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SUPPLEMENT III
COST EXPERIENCE OF AUTOMATED TRANSIT SYSTEMS

U.S. DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
Transportation Systems Center
Cambridge MA 02142

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FINAL REPORT

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16. Abstract

This report summarizes operations and maintenance cost experience for the following Automated Guideway Transit systems for the period 1976-1980: Airtrans, Sea-Tac, Tampa, Disneyworld (WEDway), Pearl Ridge, Minnesota Zoo and Morgantown. O&M data on the Morgantown system is reported through 1980 (excluding data for the year 1979).

Capital cost data is reviewed on Morgantown, Airtrans, Tampa, Sea-Tac, Miami, Busch Gardens, Disneyworld, King's Dominion, Fairlane, Atlanta and Minnesota Zoological Gardens. Updated data has been reported on Orlando and new data for the refined Houston Airport system.

System characteristics are presented for both the Duke and Pearl Ridge systems although no cost information is available at this time.

In addition to presenting capital and operating and maintenance costs and trends, this report includes analysis of the factors influencing these costs. A section on the differences between urban and non-urban settings of AGT systems has been included and shows how the costs of existing non-urban systems might relate to a system in an urban deployment in terms of site conditions and site requirements. An appendix describing the individual system descriptions in detail is also included.

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PREFACE

This report summarizes the capital and operations & maintenance cost experience and trends of automated transit systems. Differences in technologies, sites, and operational capabilities of these installations significantly influence their costs. Analysis of these factors is included.

The study was funded by the U.S. Department of Transportation, Urban Mass Transportation Administration (UMTA), Office of Technology Development and Deployment. The project was managed by the Office of Socio-Economic and Special Projects. The report was prepared by the Research and Special Programs Administration, Transportation Systems Center (TSC), Urban Systems Division.

Special acknowledgement is given to Doug Golden of Dynatrend Inc. for his invaluable assistance in the collection and analysis of information obtained from various systems and suppliers. The systems and suppliers are also acknowledged for the time and effort they spent in providing us with the essential data.

Special recognition is given to Dr. Arthur Priver and Mr. Charles Toye of TSC for their contributions and support in preparing this report on time. Also Mr. Ronald Nawrocki of UMTA provided valuable guidance and support.

Transportation Systems Center

Mary Ellen von Rosenvinge

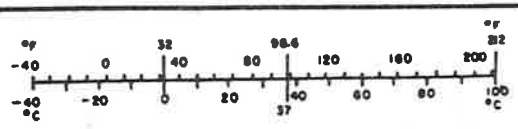
METRIC CONVERSION FACTORS

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

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	35	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



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1.0 SUMMARY

Existing Automated Guideway Transit (AGT) Systems in this country are located primarily in non urban areas and serve a variety of transportation needs at airports, universities, hospitals, shopping centers and recreation centers. The operating and maintenance (O&M) and capital costs of these systems and how they change from year to year is of significant interest in the evaluation of the services that each system provides.

During 1980, five major AGT systems in the United States (Tampa, Sea-Tac, Airtrans, Morgantown and Disneyworld) carried approximately 45 million passengers at an average O&M cost of $0.18 per passenger. This figure is considerably lower than that experienced on conventional transit which costs approximately $0.96 per passenger.

Total vehicle mileage on four major AGT systems (Tampa, Sea-Tac, Airtrans, and Disneyworld) remained constant from 1979 to 1980. The fifth major system, Morgantown, was not operational in 1979 but resumed service in 1980. Thus, total vehicle mileage reported for the major systems significantly increased in 1980 from 1979. The O&M cost per vehicle mile for 1980 was $1.36 compared to last year's value of $1.33 (1980 dollars). This increase is due largely to the addition of attendants at the Airtrans system and the inclusion of Morgantown in the 1980 figure.

Additional O&M cost data and information have been acquired from Minnesota Zoo for 1980 and from Pearl Ridge for 1979 and 1980. Although this data is presented in the report the values are not included in determining the average because of the low vehicle miles accumulated at those systems.

Capital costs have been updated for the Orlando airport as obtained from the airport and have been disaggregated to correspond with capital cost categories used in this report. Also added to the report this year are capital costs for the new Houston airport system.

System characteristics are presented for both the Duke and Pearl Ridge systems. Although the capital costs are not available at this time the existence of these systems is recognized and attempts are being made to acquire the information.

New correlations appear in this report in an attempt to gain a better understanding of cost data between the different systems.

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. 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 mode of transit has been installed at a number of sites in the United States and abroad; 15 of these sites are examined in this report. Those currently in operation carry more than 50 million passengers each year.

Under the Urban Mass Transportation Administration's Office of Socio-Economic and Special Projects, the capital and operating costs of these systems are being collected and analyzed to provide a better understanding of the economic characteristics of AGT systems. This effort represents the fourth in a series of reports beginning in 1978. Presented in these documents are the capital, operating and maintenance (O&M) costs, and system characteristics of selected AGT systems. Evaluations with respect to trends over time and comparisons with other transportation modes are also presented. These reports are intended to provide cost information to transportation planners and local communities in their individual transit decision-making processes. All data have been derived from actual experience with AGT systems that are in operation or under construction. The previous reports are:

- 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 & 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, Oct. 1979

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

This report supplements and builds upon the data presented in the above three reports. In addition to the data in last year's report, capital cost information has been obtained and analyzed for the new Houston airport system, the completed Morgantown system, and updated for the Orlando airport system. Operation and Maintenance (O&M) cost information are provided for calendar year 1980 on the five major systems used in past reports - Airtrans, Sea-Tac, Morgantown, Tampa, and Disneyworld. O&M data for 1979 and 1980 have been obtained from the Pearl Ridge system in Hawaii and data for 1980 from Minnesota Zoo. Although capital cost figures were not available at the time of publication, system characteristics are presented for the Duke and Pearl Ridge system. All systems are in operation with two exceptions, Houston and Orlando, which have planned passenger service operation for July 1981.

The format and content of this report is consistent with previous cost reports. New correlations and more extensive system descriptions have been included. The systems have been regrouped to illustrate cost disparities among systems with similar applications and technologies. To provide the reader with more insight into these cost ranges, discussion on the important cost differences between major subsystems has been supplied. An effort has been made in this report to provide a better understanding of the factors which affect the cost of building and operating an AGT system.

3.0 OVERVIEW OF AGT SYSTEMS

3.1 EXISTING SYSTEMS

This report addresses the capital and operations and maintenance costs of selected AGT systems in this country that are currently in operation or near completion. Figure 3-1 presents these systems ordered by the timing of their construction and operation. (Additional AGT systems exist in foreign countries, primarily in test configurations, however the availability and applicability of cost information is limited.) These systems currently satisfy a variety of transportation needs, i.e., by providing service to captive riders at airports, as a competitive service with respect to other modes at universities, shopping centers, and medical centers and by providing attractive and enjoyable rides at recreation centers. Though utilized extensively to date as the primary source of public transportation in activity center-type applications, the existing 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 extensive, multi-loop Airtrans system at the Dallas-Ft. Worth Airport to the shuttle-type 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 salient characteristics of each system. A more detailed system description broken down by subsystem is found in Appendix A through D.

The systems employ proven technology which varies from site-to-site depending on the mobility requirements of the application area and the design approach of the manufacturer. The operational and performance characteristics of these systems also vary greatly from site-to-site and reflect the adaptability of AGT systems to meet the service needs of the respective sites. Therefore, it is

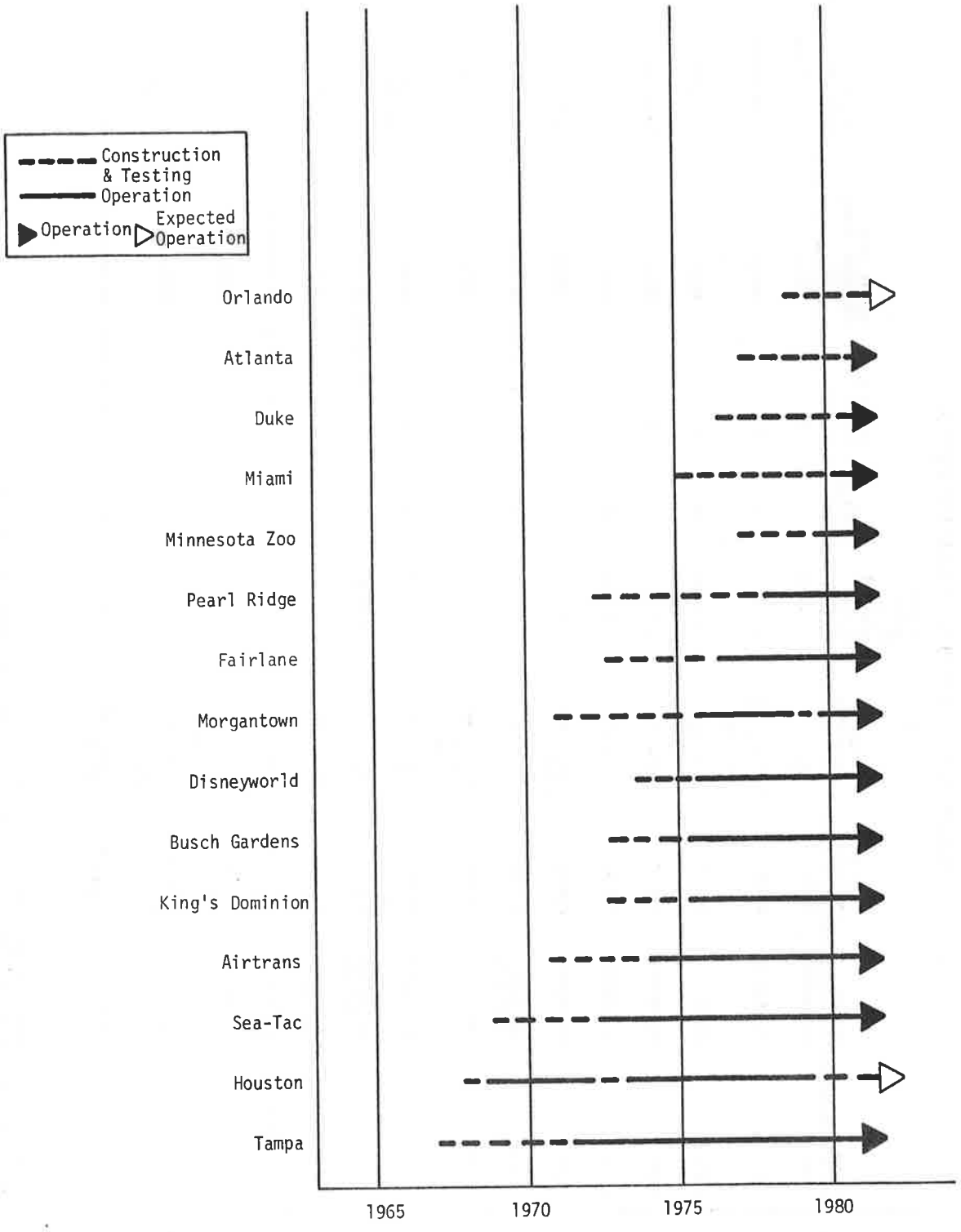


FIGURE 3-1. DOMESTIC AGT DEPLOYMENTS

TABLE 3-1. SYSTEM CHARACTERISTICS

SYSTEM	LOCATION	SUPPLIER	SITE DESCRIPTION	GUIDEWAY CONFIGURATION	GUIDEWAY LENGTH LANE MILES/ EQUIVALENT ELEVATED LANE MILES	NUMBER OF STATIONS (1)	NUMBER OF VEHICLES(2)	VEHICLE CAPACITY/ EQUIVALENT PLACES (3)	PERIOD OF OPERATIONS	INITIAL SERVICE DATE
TAMPA	TAMPA, FL	WESTINGHOUSE	AIRPORT	DOUBLE LANE SHUTTLE	1.35/1.35	8	8	100/84	18-24 HRS/DAY	4/71
SEA-TAC	SEATTLE, WA	WESTINGHOUSE	AIRPORT	2 SINGLE LANE LOOPS, SHUTTLE CONNECTION	1.71/5.13	8	12	102/86	20-24 HRS/DAY	2/73
AIRTRANS	DALLAS, TX	VOUGHT	AIRPORT	SINGLE LANE MULTI-LOOPS	12.8/6.66	28	51	40/37	24 HRS/DAY	1/74
MIAMI	MIAMI, FL	WESTINGHOUSE	AIRPORT	DOUBLE LANE SHUTTLE	0.51/0.51	2	4	99/88	24 HRS/DAY	4/80
ATLANTA	ATLANTA, GA	WESTINGHOUSE	AIRPORT	DOUBLE LANE LOOP	2.29/6.87	10	17	80/91	24 HRS/DAY	9/80
ORLANDO	ORLANDO, FL	WESTINGHOUSE	AIRPORT	DOUBLE LANE SHUTTLE	1.48/1.48	8	8	100/88	24 HRS/DAY	planned 7/81
HOUSTON	HOUSTON, TX	WALT DISNEY PRODUCTIONS	AIRPORT	SINGLE LANE LOOP	1.48/4.43	9	6 (3 car trains)	36 (train)/17	24 HRS/DAY	planned 7/81
MORGANTOWN	MORGANTOWN, WV	BOEING	UNIVERSITY	DOUBLE LANE WITH OFF-LINE STATIONS	8.60/6.79	5	71	21/26	76 HRS/WK	9/75
BUSCH GARDENS	WILLIAMSBURG, VA	WESTINGHOUSE	RECREATION CENTER	SINGLE LANE LOOP	1.33/0.84	2	2	96/89	11 HRS/DAY (APR.-OCT.)	5/75
DISNEYWORLD (WEDWAY)	ORLANDO, FL	WALT DISNEY PRODUCTIONS	RECREATION CENTER	SINGLE LANE LOOP	0.87/0.87	1	30 (5 car trains)	20 (train)/48	13 HRS/DAY*	7/75
KING'S DOMINION	DOSWELL, VA	UNIVERSAL MOBILITY	RECREATION CENTER	SINGLE LANE LOOP	2.06/0.88	1	6 (9 car trains)	96 (train)/168	11 HRS/DAY (APR.-OCT.)	4/75
MINNESOTA ZOO	APPLE VALLEY, MN	UNIVERSAL MOBILITY	RECREATION CENTER	SINGLE LANE LOOP	1.36/1.28	1	3 (6 car trains)	94 (train)/123	10 HRS/DAY*	8/79
DUKE	DURHAM, NC	OTIS/TTD	MEDICAL CENTER	DOUBLE LANE AND SINGLE LANE SHUTTLE	0.56/0.61	3	4	22/54	24 HRS/DAY	5/80
FAIRLANE	DEARBORN, MI	FORD	SHOPPING CENTER	SINGLE LANE SHUTTLE WITH BYPASS	0.61/0.61	2	2	24/41	12.0 HRS/DAY/WEEK 5.0 HRS SUN.	3/76
PEARL RIDGE	AIEA, HI	ROHR	SHOPPING CENTER	SINGLE LANE SHUTTLE	0.23/0.21	2	1 (4 car train)	64 (train)/60	69 HRS/WK	11/77

* Annual Average

(1) Airtrans also has 25 non-passenger stations, and Duke 2, Houston has 1 inactive station.

(2) Sea-Tac has 12 additional vehicles on order. Airtrans also has 17 non-passenger vehicles. Morgantown sold back 2 of 73 vehicles to Boeing.

