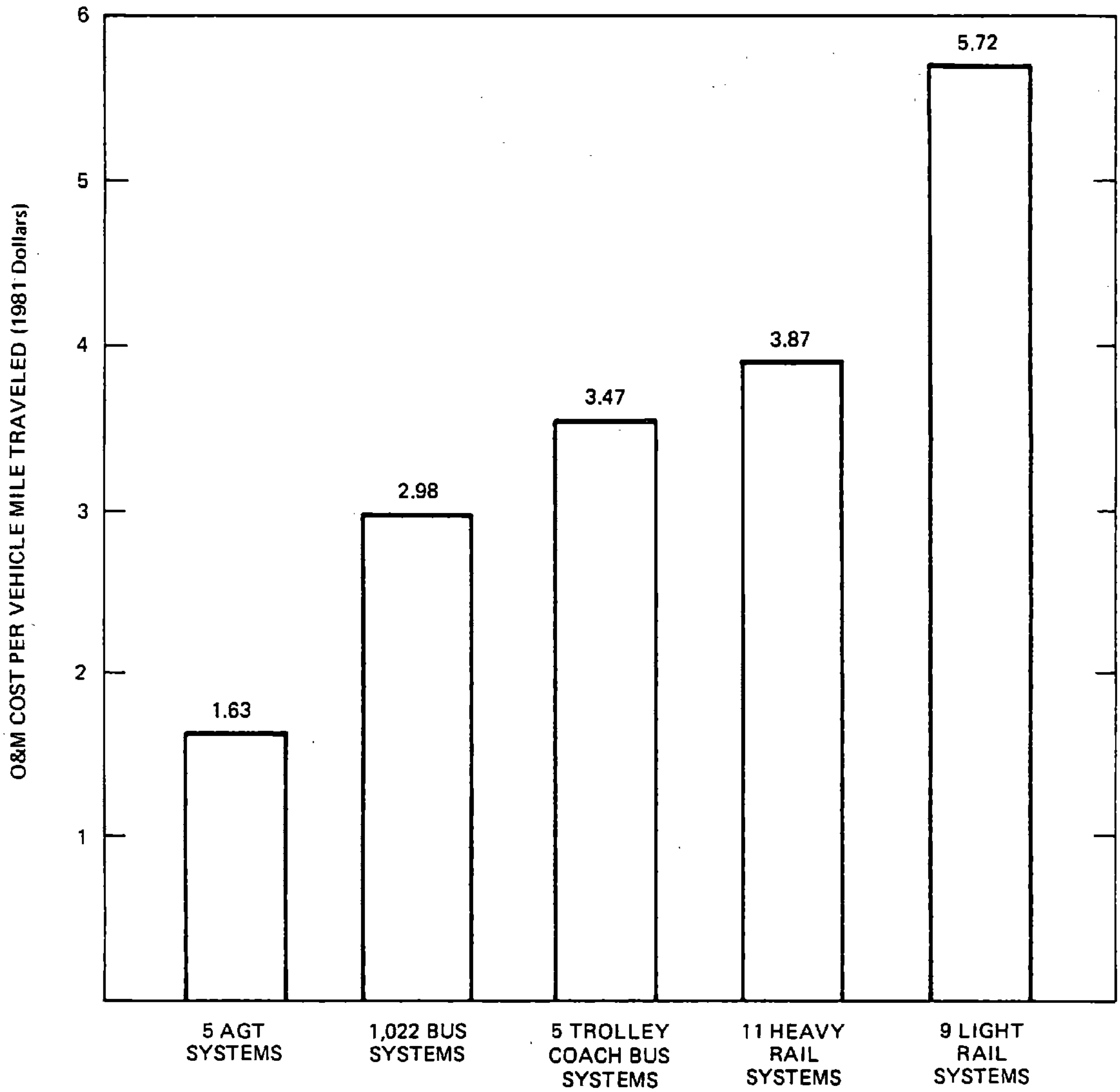


FIGURE 5-16. COMPARISON OF O&M COST PER VEHICLE MILE TRAVELED FOR FIVE DIFFERENT TRANSIT MODES

materials). Fixed costs are those components normally associated with operation and administration of the system on a daily basis. Utility costs can be comprised of both variable and fixed. Power used for vehicle propulsion varies with vehicle miles traveled while power used for system lighting and communication remains fixed. For those systems having guideway heating systems such as Morgantown's, another cost component is introduced into the O&M cost each year.