(3) Equivalent places per vehicle have been calculated on an allocation of 4 square feet per passenger, based on vehicle

TABLE 3-1 NOTES:

- Houston Airport supplier for system opening in 1981 is Walt Disney Productions. Suppliers of previous systems at Houston were Barret and WABCO AGT (Rohr).

- Systems are grouped according to site description.

- 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

- Nine car trains at King's Dominion each include one non-passenger lead car.

- Atlanta, Sea-Tac and Houston are entirely underground systems; Tampa, Miami, Orlando, Disneyworld and Minnesota Zoo are elevated systems, and the systems which are a combination of elevated and at-grade are Morgantown, Airtrans, Busch, King's Dominion, Fairlane, Duke, and Pearl Ridge.

- For those systems where cars are always entrained, the train is considered as a single vehicle unit.

- Equivalent places per vehicle have been calculated on an allocation of 4 square feet per passenger, based on vehicle dimensions for each system. This allocation corresponds to a similar computation for conventional transit.

these service needs and the physical and environmental characteristics of a given site, that have the largest impact on the specific configuration of technology deployed and its associated capital costs. Because of this relationship to site conditions and the fact that the AGT deployments to date have been primarily in activity centers, limitations exist with respect to directly transferring the cost information and experience documented to other application types and sites. The following section briefly discusses these limitations.

3.2 DIFFERENCES BETWEEN URBAN AND NON-URBAN SETTING

Domestic AGT systems are currently serving airports, recreational and shopping centers, and institutions. Only the Morgantown system, connecting the Morgantown downtown area 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 areas would be primarily 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. Congestion is likely to exist, at least in some sectors, during the peak period. Travel demand varies widely during the day, with peak levels often more than twice the off-peak demand.

These conditions have major implications for the design of the AGT system. Vehicle size and system throughput capacity must be sized to accommodate passenger loads during the peak periods.

Station size and spacing are also influenced by the need for intermodal transfer points connecting AGT with other public transportation services. Park and ride lots may be constructed to permit transfers at AGT intercept points. The likelihood of vandalism and crime in dense urban neighborhoods may require a extensive security system for surveillance and enforcement.

Other costs not identified with current AGT systems include right-of-way (ROW) acquisition, site modifications, and additional costs associated with construction in an urban area. ROW acquisition costs depend on property values, local easements, and the extent that 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 and street modifications, traffic control and site accessibility, labor rates and local codes, and many other factors. Integrating AGT stations with existing commercial structures and minimizing the disruptive impact on business in the downtown area also contribute to site-specific costs.

In addition to service requirements and site modifications, there are procedural and regulatory requirements addressed in the deployment of any form of urban public transportation that were not encountered by the existing activity center AGT systems. In order to use public funds to construct a new transportation system, an institutional/political process is involved, including local, regional, state and Federal government agencies. This process is a lengthy one, and the timetable and resultant costs are difficult to estimate. Substantial engineering costs are incurred during this phase, especially if major revisions must be made to the system design. The timetable for this phase (design/public acceptance/funding committment) is usually in the order of 2 to 5 years; hence cost increases due to inflation will occur before construction begins.

While there are constraints and complexities associated with urban AGT deployment that have not been encountered by the AGT

systems operating in activity centers, the technology and performance of these systems do meet the requirements of urban applications. The existing AGT systems encompass a variety of vehicle designs, network configurations, on/off line stations, and contr capability, thus exhibiting a range and depth of technology sufficient to comply with urban system requirements. The point be made here 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 CATEGORY DEFINITION AND OTHER QUALIFYING INFORMATION

For purposes of analysis and a means of providing useful detail to the reader, the breakdown of the costs is in the form of the following seven categories which have been identified as:

- o Guideway - The vehicle roadway including: site preparation, foundations, supporting structures, 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.
- o Maintenance and Support Facilities - Maintenance and repair shops including such equipment as engineering vehicles.
- o Power and Utilities - Electric power transformers, feeders, switchgear, wayside power rails and normal housekeeping power equipment.
- o Vehicles - The rolling stock.
- o Command and Control - Wayside and central control and communications equipment including operational software and voice and video communication systems.
- o Engineering and Project Management - Architectural and engineering services, system design and integration, acceptance testing and overall project management.

ESCALATION

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 1980 price level. In order to remain consistent with past reports the same

indices for escalation have been used and are explained below:

- o CPI: The Consumers Price Index for urban wage earners and clerical workers (U.S. cities average) is used to ad just all costs for engineering and project management.
- o PPI: The Producer Price Index for machinery and motive products (previously called the Wholesale Price Index) i used to adjust all hardware costs. This index is no longer calculated; however, there is a formula supplied by the Dept. of Labor Statistics for determining it. Averages of PPI Code 11 - Machinery and Equipment and PP Code 14 - Transportation Equipment, weighted in accordan with the All Commodities Index weightings are used to calculate the PPI index.

$$\frac{\Sigma\ W_i\ X_i}{\Sigma\ X_i}$$

Where W_1 = 11.497 (weighting code 1
W_2 = 8.192 (weighting code 1
and X_1 =239.542 (1980 avg. code 1
X_2 =206.433 (1980 avg. code 1

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

All three indices have a base of 100 for 1967. Listed belo are the indices used and their yearly averages.

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

Yearly averages have been used to escalate the costs of the systems included in the Supplement II Summary of Capital and Operations & Maintenance Cost Experience of Automated Guideway Transit Systems Costs and Trends for the Period 1976-1980. For other systems the starting point for escalation has been either

he midpoint of construction or date of procurement.

Analysis of available data shows that the various AGT systems aintained their cost records in different formats. Also in many ases the AGT system is an integral part of larger facilities, uch as airports, and the costs have not always been separated. ue to these facts, it was necessary to estimate the cost to uplicate the essential transit features.

Research and development costs and right-of-way acquisition osts have been removed from the data to the greatest extent ossible.

.2 CAPITAL COST EXHIBITS

Capital cost data for seven airport AGT systems are presented n Table 4-1A. Additional capital costs are reported on the re- onstructed Houston system and the Orlando costs have been refined ince last year's report. Figure 4-1A is the representation of he costs in a bar chart format. Table 4-1B shows the capital osts of the remaining six systems located at recreation centers, hopping centers, hospitals or universities and Figure 4-1B is a ar chart representation. The costs for Morgantown are those stimated to construct the total system and have been obtained rom an UMTA report on Morgantown replacement costs. A distri- ution of capital costs by subsystem for thirteen systems is resented in a bar chart format in Figure 4-2. The capital costs eported for each system are either acquisition or duplication ost or a combination of both.

Figures 4-3A and 4-4A represent comparisons of the guideway nit costs and vehicle unit costs of the airport systems. As is eadily seen there is a wide range of costs even when comparing ystems at similar locations. Figures 4-3B and 4-4B represent com- arisons of the guideway unit costs and vehicle unit costs of the ther systems.

Figure 4-5 shows guideway cost related to equivalent elevated ane miles. Figures 4-6 and 4-7 present correlations of fleet cost ompared to fleet weight and fleet area. Average costs have been upplied on the graphs as computed by the arithmetic mean.

TABLE 4-1A. AGT CAPITAL COST SUMMARY
AIRPORT SYSTEMS (THOUSANDS OF 1980 DOLLARS)

	TAMPA	SEA-TAC	AIRTRANS	MIAMI	ATLANTA	ORLANDO	HOUSTON
GUIDEWAY							
TOTAL COST	4,658	16,740	17,415	3,319	18,911	5,200	7,871
COST PER LANE MILE	3,450	9,789	1,361	6,508	8,258	3,514	5,318
STATIONS							
TOTAL COST	3,038	7,479	9,396	3,647	9,940	4,158	4,760
COST PER STATION	380	935	336	1,824	994	520	529
MAINTENANCE & SUPPORT							
TOTAL COST	1,235	3,888	5,195	1,008	3,673	2,162	346
COST PER VEHICLE	154	324	102	252	216	270	58
POWER & UTILITIES							
TOTAL COST	2,889	2,198	6,737	544	3,423	927	538
COST PER LANE MILE	2,140	1,285	526	1,067	1,495	626	363
VEHICLES							
TOTAL COST	3,679	6,745	16,623	1,488	12,200	4,950	1,109
COST PER VEHICLE	460	562	326	372	718	619	185
COMMAND & CONTROL							
TOTAL COST	1,880	2,770	8,802	1,078	4,495	5,512	2,333
COST PER LANE MILE	1,393	1,620	688	2,114	1,963	3,724	1,576
ENGINEERING & PROJECT MANAGEMENT							
TOTAL COST	2,127	7,492	19,237	2,305	9,126	2,600	4,609
COST PER LANE MILE	1,575	4,381	1,503	4,520	3,985	1,757	3,114
SYSTEM COST							
TOTAL COST	19,506	47,312	83,405	13,389	61,768	25,509	21,566
COST PER LANE MILE	14,449	27,668	6,516	26,253	26,973	17,236	14,572

LANE MILES ARE SINGLE LANE MILES

TABLE 4-1A NOTES:

- Where available, actual capital acquisition costs have been used and escalated to average 1980 dollars. Where actual data were not available, engineering estimates to duplicate the subject facilities were used and escalated to average 1980 dollars. These duplication costs generally do not consider the specific location of the system being examined, but rather are estimates for equivalent generic systems.

- Duplication or acquisition costs are rounded to the nearest thousand dollars after escalation. Unit costs, i.e., cost per vehicle, are calculated before rounding.

- Tampa and Miami - Guideway costs include the cost of a pedestrian walkway.

- Atlanta - Updated costs have been obtained for the total system excluding the fixed facilities costs which are being reported for the first time.

  The guideway cost figure includes a back-up pedestrian walkway and has been estimated from the total tunnel costs at the airport, using a square footage allocation for both the AGT system guideway and pedestrian walkway. The walkway amounts to about 30% of the total guideway cost shown.

  Square footage allocations of floor area have been used to determine the following costs: pedestrian mall, stations, control rooms, switchgear locations, and maintenance shops.

  Capital costs obtained in this manner have been confirmed by the system supplier.

- Orlando - Updated costs have been obtained from the airport engineer and have been disaggregated to correspond with capital cost categories used in this report.

- Houston - Capital costs for the new Houston system have been obtained from the system supplier. As this system will utilize the tunnel and stations (and maintenance area) of the previous airport system, costs of these items have been escalated to 1980 dollars and included in the costs for the new system.

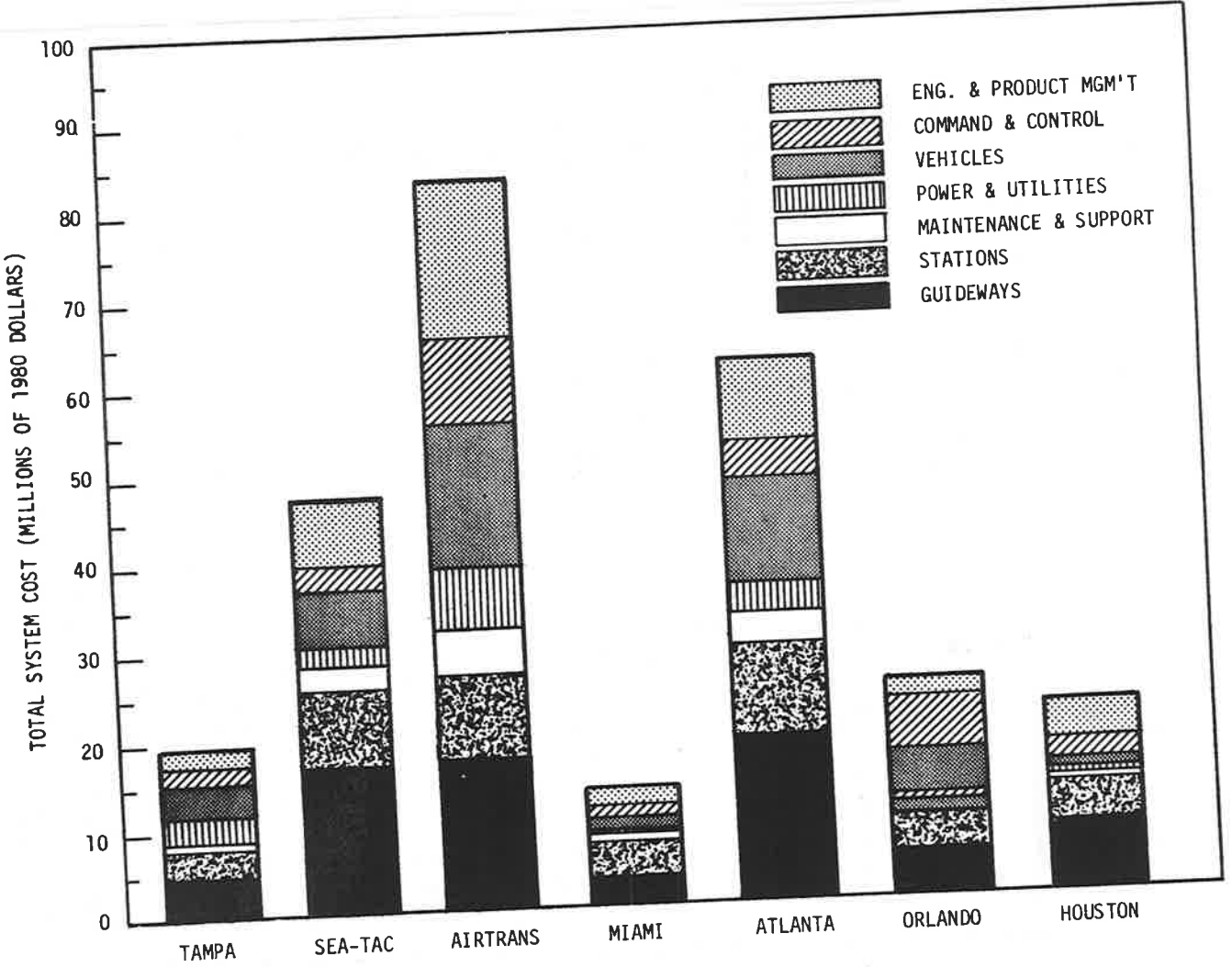


FIGURE 4-1A. AGT CAPITAL COST BREAKDOWN AIRPORT SYSTEMS

TABLE 4-1B. AGT CAPITAL COST SUMMARY
OTHER SYSTEMS (THOUSANDS OF 1980 DOLLARS)

	MORGANTOWN	BUSCH GARDENS	DISNEYWORLD	KING'S DOMINION	MINNESOTA ZOO	FAIRLANE
GUIDEWAY						
TOTAL COST	36,429	2,321	2,660	1,458	2,965	2,808
COST PER LANE MILE	4,236	1,746	3,058	708	2,180	4,603
STATIONS						
TOTAL COST	6,648	176	2,174	243	353	563
COST PER STATION	1,330	88	2,174	243	353	281
MAINTENANCE & SUPPORT						
TOTAL COST	5,718	310	812	280	737	161
COST PER VEHICLE	81	155	27	47	246	80
POWER & UTILITIES						
TOTAL COST	8,775	514	1,074	435	806	1,269
COST PER LANE MILE	1,020	387	1,234	211	592	2,080
VEHICLES						
TOTAL COST	18,312	1,122	4,347	3,066	2,565	997
COST PER VEHICLE	258	561	145	511	855	499
COMMAND & CONTROL						
TOTAL COST	26,603	691	4,387	47	380	998
COST PER LANE MILE	3,093	520	5,043	23	279	1,635
ENGINEERING & PROJECT MANAGEMENT						
TOTAL COST	38,813	1,220	1,184	2,054	784	1,576
COST PER LANE MILE	4,513	918	1,361	977	577	2,584
SYSTEM COST						
TOTAL COST	141,303	6,354	16,638	7,583	8,590	8,372
COST PER LANE MILE	16,431	4,777	19,124	3,681	6,316	13,725

LANE MILES ARE SINGLE LANE MILES

- Where available, actual capital acquisition costs have been used and escalated to average 1980 dollars. Where actual data were not available, engineering estimates to duplicate the subject facilities were used and escalated to average 1980 dollars. These duplication costs generally do not consider the specific location of the system being examined, but rather are estimates for equivalent generic systems.

- Duplication or acquisition costs are rounded to the nearest thousand dollars after escalation. Unit costs, i.e. cost per vehicle, are calculated before rounding.

- Morgantown - Capital costs include costs for the entire system and have been obtained from an UMTA report on Morgantown replacement costs and adjusted to average 1980 dollars. Initial engineering and design costs have been removed.

- Minnesota Zoo - The single station at the Minnesota Zoo is an integral part of the visitor's center; thus, the station cost is an estimate based on that portion of the total structure that is used for the AGT system.

  Cost of Command & Control System includes allocation made for a portion of on-board vehicle control system.

  Power and utilities cost does not include the primary source of electric power which was supplied by the zoo, such as transformers, etc.

- The scale on the left applies to the Morgantown system while the scale on the right applies to Busch, Disneyworld, King's Dominion, Minnesota Zoo and Fairlane.

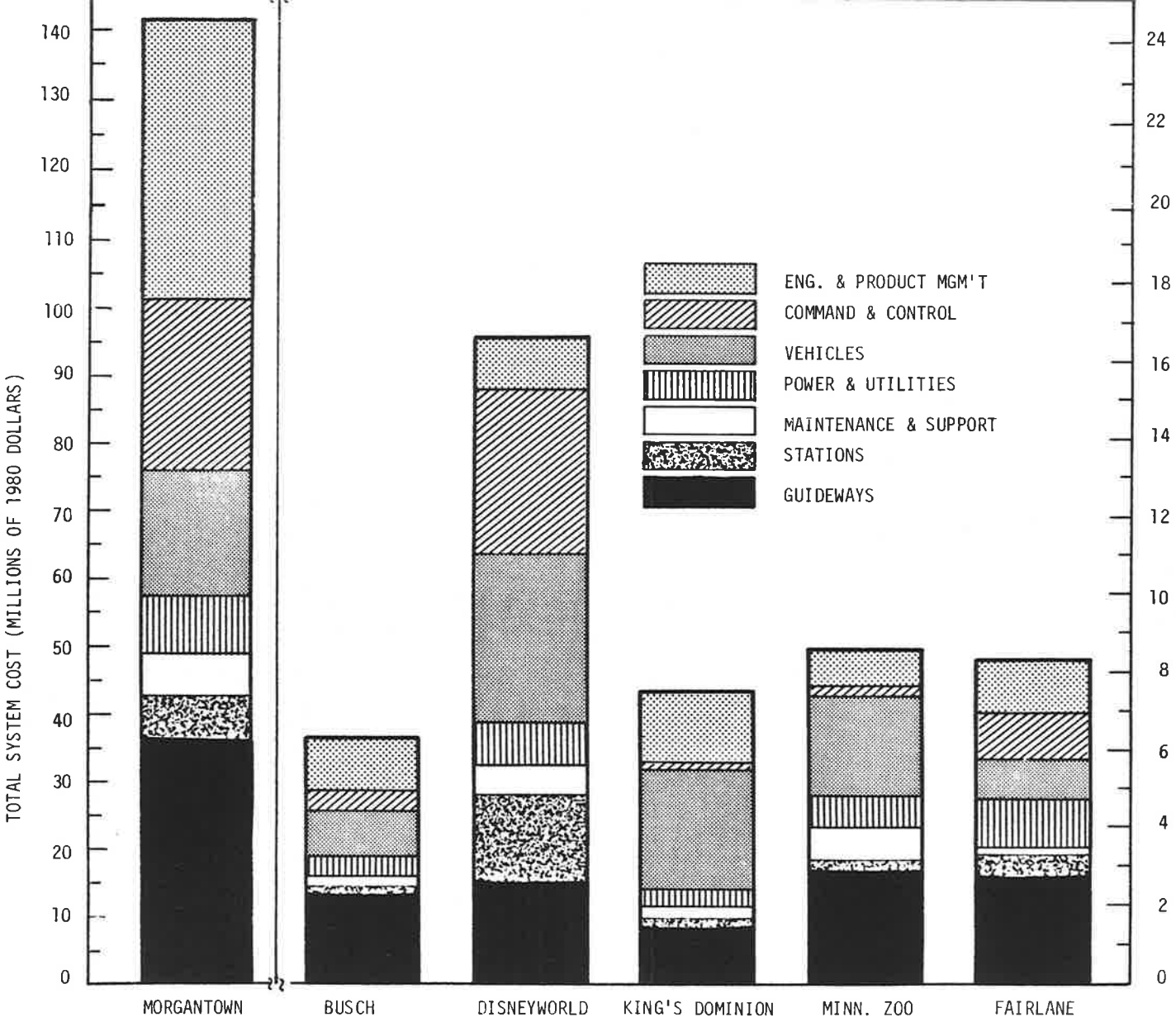


FIGURE 4-1B. AGT CAPITAL COST BREAKDOWN OTHER SYSTEMS

NOTE: The scale on the left is for the Morgantown system while the scale on the right is for the 5 remaining systems.

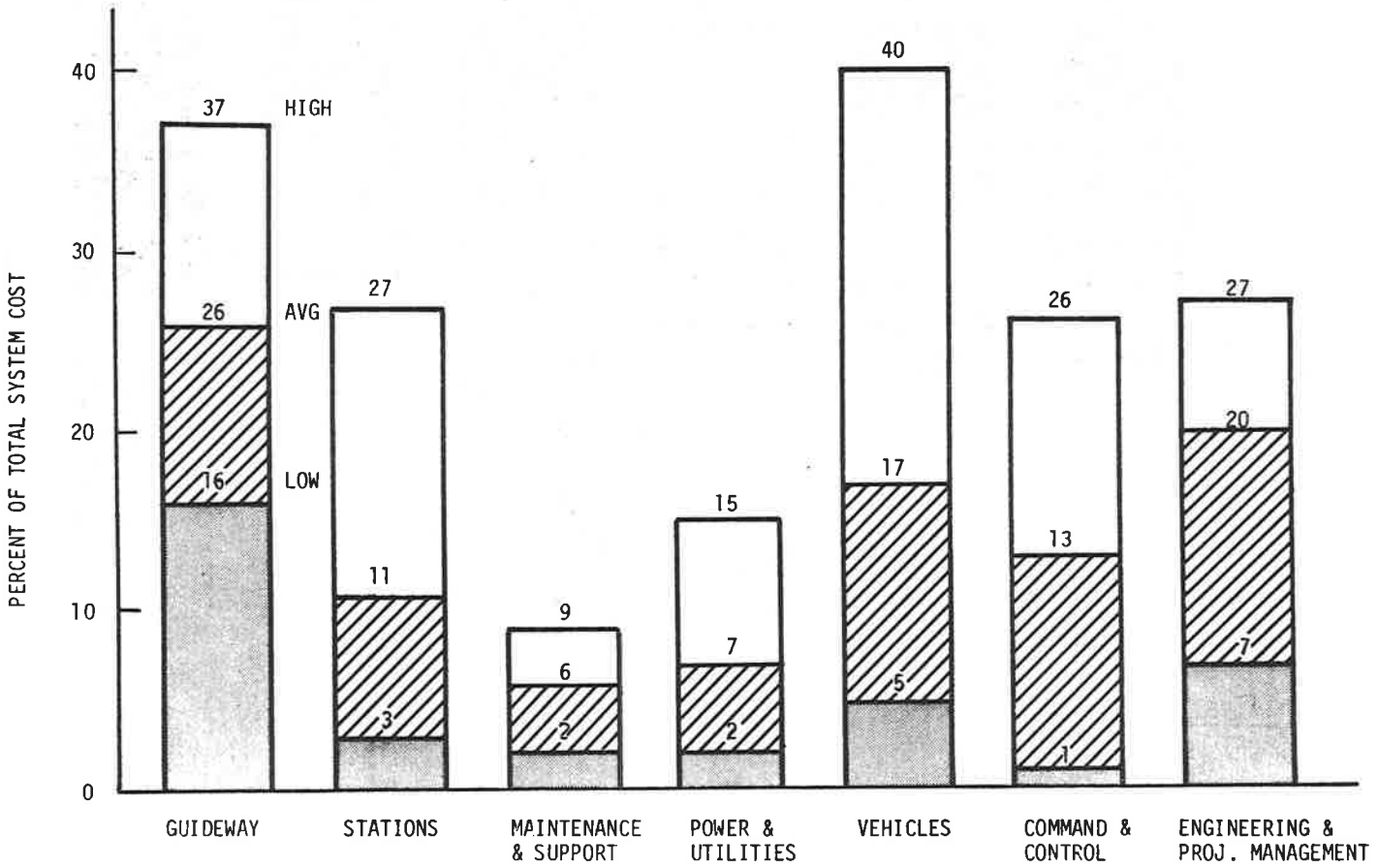


FIGURE 4-2. DISTRIBUTION OF CAPITAL COSTS FOR THIRTEEN AGT SYSTEMS

FIGURE 4-2 NOTES:

- Average distribution of capital costs for thirteen AGT systems is: Guideway 26%, Stations 11%, Maintenance and Support 6%, Power and Utilities 7%, Vehicles 17%, Command and Control 13%, and Engineering and Project Management 20%.

- A wide range of distributions exist for each system that may vary significantly from the average. Therefore, high and low values have been shown for each capital cost category:
  - Guideway: High - Houston (37%); Low - Disneyworld (16%)
  - Stations: High - Miami (27%); Low - Busch Gardens, King's Dominion (3%)
  - Maintenance and Support: High - Minnesota Zoo (9%); Low - Houston, Fairlane (2%)
  - Power & Utilities: High - Tampa, Fairlane (15%); Low - Houston (2%)
  - Vehicles: High - King's Dominion (40%); Low - Houston (5%)
  - Command & Control: High - Disneyworld (26%); Low - King's Dominion (1%)
  - Engineering & Project Management: High - Morgantown (27%); Low - Disneyworld (7%)

- The thirteen AGT systems are:
  - Atlanta
  - Airtrans
  - Busch Gardens
  - Disneyworld
  - Fairlane
  - Houston
  - King's Dominion
  - Morgantown
  - Miami
  - Minnesota Zoo
  - Orlando
  - Sea-Tac
  - Tampa

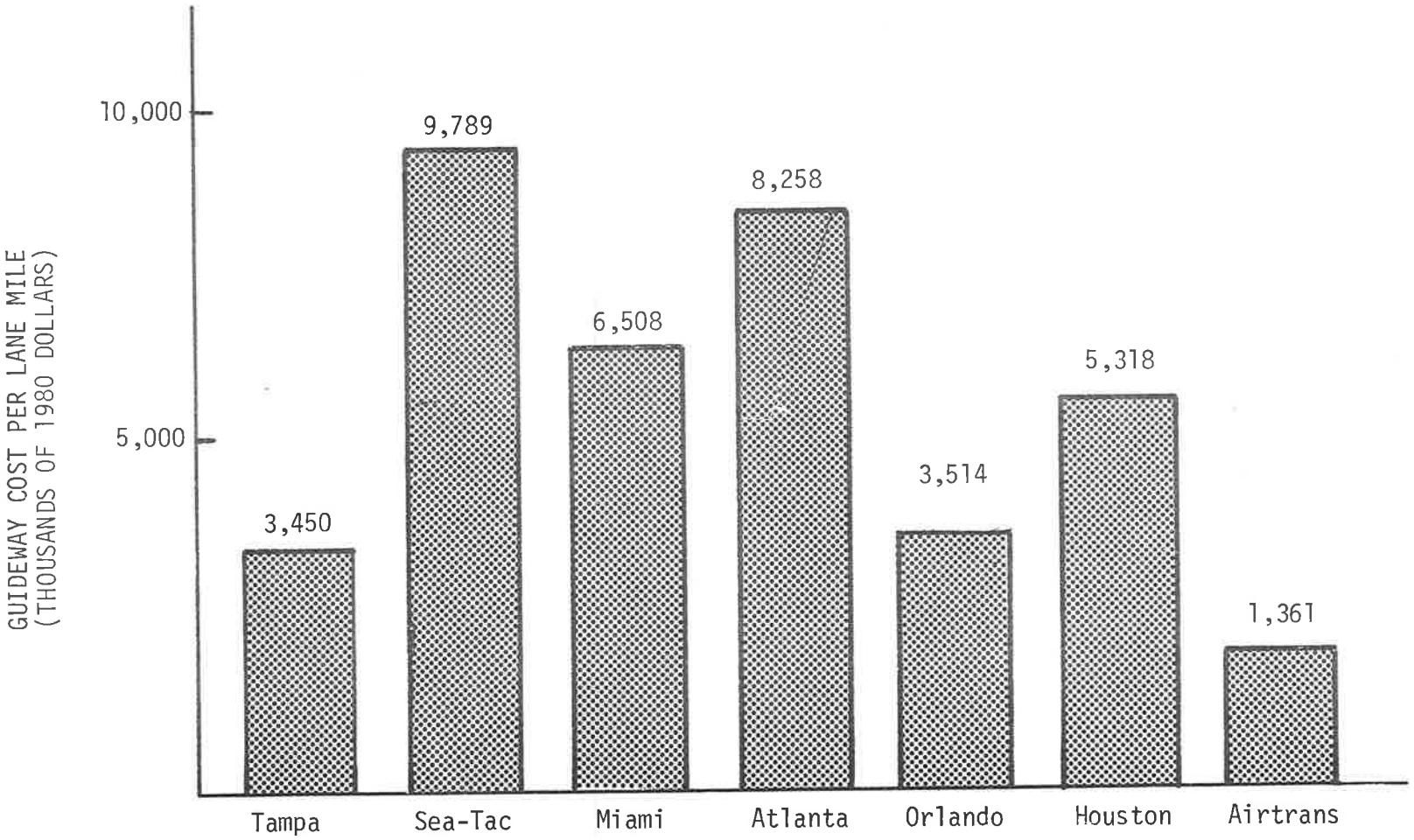


FIGURE 4-3A. COMPARISON OF GUIDEWAY UNIT COSTS FOR AIRPORT SYSTEMS

FIGURE 4-3A NOTES:

- Tampa, Sea-Tac, Miami, Atlanta, and Orlando are all Westinghouse systems.

- Tampa, Miami, and Orlando are elevated systems. Tampa and Orlando are approximately the same length systems and have correspondingly similar costs per mile. Miami is a short system, which may account for its substantially higher cost per mile.

- Sea-Tac, Atlanta, and Houston are underground systems. The longer length of the Atlanta system may account for its lower cost per mile than Sea-Tac. A smaller tunnel bore may account for the low Houston cost per mile.

- Airtrans is largely an at-grade system, accounting for its low cost per mile.