The average distribution of O&M costs for fourteen AGT systems operating in the United States is shown in Figure 5-1. (A breakdown of total O&M costs for Fairlane was not available). However, a wide range of distributions exist and in some cases differ significantly from the average. Therefore, high and low values for each O&M cost category are shown below:

- Labor:
  High - Orlando (85%)
  Low - Houston, Miami (0%)
- Utilities:
  High - King's Dominion (51%)
  Low - Duke, Houston, Pearlridge, Sea-Tac (3%)
- Materials and Services:
  High - Houston (97%)
  Low - Orlando (4%)
- General and Administrative:
  High - Pearlridge (22%)
  Low - Busch Gardens, Duke, Houston, King's Dominion, Miami, Sea-Tac (0%)

Variations in labor costs are often due to differences in wage rates found in different geographic areas. Variations are also dependent on whether laborers are dedicated to only AGT servicing or are part of the O&M crew for the entire facility for which the system is a part. The lack of labor costs for Houston and Miami and the low figure for Tampa (4 percent) are reflected in correspondingly high materials and services costs. This is due to a contract services agreement that places labor dollars in the materials and services category.

Data received on utilities reflects a wide range in the costs. This may be due to regional differences in cost per kilowatt hour (kwh). For example, Atlanta reports a cost of $ 0.04 per kwh, King's Dominion $ 0.065 per kwh, Miami $ 0.09 per kwh, and Sea-Tac $ 0.015 per kwh.

Variations in materials and services costs have already been touched on. Percentages at the high end of the range are due to labor dollars being included through contract services agreements. The low figure for Orlando is due to a warranty on the new system for which there is no charge for any necessary spare parts and materials.

The zero dollar amounts for general and administrative costs at Busch Gardens, Duke, Houston, King's Dominion, Miami, and Sea-Tac are because the systems are considered part of the overall facility so that these costs are not separately recorded.

5.3.2. Operational Analysis

When comparing O&M costs it is important to identify the levels of service provided and the operating environment. These differing factors will impact the total O&M cost for each system. Correlations between various operating characteristics and O&M costs are evident from the linear regression analysis performed with the data shown in Figures 5-2 through 5-5.

Based on the fifteen operating AGT systems, the following average cost measures for 1981 were calculated:

- O&M Cost per Vehicle Mile Traveled = $ 2.25
- O&M Cost per Equivalent Place Mile = $ 0.042
- O&M Cost per Passenger Carried = $ 0.19
- O&M Cost per System Operating Hour = $ 208.35

Generally, the more vehicle miles traveled, passengers carried, and hours in operation, the higher the total O&M cost; likewise, the fewer vehicle miles traveled, passengers carried, and hours in operation, the lower the total O&M

cost. Airport systems have the greatest overall O&M costs which is to be expected since these systems operated 20 to 24 hours per day year-round and transported over 82 percent of all passengers carried in 1981. Houston and Orlando appear to be exceptions; however, it must be remembered that they were only in operation for less than six months in 1981.

5.3.3 Trend Analysis

While the average figures for O&M costs and operating statistics have remained relatively stable over the last six years, totals for 1981 showed an overall decline. This is not surprising since almost half of the domestic AGT systems are located at airports.

O&M unit cost measures showed a tendency to increase over the past year. This is consistent with the downward trends in vehicle miles traveled, equivalent place miles, and passengers carried described earlier. Once again the ramifications of reduced air travel is exemplified through its impact on supplementary transit services.

5.3.4 AGT and Conventional Transit O&M Cost Comparison

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.

On the basis of O&M cost per vehicle mile traveled, AGT systems compare very favorably to other conventional transit modes. O&M costs per vehicle mile traveled for both AGT and conventional transit have risen over the last six years with conventional transit costs being double that of AGT costs. Several factors may lead to these differences. The marketing and advertising activity that is an essential part of urban public transportation requires larger administrative staffs with associated increases in G&A expenses. The wage rates for personnel needed to operate the vehicles, rising fuel prices, and varying operating conditions (e.g., frequency of stops) at each system will also impact this cost measure.