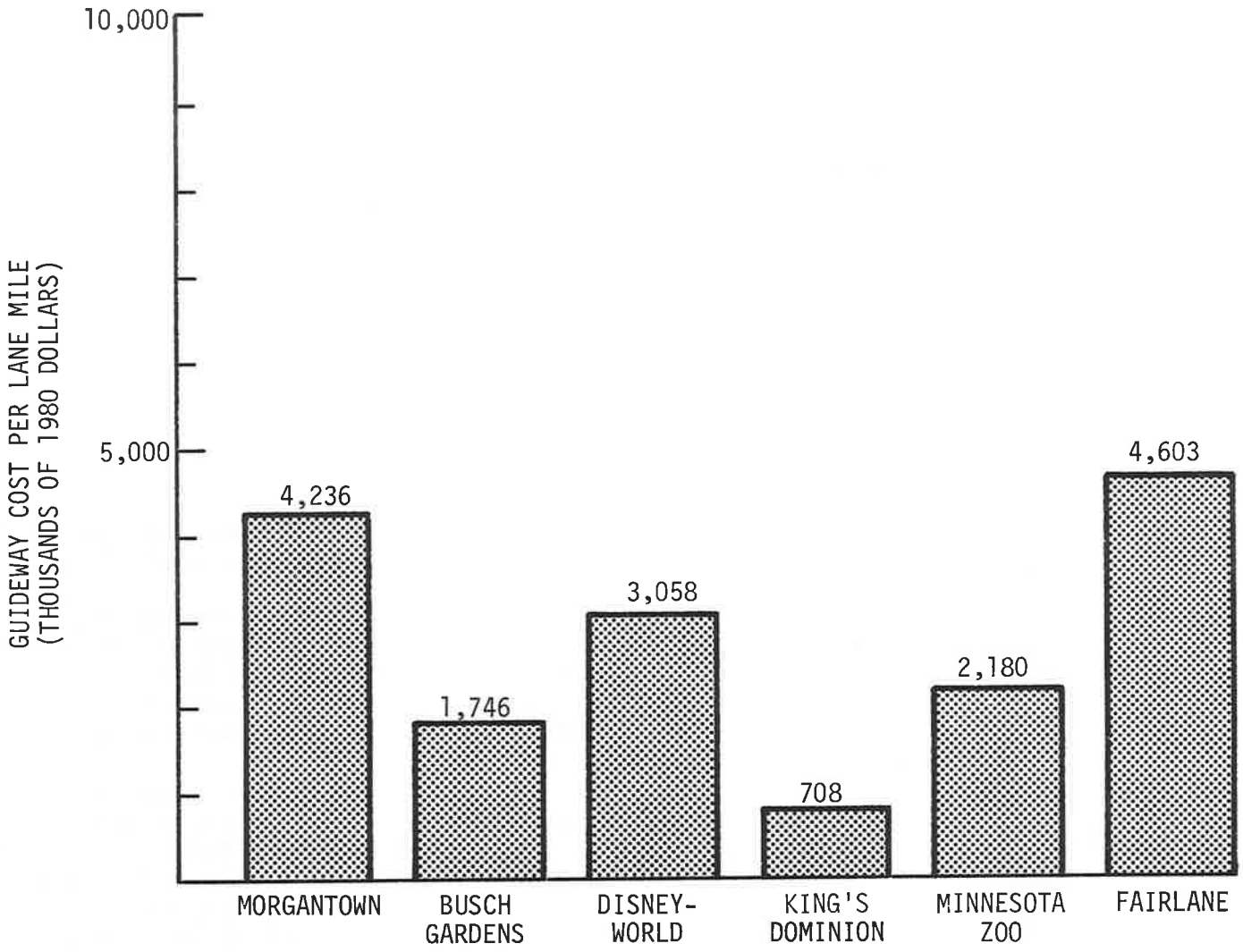


FIGURE 4-3B. COMPARISON OF GUIDEWAY UNIT COSTS FOR OTHER SYSTEMS

FIGURE 4-3B NOTES:

- Disneyworld and Fairlane are totally elevated systems and Minnesota Zoo is 90% elevated.

- King's Dominion, a simple system is 95% at grade. This may account for the low guideway cost per lane mile.

- Fairlane is a short system, which may account for its higher cost per lane mile.

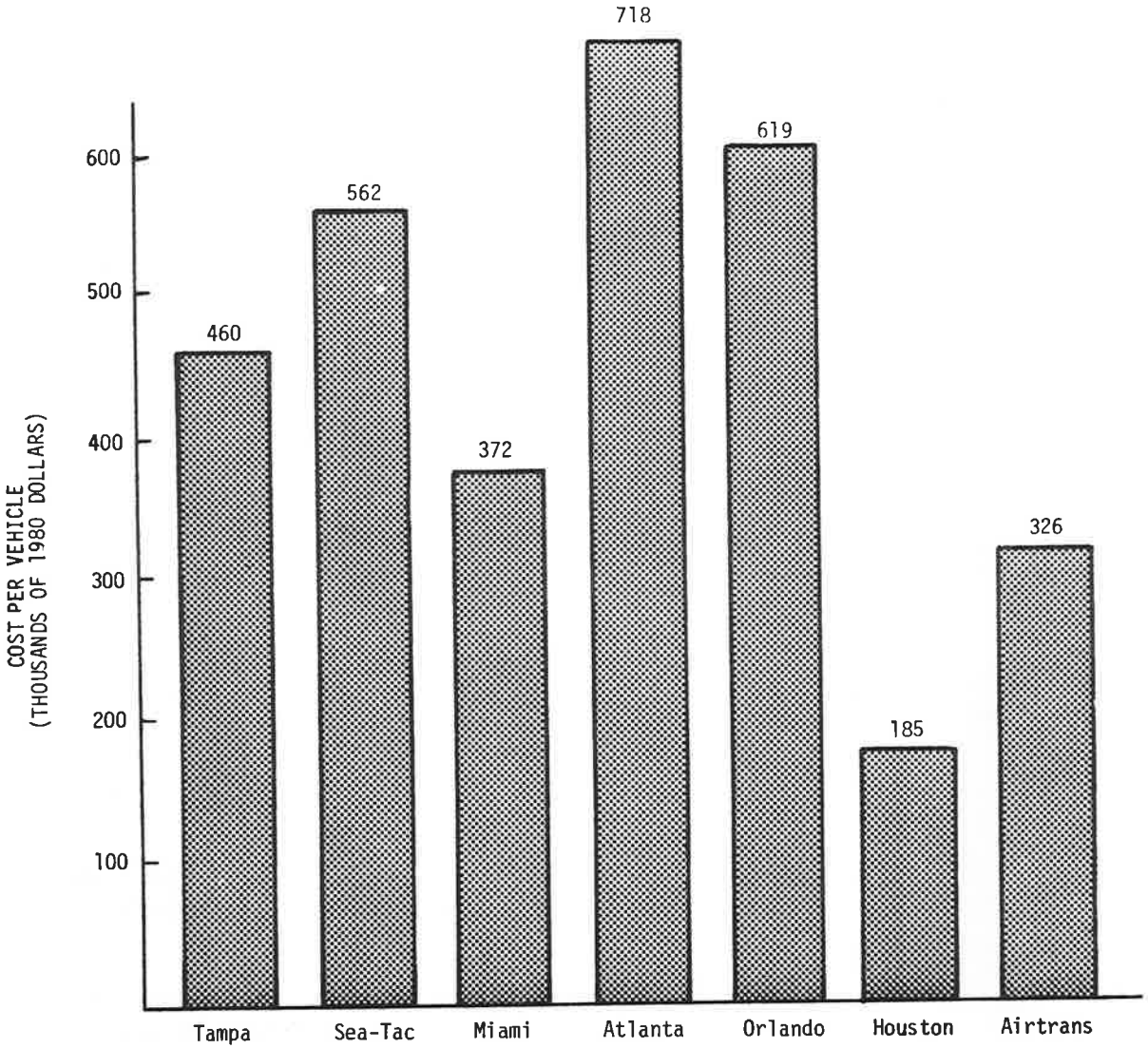


FIGURE 4-4A. COMPARISON OF VEHICLE UNIT COSTS FOR AIRPORT SYSTEMS

FIGURE 4-4A NOTES:

- Tampa, Sea-Tac, Miami, Atlanta, and Orlando are all Westinghouse systems.

- Fleet sizes are: Tampa-8 vehicles; Sea-Tac-12; Miami-4; Atlanta-17; Orlando-8; Houston-6 trains of 3 cars each; Airtrans-51 (does not include 17 utility vehicles).

- No correlations appear to exist based on a common supplier or by size of the vehicle order. Correlations, however, do exist based upon overall fleet weight and area (see Figures 4-6 and 4-7).

- Two of the Miami vehicles are passive, which may account for lower costs.

- Unlike other Westinghouse vehicles, Atlanta vehicles have the capability of negotiating switches, which may account for the higher cost.

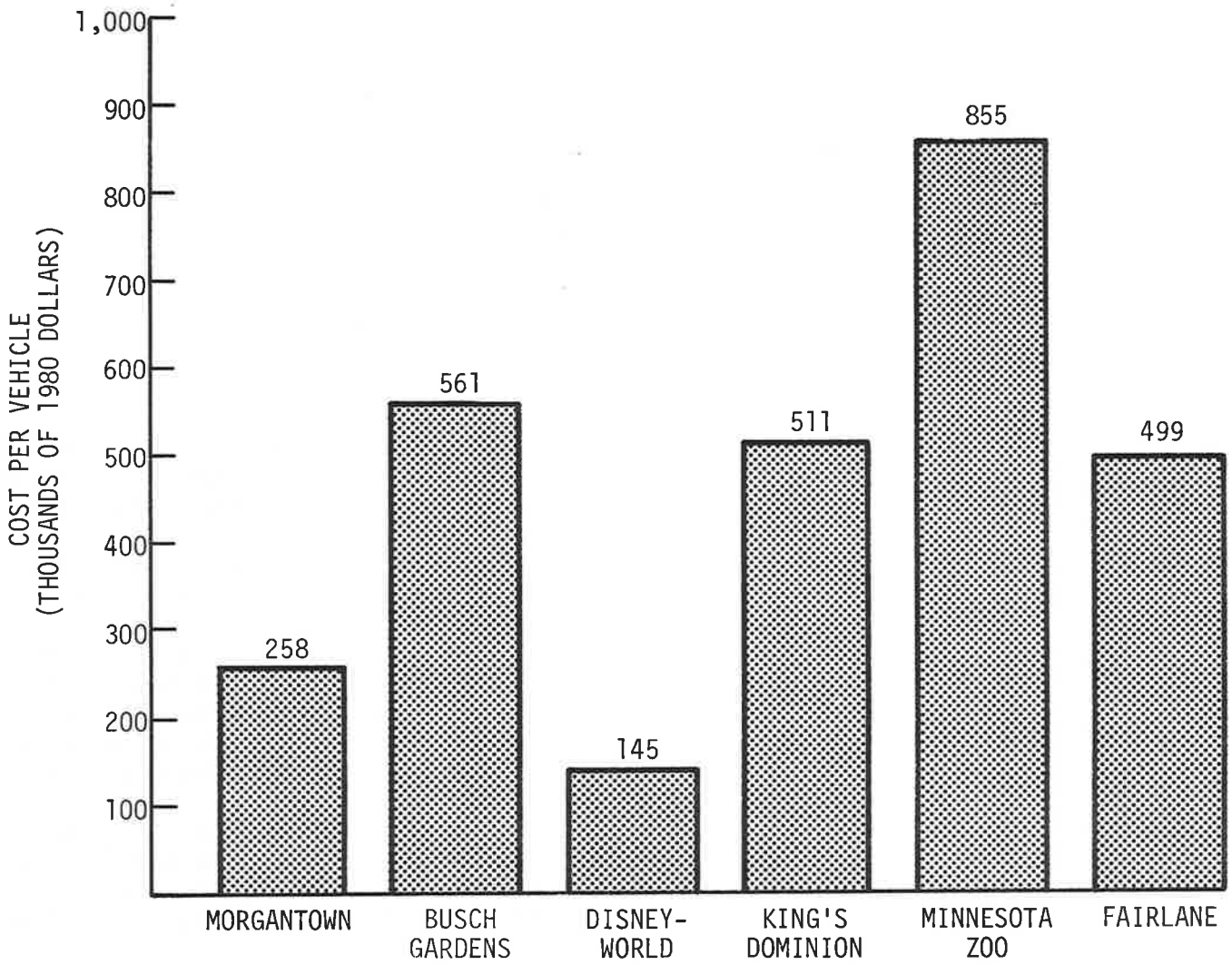


FIGURE 4-4B. COMPARISON OF VEHICLE UNIT COSTS FOR OTHER SYSTEMS

FIGURE 4-4B NOTES:

- Fleet size are: Morgantown - 71 vehicles; Busch Gardens - 2 vehicles; Disneyworld - 30 trains of 5 cars each; King's Dominion - 6 trains of 9 cars each; Minnesota - 4 vehicles; Fairlane 2 vehicles.

- Minnesota Zoo's vehicles are comprised of six car trains which makes costs appear higher.

- Disneyworld vehicles are open passive vehicles and therefore their costs are low.

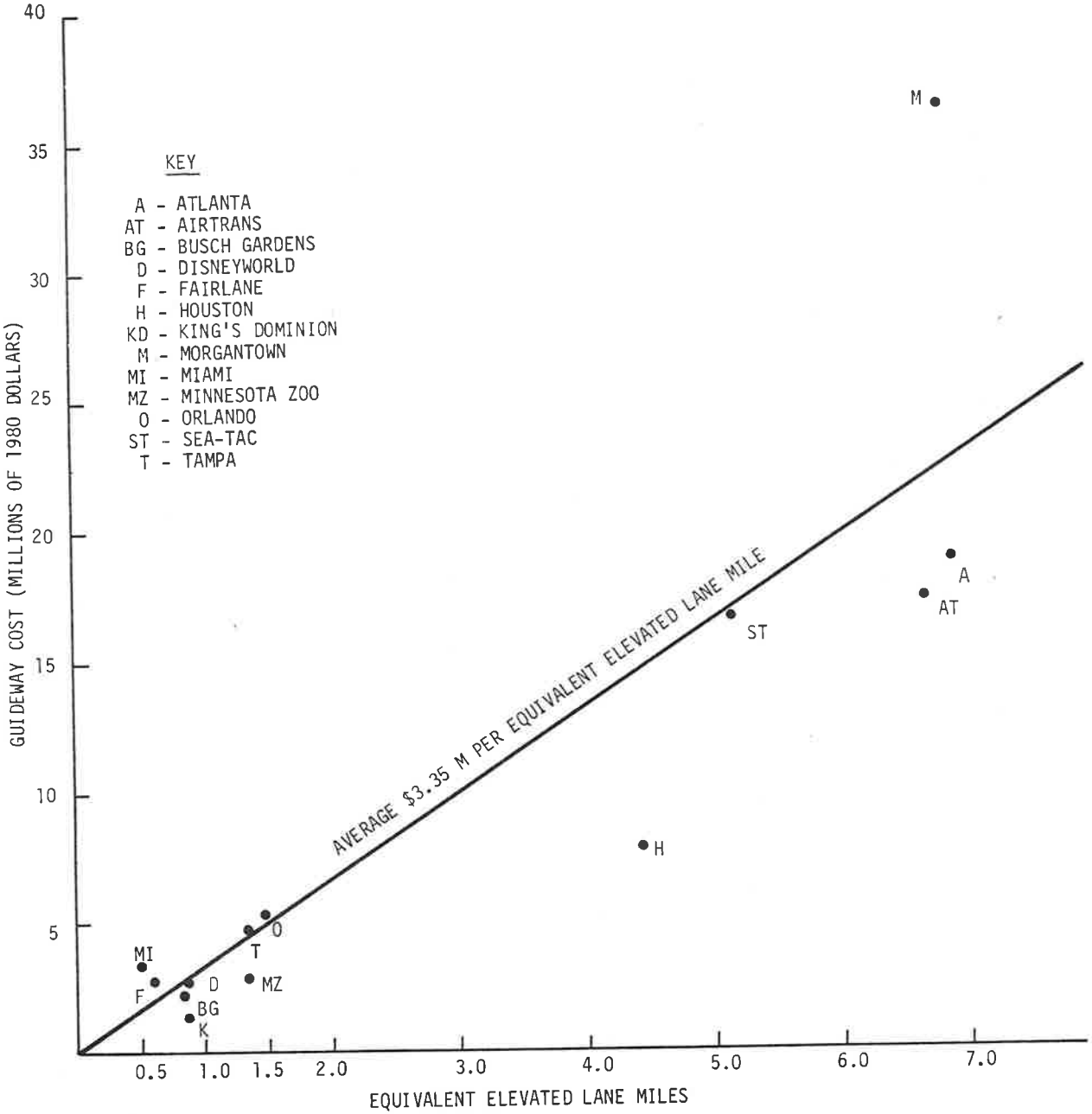


FIGURE 4-5. GUIDEWAY COST VS. EQUIVALENT ELEVATED LANE MILES

FIGURE 4-5 NOTES:

- Equivalent elevated lane miles have been calculated using the following factors: 0.4 for at-grade, 3.0 for underground, and 1.0 for elevated.
- Morgantown is significantly off the curve because of the special circumstances involved in the construction of the system.
- The average of $3.35 million per equivalent elevated lane mile is the arithmetic mean of the thirteen systems plotted. The median value of the thirteen systems is $3.06 million per equivalent elevated lane mile.

Data Points

SYSTEM	EQUIVALENT ELEVATED LANE/MILES	GUIDEWAY COST (MILLIONS OF 1980 DOLLARS)
Atlanta	6.87	18.9
Airtrans	6.66	17.4
Busch Gardens	0.84	2.3
Disneyworld	0.87	2.7
Fairlane	0.61	2.8
Houston	4.43	7.9
King's Dominion	0.88	1.5
Morgantown	6.79	36.4
Miami	0.51	3.3
Minnesota Zoo	1.36	3.0
Orlando	1.48	5.2
Sea-Tac	5.13	16.7
Tampa	1.35	4.7

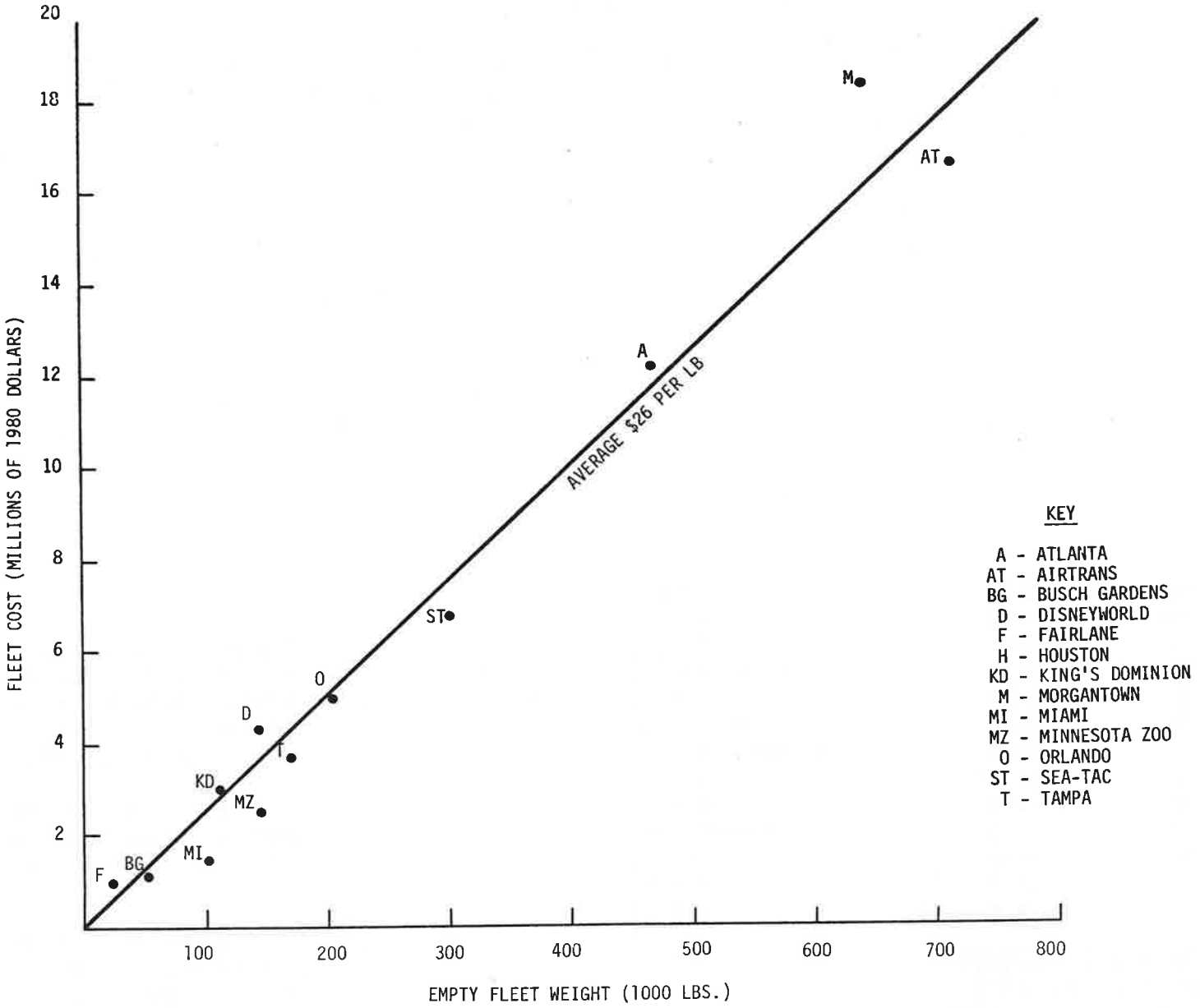


FIGURE 4-6. FLEET COST VS. EMPTY FLEET WEIGHT

FIGURE 4-6 NOTES:

- Empty vehicle weights have been obtained from either assessment reports or discussion with suppliers. These values are:

Atlanta	27,500 lbs	Morgantown	8,600 lbs
Airtrans	14,000	Miami	25,800
Busch Gardens	26,500	Minnesota Zoo	47,800
Disneyworld	4,800	Orlando	25,600
Fairlane	12,500	Sea-Tac	25,000
King's Dominion	18,700	Tampa	21,500

- Weights for Disneyworld, King's Dominion, and Minnesota Zoo represent the weight of a train, not individual vehicles.

- A correlation around empty fleet weight was chosen not only to represent the weight of each vehicle, but to account for the size of the order as well.

- The average of $26 per pound is the arithmetic mean of the twelve systems plotted. The median value of the twelve systems is $24 per pound.

- The on-board vehicle command and control system on the Morgantown vehicles could account for Morgantown's being significantly above the average.

- Houston data point has been excluded from this correlation because the vehicle weight was not available.

Data Points SYSTEM	FLEET COST (MILLIONS OF 1980 DOLLARS)	EMPTY FLEET WEIGHT (1000 LBS)
Atlanta	12.2	468
Airtrans	16.6	714
Busch Gardens	1.1	53
Disneyworld	4.3	144
Fairlane	1.0	25
King's Dominion	3.1	112
Morgantown	18.3	628
Miami	1.5	103
Minnesota Zoo	2.6	143
Orlando	5.0	205
Sea-Tac	6.7	300
Tampa	3.7	172

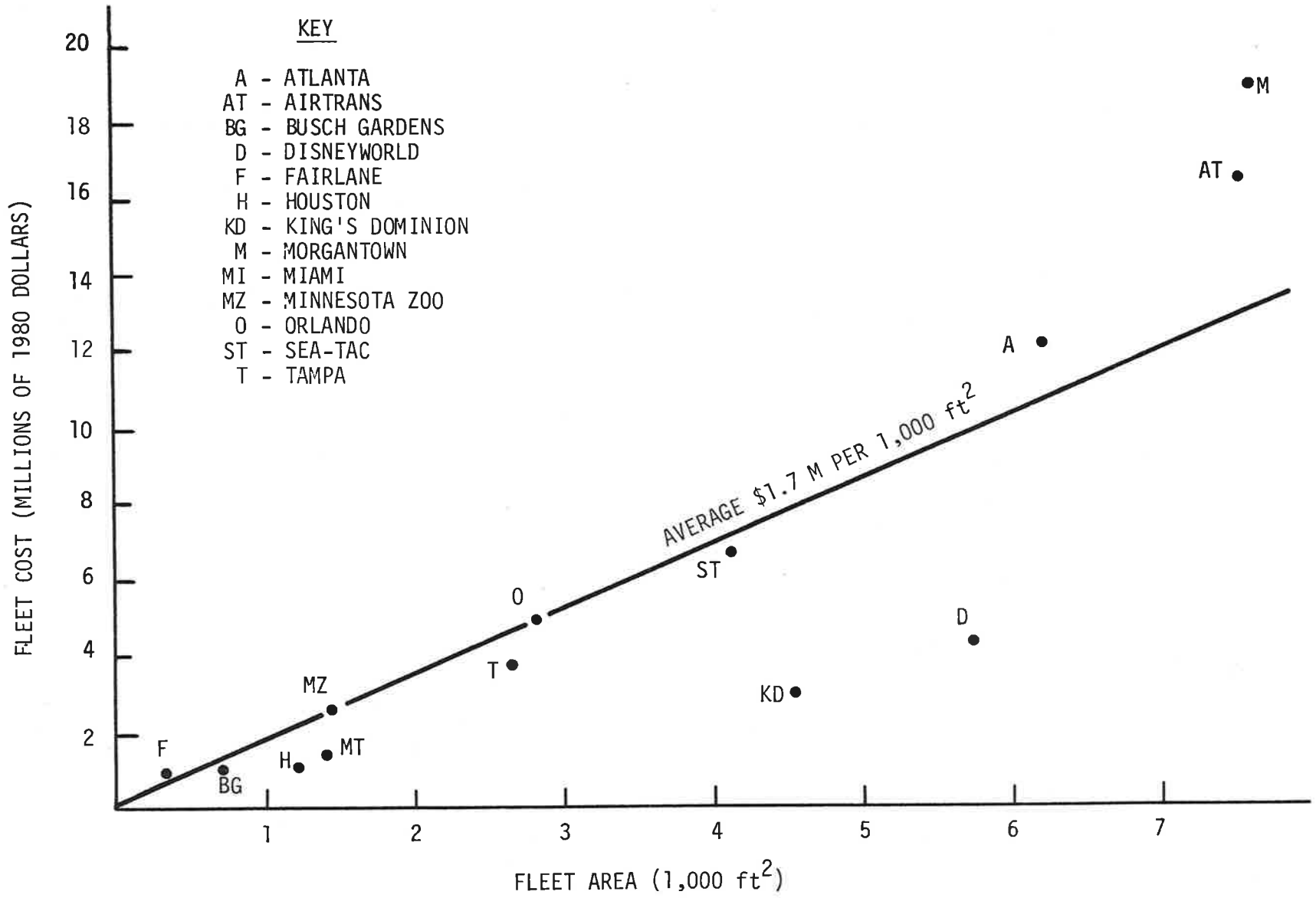


FIGURE 4-7. FLEET COST VS. FLEET AREA

FIGURE 4-7 NOTES:

- Vehicle areas have been obtained from either assessment reports or discussions with suppliers. These values are:

Atlanta	365 ft^2	Morgantown	104 ft^2
Airtrans	147	Miami	353
Busch Gardens	356	Minnesota Zoo	82
Disneyworld	38	Orlando	351
Fairlane	165	Sea-Tac	343
Houston	69	Tampa	337
King's Dominion	84		

- Areas for Disneyworld, Houston, King's Dominion, and Minnesota Zoo represent the size of individual vehicles, not the unit train.

- A correlation around fleet area was chosen not only to represent the area of each vehicle, but to account for the size of the order as well.

- The average of $1.7 million per 1,000 square feet is the arithemetic mean of the thirteen systems plotted. The median value of the thirteen systems is $1.65 million per 1,000 square feet.

- Morgantown's on-board vehicle command and control system may account for its being above the average, while the Disneyworld vehicles are not enclosed, which may account for its being significantly below the average.

Data Points

SYSTEM	FLEET COST (MILLIONS OF 1980 DOLLARS)	FLEET AREA (1000 ft^2)
Atlanta	12.2	6.2
Airtrans	16.6	7.5
Busch Gardens	1.1	0.7
Disneyworld	4.3	5.7
Fairlane	1.0	0.3
Houston	1.1	1.2
King's Dominion	3.1	4.5
Morgantown	18.3	7.6
Miami	1.5	1.4
Minnesota Zoo	2.6	1.5
Orlando	5.0	2.8
Sea-Tac	6.7	4.1
Tampa	3.7	2.7

Explanatory notes are provided with each figure.

4.3 DISCUSSION OF CAPITAL COST VARIATIONS

Significant cost variations among the AGT deployments are noted. One of the primary reasons for the variations in total system costs is the difference in system size, ranging from one-quarter mile at Pearl Ridge 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, universities, and hospitals to shopping centers and recreation centers. The design factors of an airport system (e.g., component redundancy) requiring almost 100 percent availability, 24 hours per day, 365 days per year vary considerably from a recreation center system needing 80 percent availability, 12 hours per day, 140 days per year. Locations vary from sites located near metropolitan areas such as Atlanta and Miami, to nonurban settings, such as Doswell, Virginia. Studies have shown that construction in urban areas may cost 25 to 50 percent above projects in nonurban locations, and among urban locations, construction cost indices may vary by 30 to 50 percent.

The technology employed will also vary costs. Aside from the basic differences in highly complex to relatively simple technologies, a supplier with five or six systems should have developed learning curve economies that a one system supplier has not attained. Another factor contributing to system variations is the competitiveness of the 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.

4.3.1 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. The range of guideway costs varies from $708,000 per lane mile at King's Dominion to $9,789,000 at Sea-Tac and from 16 percent of system costs at Disneyworld to 37 percent at Houston. The King's Dominion system has a simple, at-grade guideway design, while both Sea-Tac and Houston are underground systems.

Among the factors resulting in cost variations are:

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

4.3.2 Stations

Station costs, like guideway costs, may vary significantly due to both design specific and site specific factors. The range of station costs goes from $88,000 per station at Busch Gardens to $2,174,000 at Disneyworld and from 3 percent of system costs at King's Dominion to 27 percent at Miami. The Busch Gardens and King's Dominion stations are both spartan and seasonal, while the Disneyworld station contains a rather elaborate passenger loading and unloading moving ramp.