When compared on an equivalent place mile basis, AGT and conventional transit O&M costs are relatively equal. This has not always been the case. Prior to the expansion of the Morgantown system in 1979, adjusted O&M costs were disproportionately high. Now it appears that average costs for the two transportation modes will be within the same range.

Over the last six years, the O&M costs per passenger for conventional transit has dropped slightly in terms of 1981 dollars; however, in terms of actual dollars the cost has risen by 40 percent. Since data on passengers carried for AGT systems are available for only the last three years, no significant trends can be discerned. However, 1981 results were affected by an air traffic controller's strike which drastically reduced air travel and thereby impacted the ridership on the airport-based AGT systems. Large O&M cost differences per passenger carried ($ 1.05 for conventional transit and $ 0.33 for AGT) may be due to significant differences in service levels. That is, trip length per passenger on AGT systems is considerably shorter than the length of a trip on conventional transit.

APPENDIX A

CHARACTERISTICS OF FIFTEEN DOMESTIC AGT SYSTEMS

TABLE A-1. GENERAL AGT SYSTEM CHARACTERISTICS

SYSTEM	SUPPLIER	SITE DESCRIPTION	INITIAL OPERATION DATE	PERIOD OF OPERATION HRS/DAY OR WK	PERIOD OF OPERATION DAYS/YR	SYSTEM CONFIGURATION
AIRTRANS	VOUGHT	AIRPORT	1/74	24 HRS/DAY	365	SINGLE-LANE MULTI-LOOPS
ATLANTA	WESTINGHOUSE	AIRPORT	9/80	21 HRS/DAY	365	DUAL-LANE SHUTTLE WITH BYPASS
BUSCH GARDENS	WESTINGHOUSE	RECREATION CENTER	5/75	11 HRS/DAY	140	SINGLE-LANE LOOP
DISNEYWORLD	WED TRANS. SYSTEM, INC.	RECREATION CENTER	7/75	13 HRS/DAY	365	SINGLE-LANE LOOP
DUKE	OTIS/TTD	MEDICAL CENTER	5/80	24 HRS/DAY	365	DUAL-LANE AND SINGLE-LANE SHUTTLE
FAIRLANE	FORD	SHOPPING CENTER	3/76	77 HRS/WK	365	SINGLE-LANE SHUTTLE WITH BYPASS
HOUSTON	WED TRANS. SYSTEM, INC.*	AIRPORT	8/81	24 HRS/DAY	365	SINGLE-LANE LOOP
KING'S DOMINION	UNIVERSAL MOBILITY	RECREATION CENTER	4/75	11 HRS/DAY	143	SINGLE-LANE LOOP
MIAMI	WESTINGHOUSE	AIRPORT	4/80	24 HRS/DAY	365	DUAL-LANE SHUTTLE
MINNESOTA ZOO	UNIVERSAL MOBILITY	RECREATION CENTER	8/79	10 HRS/DAY	365	SINGLE-LANE LOOP
MORGANTOWN	BOEING	UNIVERSITY	9/75	76 HRS/WK	341	DUAL-LANE WITH OFF-LINE STATIONS
ORLANDO	WESTINGHOUSE	AIRPORT	9/81	24 HRS/DAY	365	2 DUAL-LANE SHUTTLES
PEARLRIDGE	ROHR	SHOPPING CENTER	11/77	69 HRS/WK	365	SINGLE-LANE SHUTTLE
SEA-TAC	WESTINGHOUSE	AIRPORT	2/73	20-24 HRS/DAY	365	2 SINGLE-LANE LOOPS WITH SHUTTLE CONNECTION
TAMPA	WESTINGHOUSE	AIRPORT	4/71	18-24 HRS/DAY	365	4 DUAL-LANE SHUTTLES

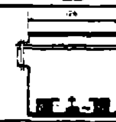
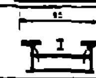
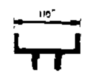
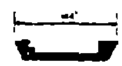
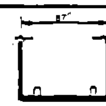
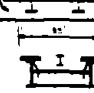
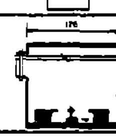
* SUPPLIERS OF PREVIOUS SYSTEMS AT HOUSTON WERE BARRETT AND WABCO AGT (ROHR).