Among the factors resulting in cost variations are:

- o Size and number of stations.
- o Station materials and construction techniques.
- o Number elevated, at grade, and below grade.
- o Station design (open vs. enclosed; freestanding vs. contiguous vs. joint use).
- o Platform design (sides, island, etc.).
- 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.
- o Amount and type of bi-parting doors or separations.
- o Amount and type of elevators and escalators.
- o Local topographical considerations.
- o Local labor and material rates.

4.3.3 Maintenance and Support

Maintenance and support costs are impacted by many of the same factors affecting station costs, resulting in variations from one deployment to the next. The range of costs varies from

$27,000 per vehicle at Disneyworld to $324,000 at Sea-Tac and from 2 percent of system costs at Fairlane and Houston to 9 percent at Minnesota Zoo. The Disneyworld maintenance and support facilities service a large number of small-sized vehicles, while the Sea-Tac facility is below grade and service a small number of large-sized vehicles.

Among the factors resulting in 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 Facility aesthetics and environmental considerations.
- o Local topographical considerations.
- o Local labor and material rates.

4.3.4 Power and Utilities

Power and utility costs also vary from system to system. Costs range from $211,000 per lane mile at King's Dominion to $2,140,000 at Tampa and from 2 percent of total system costs at Houston to 15 percent at Fairlane and Tampa. Among the factors resulting in cost variations are:

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

4.3.5 Vehicles

Vehicle costs, even among vehicles provided by the same supplier, vary considerably, due basically to design characteristics. Vehicle costs range from $145,000 per vehicle at Disneyworld to $855,000 per vehicle at Minnesota Zoo and from 5 percent of total

system costs at Houston to 40 percent at King's Dominion. The Disneyworld system includes a large number of small, open vehicles. It is interesting to note that the Disneyworld and Houston systems are from the same supplier and, similarly, the Minnesota Zoo and King's Dominion systems are from a common supplier.

Among the factors resulting in cost variations are:

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

4.3.6 Command and Control

Command and control costs will vary from system to system based on the operating strategies at each deployment. Costs range from $23,000 per lane mile and 1 percent of total system costs at King's Dominion to $5,043,000 per lane mile and 26 percent of total system costs at Disneyworld.

Among the factors resulting in 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.

4.3.7 Engineering and Project Management

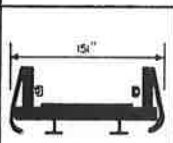
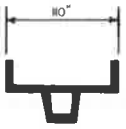
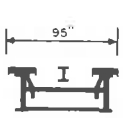
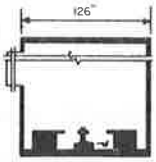
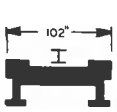
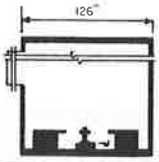
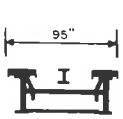
Engineering and project management costs vary among deployments due to differences in construction techniques and management strategies. Costs range from $577,000 per lane mile at Minnesota Zoo to $4,520,000 at Miami and from 7 percent of total system costs at Disneyworld to 27 percent at Morgantown. Among the factors resulting in cost variations are:

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

4.3.8 Costs of Urban Construction

AGT deployments in an urban location can be anticipated to cost more than similar deployments in non-urban settings. This is due primarily to two factors: the increased amount of construction time required by the urban environment; and the higher prices for labor and materials generally found in urban areas. More lengthy urban construction times are estimated to add 17-25 percent to civil costs, while higher urban prices for labor, materials, and contingencies are estimated to add 8-26 percent to civil costs. It must also be remembered that labor and material prices vary considerably among urban areas.

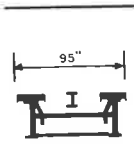
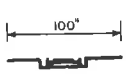
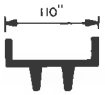
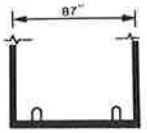
TABLE 4-2. GUIDEWAY SYSTEM CHARACTERISTICS

SYSTEM / GUIDEWAY PARAMETERS	MORGANTOWN PHASE I	AIRTRANS	TAMPA	SEA-TAC	MIAMI	ATLANTA	ORLANDO
BEAM SHAPE							
ACTUAL / EQUIV. LENGTH / ELEV. (MILES) / LENGTH	8.60/6.79	12.8/6.66	1.35/1.35	1.71/5.13	0.51/.51	2.29/6.87	1.48/1.48
PRIMARY MATERIAL(S)	Steel and Concrete	Concrete	Steel and Concrete	Concrete	Steel and Concrete	Concrete	Steel and Concrete
CONSTRUCTION TECHNIQUE	Field Construction, Composite Action	Plant Precast & Prestressed Field Post-Tensioned	Field Construction, Composite Action	Rectangular Cast-In-Place Concrete Running Surfaces	Field Construction Composite Action	Rectangular Cast-In-Place Concrete Running Surfaces	Field Construction Composite Action
COLUMN TYPE	Wine-Glass Shape, Cast-In-Place Concrete	Tapered, Rectangular Precast Concrete	Tee-Head Cast-In-Place Concrete	Not Applicable (Tunnel)	Tee-Head Cast-In-Place Concrete	Not Applicable (Tunnel)	Information Not Available
LOADED* VEHICLE WEIGHT (LBS.)	11,728	20,000	36,300	40,300	26,049	39,400	40,560
TYPICAL SPAN LENGTH (FT.)	66	90	58	Not Applicable (Tunnel)	50-110	Not Applicable (Tunnel)	Information Not Available
% ELEVATED	60	20	100	———	100	———	100
% AT GRADE	40	80	———	———	———	———	———
% UNDERGROUND	———	———	———	100	———	100	———
GUIDEWAY COST PER LANE MILE (1000's of '80 Dollars)	4,236	1,361	3,450	9,789	6,508	8,258	3,514
GUIDEWAY COST PER EQUIVALENT LANE MILE (1000's of '80 Dollars)	5,365	2,615	3,450	3,263	6,508	2,753	3,514

*Loaded Vehicle = Empty Vehicle Weight + 150 pounds x (actual vehicle capacity).

**Train Weight

TABLE 4.2. CONCLUDED

BUSCH GARDENS	DISNEYWORLD	KING'S DOMINION	MINNESOTA ZOOLOGICAL GARDENS	FAIRLANE TOWN CENTER	PEARL RIDGE	DUKE	HOUSTON
							
1.33/.84	0.87/.87	2.06/.88	1.56/1.28	0.61/.61	0.25/0.21	0.56/0.61	1.48/1.43
Steel and Concrete	Steel and Concrete	Steel	Steel	Concrete	Steel and Concrete	Concrete	Steel and Concrete
Field Construction Composite Action	Continuous Cast-In-Place Concrete	Prefabricated Off-Site, Field Welded	Prefabrication Off-Site, Field Welded	Plant Precast & Prestressed, Field Post-Tensioned	Prefabricated Steel Beam, Steel Columns & Precast Concrete Columns	Cast-in-Place, Reinf. Concrete & Precast, Pre-stressed Concrete	Prefabricated Steel Tubes, Welded End to End, Anchored to Concrete
Rectangular Cast-In-Place Concrete	Structural Steel	Structural Steel	Structural Steel W Shape	Tapered, Rectangular W/ Rounded Corners, Precast Concrete	Tapered Rectangular Precast Concrete Steel Tubular	Cast-in-Place Reinf. Concrete	Not Applicable (Tunnel)
40,001	7,770**	33,100**	61,880**	16,100	28,110**	15,910	17,000**
73	50	27-60	73	60	50-128	56	24 Tube Sections
40	100	5	90	100	96	30	—
60	—	95	10	—	4	5*	—
—	—	—	—	—	—	13	100
1,745	3,058	708	2,180	4,605	N/A	N/A	5,318
2,763	3,058	1,657	2,316	4,605	N/A	N/A	1,773

5. OPERATING 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 five major operating AGT systems in this country. These five systems represent a significant amount of the vehicle miles traveled by AGT systems in the United States. Also included this year are data on Pearl Ridge, Minnesota Zoo, Miami, and Busch Gardens. These data are not used in establishing trends because the systems accumulate very low vehicle mileage, but are presented as a source of information.

	Fleet Size	Vehicle Miles Traveled in 1980
Tampa	8	365,000
Sea-Tac	12	550,724
Airtrans	51	3,282,959
Morgantown	71	1,218,780
Disneyworld	30	719,600

These systems have all been operating over five years, permitting analysis of trends in operating cost over time, as well as breakdowns of operating cost by category such as labor, materials and utilities. Three of the five systems are located at airports, while the Morgantown System is located at West Virginia University and the fifth system is located at Disneyworld in Florida.

When comparing the 1980 O&M costs for AGT systems with the 1979 data for both AGT and conventional transit, the Consumer Price Index (CPI) for urban wage earners and clerical workers in the United States was used to adjust the pre-1980 costs to 1980 dollars. Conventional transit operating cost data for 1980 were not yet available at the time of report publication.

5.2 O&M COST EXHIBITS

A summary of operations and maintenance costs for 1980 is shown in Table 5-1 along with other pertinent operating information. In order to consistently compare place miles provided and unit costs based on vehicle capacity, an equivalent vehicle capacity is used. Equivalent places per vehicle have been calculated on an allocation of 4 square feet per passenger based on vehicle dimensions for each system. This allocation corresponds with a similar computation for conventional transit. Equivalent place miles are computed by multiplying equivalent passenger places per vehicle times the vehicle miles traveled for each system. In order to supply more information to the reader operations and maintenance data has been obtained for four additional systems to the ones used in past reports from which trends have been established. All nine systems are shown in Table 5-1.

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 several operating parameters. The seven systems providing sufficient data are included in this table.

Figure 5-1 represents the O&M cost distribution for all seven AGT systems in bar chart format. A high, low and average is given for each breakdown.

Figures 5-2 through 5-5 present the O&M cost, the vehicle miles traveled, and O&M cost per vehicle mile traveled and per vehicle in bar chart form for the year 1980 for the seven systems which have supplied detailed information. Vehicle miles for the four systems remained constant in 1980; however, the inclusion of the Morgantown system for which no data were available in 1979, increases the total vehicle mileage by 25 percent.

When analyzing O&M costs per vehicle mile, it should be understood that certain components of the O&M cost 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 (see Figure 5-2) that vary with

vehicle mileage are related primarily to maintenance of the system (maintenance labor, spare parts, and materials); in addition, a significant portion of the utility costs is related to power used for vehicle propulsion and is therefore dependent on vehicle miles also. Fixed costs are those components normally associated with operation and administration of the system as well as those utility costs associated with the housekeeping power of the system (lights, communication). For those systems having guideway heating systems such as Morgantown, another variation is introduced into the O&M cost each year, dependent on the severity of the winter environment.

Vehicle mileage and O&M cost trends over the last five years (1976-1980) are depicted in Figures 5-6 through 5-8. All costs are adjusted to 1980 price levels, using the Consumer Price Index, so that trends are distinguishable from inflationary increases over this period. O&M imformation was available from 1976 to 1980 for Morgantown with the exception of data for 1979. On each exhibit a five system average is shown by a straight line from 1978 to 1980 to depict the lack of Morgantown data for 1979. However, a four system average data point is shown. The overall average of vehicle miles traveled increased slightly in 1980 while the average O&M cost for five systems has remained relatively constant. The O&M cost per vehicle mile has decreased slightly.

TABLE 5-1. 1980 OPERATIONS AND MAINTENANCE COST BREAKDOWN
(1980 DOLLARS)

	TAMPA	SEA-TAC	AIRTRANS	MORGANTOWN	DISNEYWORLD	MINNESOTA ZOO	PEARL RIDGE	MIAMI	BUSCH GARDENS
Operational Statistics									
Vehicle Miles	365,000	550,724	3,282,959	1,218,780	719,600	7,606	12,500	76,136	44,500
Equivalent Place Miles	30,660,000	47,362,264	121,469,483	31,688,280	34,540,800	935,538	750,000	6,699,968	3,960,500
Passengers Carried	19,223,500	10,941,450	7,013,994	3,009,762	5,328,510	374,280	1,200,000	4,618,296	1,365,086
System Operating Hours	8,784	8,052	8,597	4,121	4,797	3,245	3,750	N/A	1,395
Number of Employees	6.6	17.25	143	81	18	15.4	13	N/A	12
Operations & Maintenance Costs ($)									
LABOR	17,706	602,389	3,064,315	1,086,599	287,779	198,947	252,884	-	-
Operations	5,059	198,789	881,142	244,481	159,659	91,394	68,731	-	48,700
Maintenance	12,647	403,600	1,891,873	576,548	128,120	107,553	168,422	-	-
Other	-	-	291,300	265,570	-	-	15,731	-	-
UTILITIES	86,453	17,941	296,865	367,878	64,345	30,647	7,204	20,397	14,000
MATERIALS & SERVICES	493,615	156,860	940,039	699,028	-	25,828	30,880	-	-
Spare Parts & Materials	74,042	126,860	696,312	439,998	-	23,078	30,880	-	-
Contract Services	419,573	30,000	243,727	259,030	-	2,750	-	-	-
GENERAL & ADMINISTRATIVE	14,487	20,006	81,801	-	31,932	-	35,100	-	-
TOTAL ANNUAL COST	612,261	797,196	4,383,020	2,153,505	384,056	255,422	326,068	N/A	N/A

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

N/A Not Available.

TABLE 5-1 NOTES:

- Tampa - Vehicle miles were not measured, but were computed based upon previous studies. Passengers carried was not recorded, but was estimated at a factor of 2.5 times the number of passengers using the airport. This estimate corresponds with data reported in Tampa's Annual Report and employs a factor equal to that used by Sea-Tac Airport. Passenger miles are based on an average passenger trip of 0.17 miles per trip. It is assumed that the low labor dollar figure does not include labor costs included in high contract services dollar figure.

- Sea-Tac - Passenger miles are based on an average passenger trip of 0.35 miles per trip.

- Airtrans - Thirty-six Passenger Service Agents were employed at a cost of $581,733. This has been included in Operations Labor. Vehicle miles are for passenger vehicles only.

- Morgantown - Labor categories include some fringe benefits. Other fringe benefits are paid by the State of West Virginia and are not reported. Statistics and costs represented the complete Morgantown system.

- Disneyworld - Operations labor includes station agents. No materials and services costs were reported. Vehicle miles are for train miles.

- Minnesota Zoo - Vehicle miles are for train miles.

- Pearl Ridge - Statistics and costs based on 1980 operating budget. Vehicle miles are for train miles.

- Miami - Utilities are based on the cost per kwh reported for Tampa times the average kwh per vehicle mile reported by Miami for January 1981.

- Busch Gardens - Utilities are based on the cost per kwh reported by VEPCO times the average kwh per vehicle mile reported in the Assessment Report.

- Equivalent place miles are computed by multiplying equivalent passenger places per vehicle times the vehicle miles traveled for each system.

- Due to the lack of uniformity in collection of O&M data at the various systems the breakdown of the costs by specific categories may not be comparable, but the total costs are reasonably accurate.

- Data received on utilities reflects a wide range in the costs. This may be due to the regional differences in cost per kilowatt hour. For example, Sea-Tac reports a cost slightly over 1¢ per kwh, Tampa reports slightly over 4¢ per kwh, and Busch Gardens over 8¢ per kwh.

- Incomplete information has been provided on the Miami and Busch Gardens systems and therefore they are not included in the total.

TABLE 5-2. 1980 OPERATIONS AND MAINTENANCE COST MEASURES
(1980 DOLLARS)

	TAMPA	SEA-TAC	AIRTRANS	MORGAN-TOWN	DISNEYWORLD	MINNESOTA ZOO	PEARL RIDGE
O&M Cost Per Vehicle Mile	$1.68	$1.45	$1.34	$1.77	$.53	$33.58	$26.09
O&M Cost Per Vehicle (Train)	76,533	66,433	85,942	29,500	12,802	85,141	81,517
O&M Cost Per Equivalent Place Mile	0.020	0.017	0.036	0.068	0.011	0.273	0.435
O&M Cost Per Passenger	0.03	0.07	0.62	0.72	0.07	0.68	0.27
O&M Cost Per Passenger Mile	0.19	0.21	N/A	N/A	0.08	0.50	1.19

TABLE 5-2 NOTES:

- Minnesota Zoo and Pearl Ridge cost per vehicle mile are not representative of AGT systems in general due to the abnormally low number of vehicle miles operated by each system. Therefore, their values will not be included in the overall average.

- The average O&M cost per vehicle mile is $1.36 as compared to the 1979 average of $1.13 (1980 $). This is due to the large increase in cost per vehicle mile at Airtrans which resulted from an increase in operating personnel (passenger service agents) and a decrease in vehicle miles operated compared to previous years. Due to the large number of vehicle miles operated, Airtrans dominates the overall five system average. The cost per vehicle mile travelled (VMT) at Tampa, Sea-Tac and Disneyworld actually declined. The following are costs per VMT in 1980 dollars:

	1979	1980
Tampa	1.72	1.68
Sea-Tac	1.54	1.45
Airtrans	1.11	1.34
Morgantown	-	1.77
Disneyworld	.55	.53

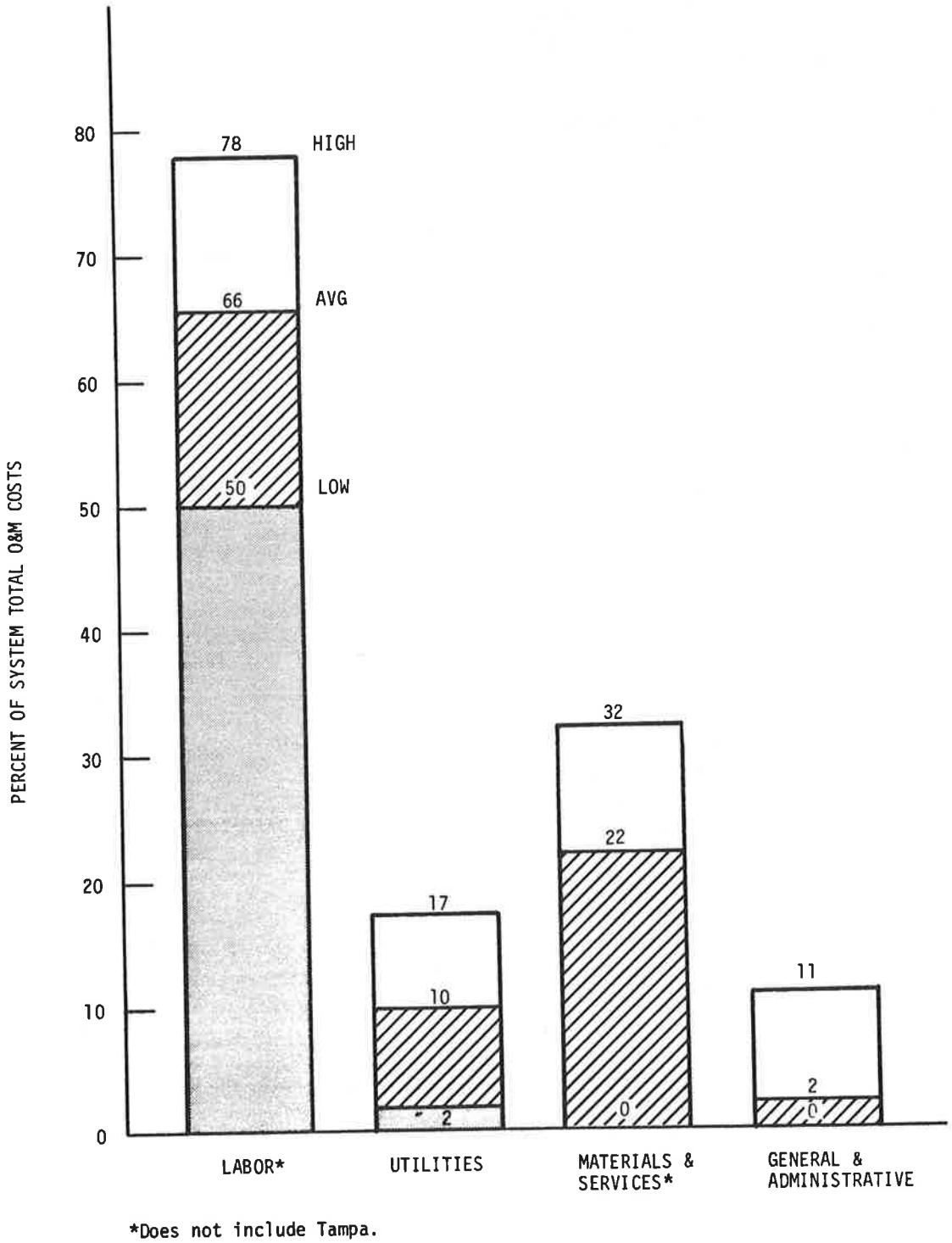


FIGURE 5-1. 1980 O&M COST DISTRIBUTION FOR SEVEN AGT SYSTEMS

FIGURE 5-1 NOTES:

- Average distribution of operating and maintenance costs for seven AGT systems is: Labor 66%, Utilities 10%, Materials and Services 22%, and General and Administrative 2%.

- A wide range of distributions exist for each system that may vary significantly from the average. Therefore, high and low values have been shown for each O&M cost category:

  Labor: High - Minnesota Zoo, Pearl Ridge (78%);
  Low - Morgantown (50%)
  Utilities: High - Morgantown, Disneyworld (17%);
  Low - Sea-Tac (2%)
  Materials & Services: High - Morgantown (32%);
  Low - Disneyworld (0%)
  General & Administrative:
  High - Pearl Ridge (11%);
  Low - Morgantown, Minnesota Zoo (0%)

- Tampa has not been included in Labor or Materials and Services due to variations in accounting practices that place labor dollars under the materials and services category.

- The seven AGT Systems are:

  Airtrans
  Disneyworld
  Minnesota Zoo
  Morgantown
  Pearl Ridge
  Sea-Tac
  Tampa

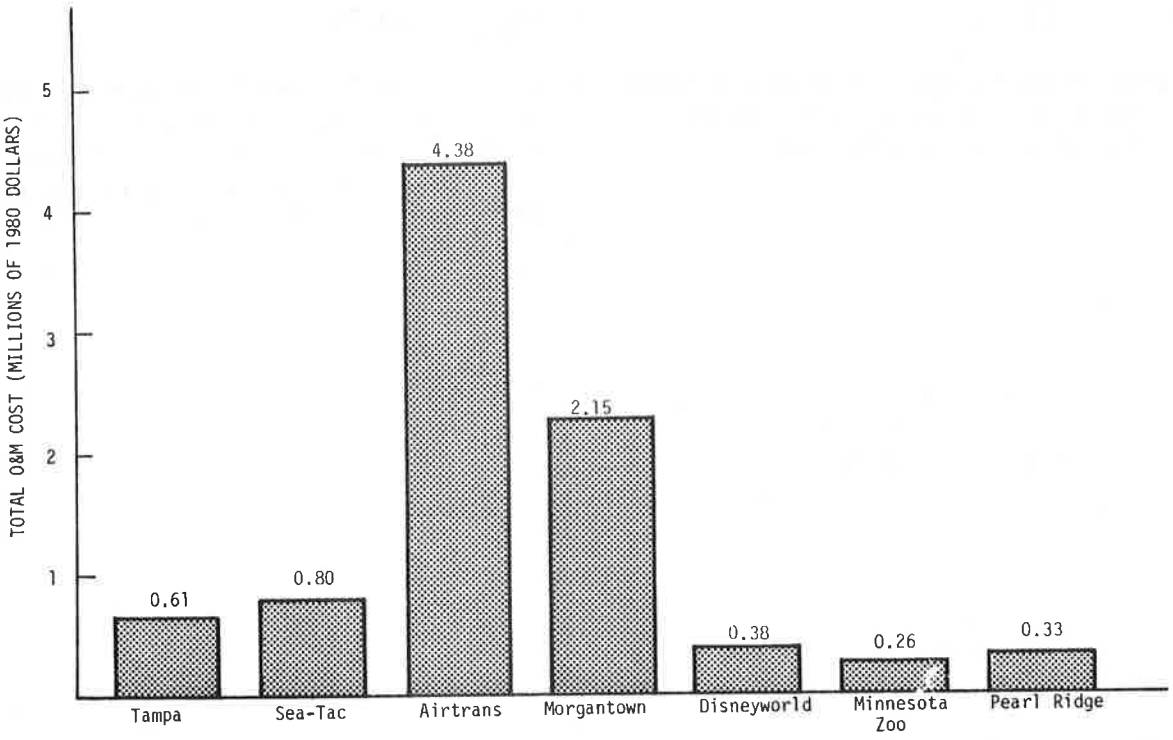


FIGURE 5-2. 1980 TOTAL O&M COSTS FOR SEVEN AGT SYSTEMS

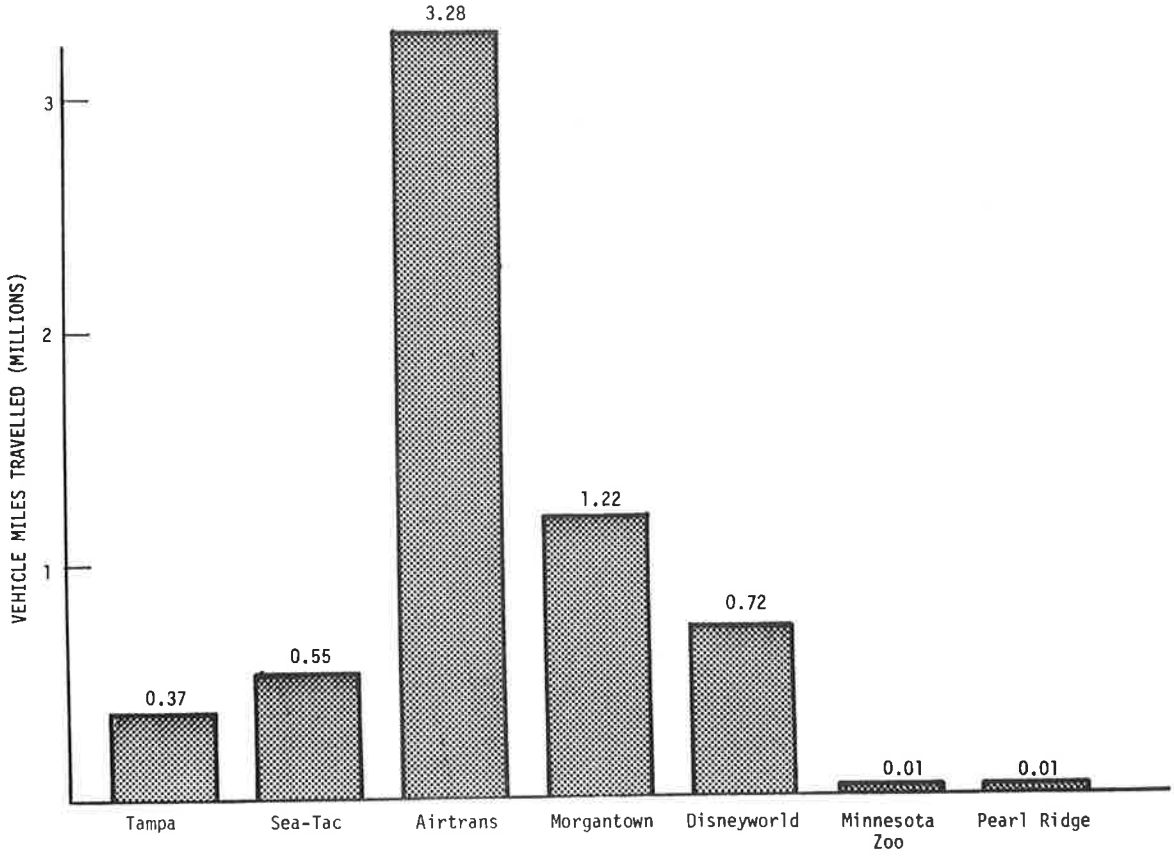


FIGURE 5-3. VEHICLE MILEAGE TRAVELLED BY SEVEN AGT SYSTEMS

FIGURE 5-2 NOTES:

- Graph reflects total operating costs but does not include differences in levels of service provided.

FIGURE 5-3 NOTES:

- Difference in levels of service provided are shown. Higher overall O&M costs for systems shown in Figure 5-2 correspond to the higher vehicle miles shown on this graph.

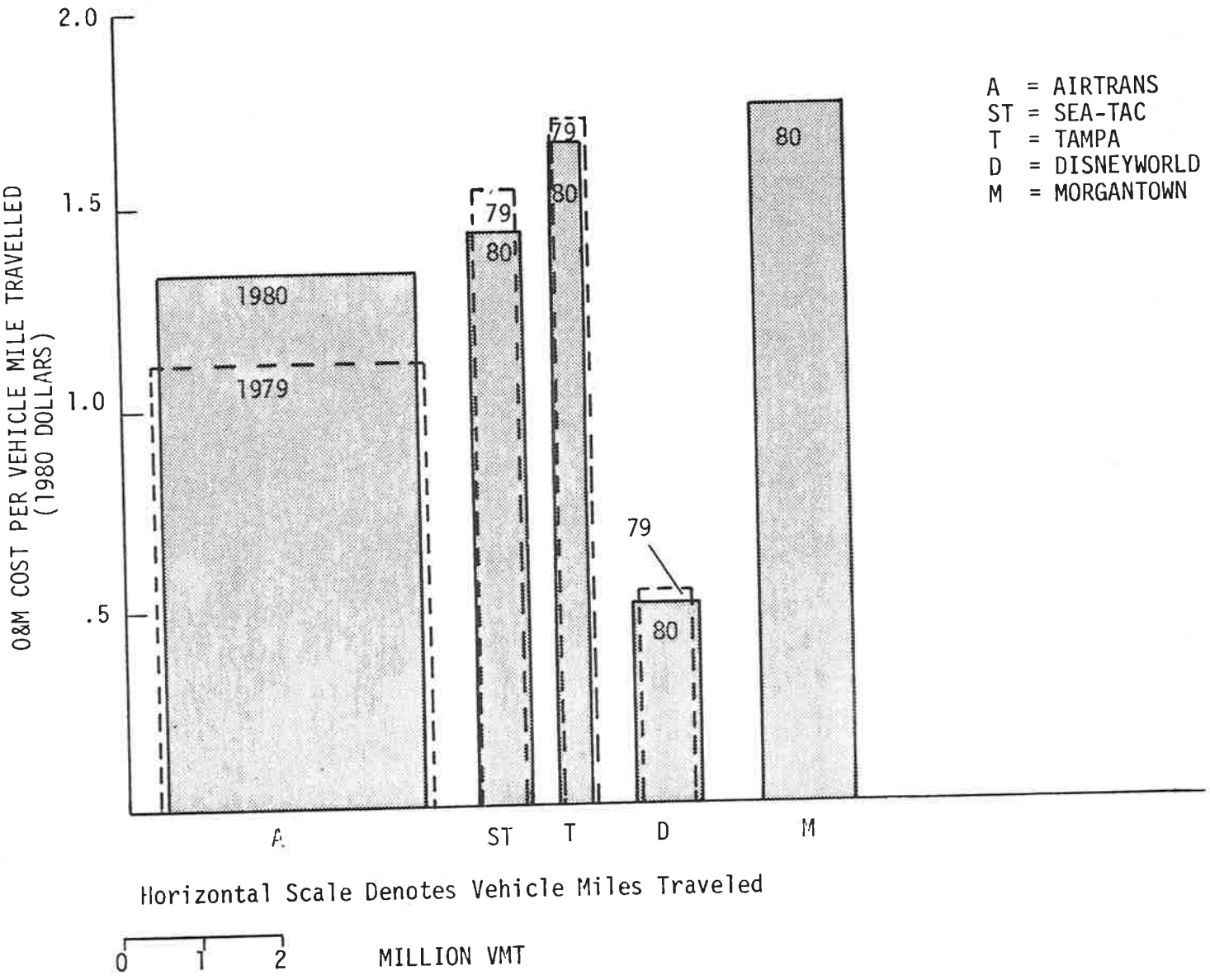


FIGURE 5-4. COMPARISON OF O&M COSTS PER VEHICLE MILES TRAVELLED (VMT) FOR 1979 & 1980

FIGURE 5-4 NOTES:

- Shaded areas reflect 1980 data. Where 1979 data differ, these amounts are indicated by dotted lines.