TABLE A-2. AGT GUIDEWAY CHARACTERISTICS

SYSTEM	GUIDEWAY LENGTH (MI.)	GUIDEWAY ELEVATION (%) ELEVATED/AT-GRADE/ UNDERGROUND	GUIDEWAY CROSS-SECTION SHAPE	GUIDEWAY POWER	GUIDEWAY SWITCHES #/TYPE	GUIDEWAY GRADE (MAX. %)	ALL-WEATHER PROVISIONS
AIRTRANS	12.8/0	20/80/0	U-SHAPE	480 VAC, 60Hz	71/MBE	8	GUIDEWAY ICE REMOVAL VEHICLE
ATLANTA	1.89/0.20	0/0/100	BOX-BEAM	600 VAC, 60Hz	13/HPG	LEVEL	NONE (UNDERGROUND)
BUSCH GARDENS	1.33/0	40/60/0	I-BEAM	600 VAC, 60Hz	NONE/TT	10	NONE
DISNEYWORLD	0.87/0	100/0/0	V-SHAPE	240 VAC, 60Hz	2/RT	LEVEL	NONE
DUKE	0.11/0.23	20/45/35	U-SHAPE	480 VAC, 60Hz	2/LDM	4	NONE
FAIRLANE	0.38/0.11	100/0/0	U-SHAPE	480 VAC, 60Hz	2/SWA	2.5	ELECTRIC HEATING CABLES
HOUSTON	1.48/0	0/0/100	RAIL	240 VAC, 60Hz	NONE	LEVEL	NONE (UNDERGROUND)
KING'S DOMINION	2.06/0	5/95/0	BOX-BEAM	440 VAC, 60Hz	1/HSS	8	NONE
MIAMI	0/0.26	100/0/0	I-BEAM	480 VAC, 60Hz	NONE	4	NONE
MINNESOTA ZOO	1.36/0	90/10/0	BOX-BEAM	440 VAC, 60Hz	1/HSS	3	ELECTRIC HEATED RAILS
MORGANTOWN	0/4.30	60/40/0	U-SHAPE	575 VAC, 60Hz	57/OBS	10	HEATED PIPES
ORLANDO	0/0.74	100/0/0	I-BEAM	600 VAC, 60Hz	NONE	1	NONE
PEARLRIDGE	0.23/0	90/10/0	BOX-BEAM	480 VAC, 60Hz	NONE	4.5	NONE
SEA-TAC	1.71/0	0/0/100	BOX-BEAM	600 VAC, 60Hz	NONE/TT	4.5	NONE (UNDERGROUND)
TAMPA	0/0.68	100/0/0	I-BEAM	480 VAC, 60Hz	NONE	0	NONE

SWITCHES:
- HPG - HYDRAULIC PIVOTING GUIDEBEAMS
- MSS - MANUAL SEGMENT SUBSTITUTION
- HSS - HYDRAULIC SEGMENT SUBSTITUTION
- LDM - LATERAL DOCKING MECHANISM
- MBE - MOVABLE BLADE AND ENTRAPPING RAIL
- SWA - SWITCH WHEEL TO GUIDE RAIL ARM
- RT - RAILWAY-TYPE
- OBS - ON-BOARD SWITCHING
- TT - TRANSFER TABLE FOR VEHICLE MOVEMENT

TABLE A-3. AGT GUIDEWAY PARAMETERS

SYSTEM \ GUIDEWAY PARAMETERS	PRIMARY MATERIAL(S)	CONSTRUCTION TECHNIQUE	COLUMN TYPE	LOADED VEHICLE WEIGHT(1) (LBS)	TYPICAL SPAN LENGTH (FT)	BEAM SHAPE
AIRTRANS	CONCRETE	PLANT PRECAST & PRESTRESSED FIELD POST-TENSIONED	TAPERED, RECTANGULAR PRECAST CONCRETE	20,000	90	
ATLANTA	CONCRETE	RECTANGULAR CAST-IN-PLACE CONCRETE RUNNING SURFACES	NOT APPLICABLE (TUNNEL)	39,400	NOT APPLICABLE (TUNNEL)	
BUSCH GARDENS	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	RECTANGULAR CAST-IN-PLACE CONCRETE	40,001	73	
DISNEYWORLD	STEEL AND CONCRETE	CONTINUOUS CAST-IN-PLACE CONCRETE	STRUCTURAL STEEL	7,700*	50	
DUKE	CONCRETE	CAST-IN-PLACE REINF. CONCRETE & PRECAST. PRE-STRESSED CONCRETE	CAST-IN-PLACE REINF. CONCRETE	13,940	56	
FAIRLANE	CONCRETE	PLANT PRECAST & PRESTRESSED FIELD POST-TENSIONED	TAPERED, RECTANGULAR W/ ROUNDED CORNERS. PRECAST CONCRETE	16,100	60	
HOUSTON	STEEL AND CONCRETE	PREFABRICATED STEEL TUBES, WELDED END TO END. ANCHORED TO CONCRETE	NOT APPLICABLE (TUNNEL)	17,000*	24 TUBE SECTIONS	
KING'S DOMINION	STEEL	PREFABRICATED OFF-SITE, FIELD WELDED	STRUCTURAL STEEL	33,100*	27-60	
MIAMI	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	TEE-HEAD CAST-IN-PLACE CONCRETE	26,049	50-110	
MINNESOTA ZOO	STEEL	PREFABRICATED OFF-SITE, FIELD WELDED	STRUCTURAL STEEL W SHAPE	61,880*	73	
MORGANTOWN(2)	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	WINE-GLASS SHAPE, CAST-IN-PLACE CONCRETE	11,728	66	
ORLANDO	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	INFORMATION NOT AVAILABLE	40,560	INFORMATIION NOT AVAILABLE	
PEARLRIDGE	STEEL AND CONCRETE	PREFABRICATED STEEL BEAM. STEEL COLUMNS & PRECAST CONCRETE COLUMNS	TAPERED, RECTANGULAR PRECAST CONCRETE STEEL TUBULAR	28,416*	50-128	
SEA-TAC	CONCRETE	RECTANGULAR CAST-IN-PLACE CONCRETE RUNNING SURFACES	NOT APPLICABLE (TUNNEL)	40,300	NOT APPLICABLE (TUNNEL)	
TAMPA	STEEL AND CONCRETE	FIELD CONSTRUCTION, COMPOSITE ACTION	TEE-HEAD CAST-IN-PLACE CONCRETE	36,500	58	

(1) LOADED VEHICLE WEIGHT = EMPTY VEHICLE WEIGHT + 150 LBS x (ACTUAL VEHCILE CAPACITY)
(2) MORGANTOWN DATA IS FROM PHASE I
* TRAIN WEIGHT

TABLE A-4. AGT STATION CHARACTERISTICS

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

(1) ONLY AIRLINE PASSENGER STATIONS SHOWN; AIRTRANS HAS A TOTAL OF 53 STATIONS (INCLUDING 25 UTILITY, 14 EMPLOYEES).

(2) DUKE ALSO HAS TWO NON-PASSENGER STATIONS.

(3) HOUSTON HAS ONE INACTIVE STATION.

TABLE A-5. AGT 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 (INCLUDES DWELL TIME)	VEHICLE SUSPENSION	VEHICLE STEERING	VEHICLE PROPULSION	VEHICLE CONTROL
AIRTRANS(1)	51	21.0/7.0/10.0	14,000/20,700	16/24	17/10	RTOC, SPDR	SGW	DCTM	PF, FB
ATLANTA(2)	17	39.0/9.3/11.0	27,500/12,100	16/24	27/13	RTOC, SPDR	FGB	DCTM	PF, FB
BUSCH GARDENS	2	36.3/9.8/11.0	26,500/43,800	8/88	30/11	RTOC, SPDR	CGB	DCTM	PF, FB
DISNEYWORLD	30 (5 CAR TRAIN)	8.0/4.8/3.8	4,800/7,800	20/0	14/5	SWOS, SPDR	SGW	SLIM	VF, FB
DUKE	4	20.0/10.8/9.8	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, SPDR	SGW	DCTM	PF, FB
HOUSTON	6 (3 CAR TRAIN)	12.0/5.8/8.0	N/A	18/18	15/6	SWOS, SPDR	SGW	SLIM	VF, FB
KING'S DOMINION	6 (9 CAR TRAIN)	14.0/6.0/7.4	18,700/31,500	96/0	18/6	RTOS, SPMR	SGW	DCTM	VF, FB
MIAMI	6	36.3/9.7/11.0	25,800/43,800	2/97	28/17	RTOC, SPDR	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	71	15.5/6.7/8.8	8,600/11,800	8/13	30/17	RTOC, SPDR	SWF	DCTM	PF, FB
ORLANDO	8	39.0/9.0/11.0	25,600/46,000	0/100	28/21	RTOC, SPDR	CGB	DCTM	PF, FB
PEARLRIDGE	1 (4 CAR TRAIN)	60.0/6.7/8.5	29,200/40,800	32/32	8/7	RTOC, SPDR	CGB	DCTM	PF, FB
SEA-TAC(3)	12	37.0/9.3/11.0	25,000/46,700	12/90	26/9	RTOC, SPDR	CGB	DCTM	PF, FB
TAMPA	8	36.3/9.3/11.0	21,500/40,300	0/100	30/9	RTOC, SPDR	CGB	DCTM	PF, FB

VEHICLE SUSPENSION:

- AC - AIR CUSHION
- DCTM - DIRECT CURRENT TRACTION MOTOR
- FB - FIXED BLOCK
- PF - POINT FOLLOWER CONTROL
- RTOC - RUBBER TIRE ON CONCRETE
- RTOS - RUBBER TIRE ON STEEL
- SLIM - SINGLE-SIDED LINEAR INDUCTION MOTOR
- SPDR - SUPPORTED DUAL-RAIL
- SPMR - SUPPORTED MONORAIL
- VF - VEHICLE FOLLOWER CONTROL
- SWOS - STEEL WHEEL ON STEEL

STEERING (ALL HAVE RUBBER GUIDE WHEEL):

- CGB - CENTER GUIDE BEAM
- SGW - SIDE GUIDANCE SURFACE
- SWF - SIDE WALL FOLLOWER/ON-BOARD SWITCH

(1) AIRTRANS ALSO HAS 17 NON-PASSENGER VEHICLES.
(2) ATLANTA HAS PASSENGER VEHICLES ON ORDER FOR 1983.
(3) SEA-TAC HAS 24 PASSENGER VEHICLES ON ORDER FOR 1982.
N/A Not Available

APPENDIX B

LOCATIONS AND CONTACTS FOR FIFTEEN DOMESTIC AGT SYSTEMS

Busch Gardens

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

Attention: D. Potter
Title: Operations Manager
Telephone: FTS 937-6011
COM 804/253-3200

Dallas-Fort Worth Airport

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

Attention: D. Leftwich
Title: Director of Transportation
Telephone: 214/574-6000

Duke University Medical Center

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

Attention: A.E. Blaloch
Title: Maintenance Engineer
Telephone: 919/681-4192

Fairlane Shopping Center

Ford Aerospace & Communication Corp.
2015 Bailey Street
Dearborn, MI 48121

Attention: R. Reed
Title: Supervisor, ACT Systems
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Hartsfield International Airport

Hartsfield International Airport
Department of Aviation
Atlanta, GA 30320

Attention: M.W. Walker
Title: Director of Planning and Development
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Houston Intercontinental Airport

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

Attention: R. Weidenbeck
Title: General Manager
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COM 305/824-5050

King's Dominion Amusement Park

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

Attention: A. Ryland
Title: Rides Manager
Telephone: FTS 937-6011
COM 804/876-5000

Miami International Airport

Dade County Aviation Department
P.O. Box 59-2075
Miami, FL 33159

Attention: R. Kemmink
Title: Construction Manager
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COM 305/526-2017

Minnesota Zoological Garden

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

Attention: S.A. Iserman
Title: Administrative Officer
Telephone: 612/432-9010

Orlando International Airport

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

Attention: G. Seel
Title: Director of Facilities
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COM 305/826-2016

Pearlridge Center

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

Attention: W. Bricker
Title: President
Telephone: 808/488-1928

Seattle-Tacoma International Airport

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

Attention: M.K. Bitts
Title: Electronics Superintendent
Telephone: 206/433-5407

Tampa International Airport

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

Attention: P.T. MacAlester
Title: Director of Information
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COM 813/883-3400

Walt Disney World

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

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Telephone: FTS 826-2211
COM 305/824-5050

West Virginia University

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

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