- O&M costs per vehicle mile travelled (VMT) between 1979 and 1980 went down for all systems except Airtrans. This increase at Airtrans is due to the addition of passenger service agents and decline in vehicle miles travelled.

Data Points (1980 Dollars)

	1979		1980	
	VMT (MILLIONS)	O&M/VMT	VMT (MILLIONS)	O&M/VMT
Airtrans	3.36	1.11	3.28	1.34
Sea-Tac	.53	1.54	.55	1.45
Tampa	.38	1.72	.37	1.68
Disneyworld	.62	.55	.72	.53
Morgantown	--	--	1.22	1.77

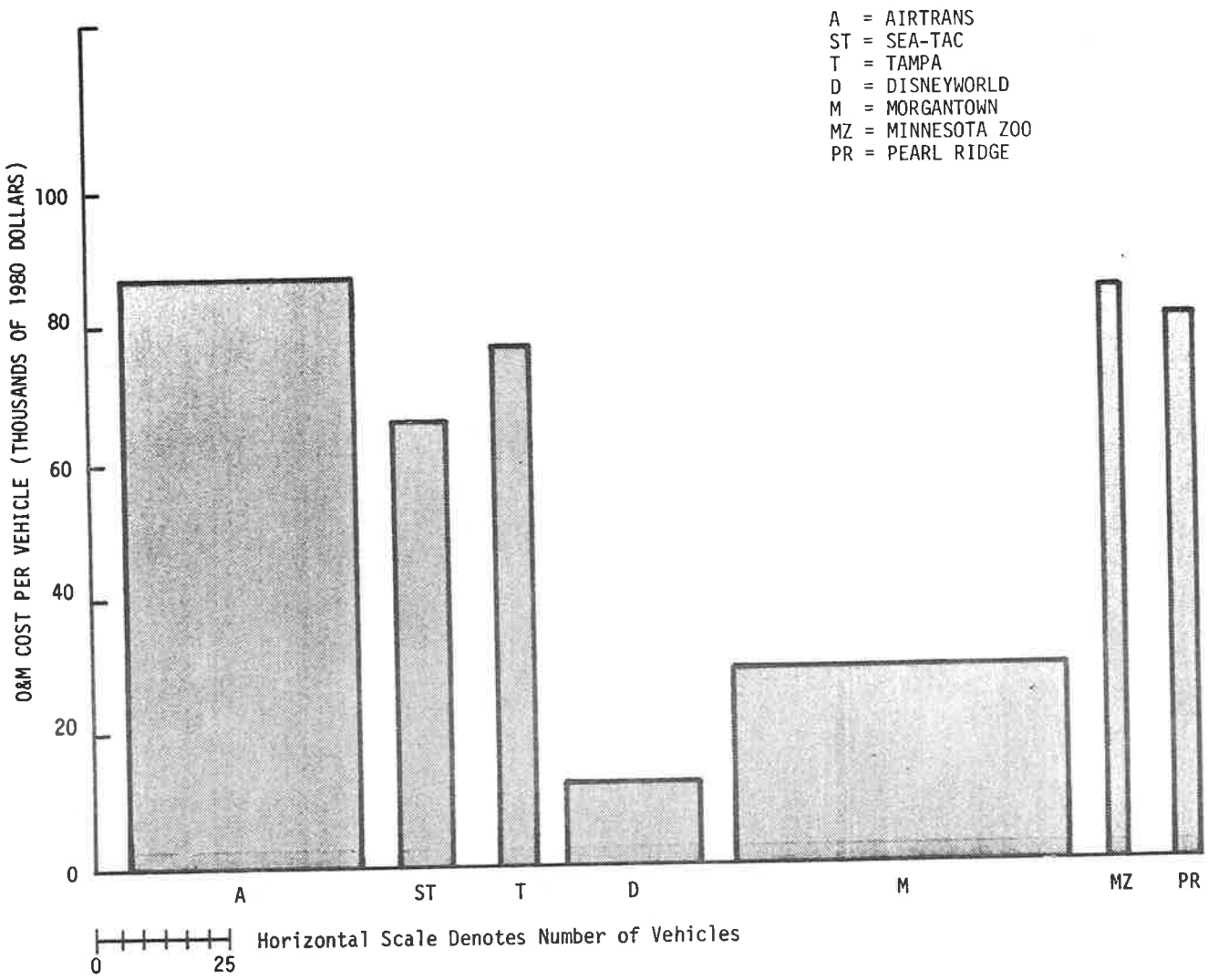


FIGURE 5-5. COMPARISON OF O&M COSTS PER VEHICLE FOR 1980

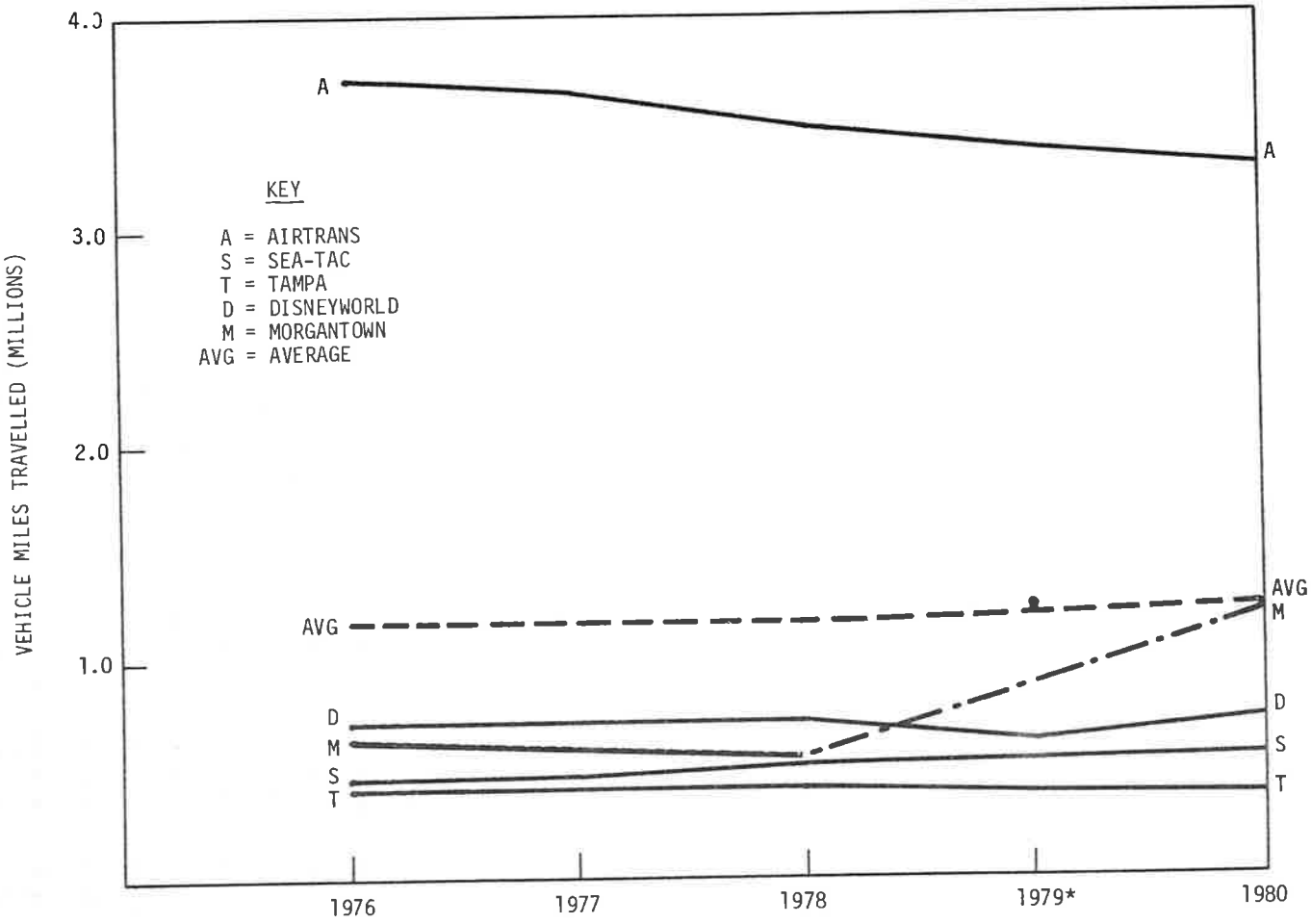
FIGURE 5-5 NOTES:

- There does not appear to be a correlation between O&M costs and the number of vehicles per system.

Data Points

SYSTEM	NO. VEHICLES	TOTAL O&M COST PER VEHICLE (DOLLARS)
Airtrans	51	86
Sea-Tac	12	66
Tampa	8	77
Disneyworld	30	13
Morgantown	73	30
Minnesota Zoo	3	85
Pearl Ridge	1	330

- Where vehicles are entrained, the number of vehicles is defined as the number of trains. Disneyworld uses 30, five-car trains and Pearl Ridge uses 1, four-car train.



*1979 does not include Morgantown (the isolated point denoting the four system average is not included in the plot of the average.

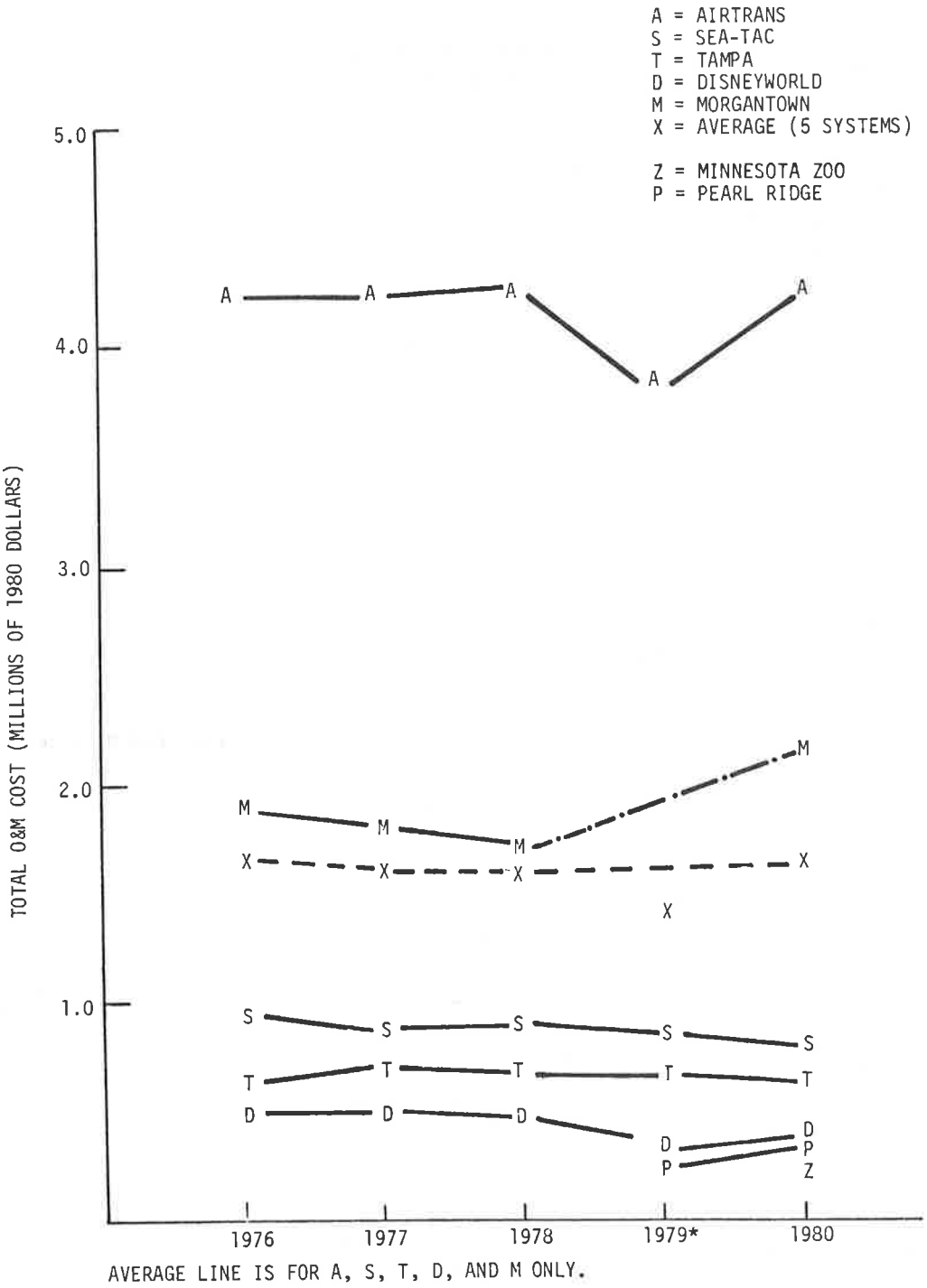
FIGURE 5-6. TREND OF VEHICLE MILES TRAVELLED FOR FIVE AGT SYSTEMS

FIGURE 5-6 NOTES:

- Absence of data for the Morgantown system for 1979 is represented by a dashed line between 1978 and 1980 data points.
- The 5 system average is shown by a straight line from 1978 to 1980 to depict the lack of Morgantown data for 1979. However, a 4 system average data point is shown.
- The overall average of vehicle miles travelled increased in 1980 as increases at Morgantown and Disneyworld offset a decline at Airtrans.

Data Points

System	Vehicle Miles Travelled				
	1976	1977	1978	1979	1980
Airtrans	3.70	3.63	3.47	3.36	3.28
Sea-Tac	.45	.46	.51	.53	.55
Tampa	.40	.40	.41	.38	.37
Disneyworld	.71	.71	.71	.62	.72
Morgantown	.63	.58	.55	-	1.22
Average	1.18	1.16	1.13	1.22	1.23



*1979 does not include Morgantown (the isolated point denoting the four system average is not included in the plot of the average.

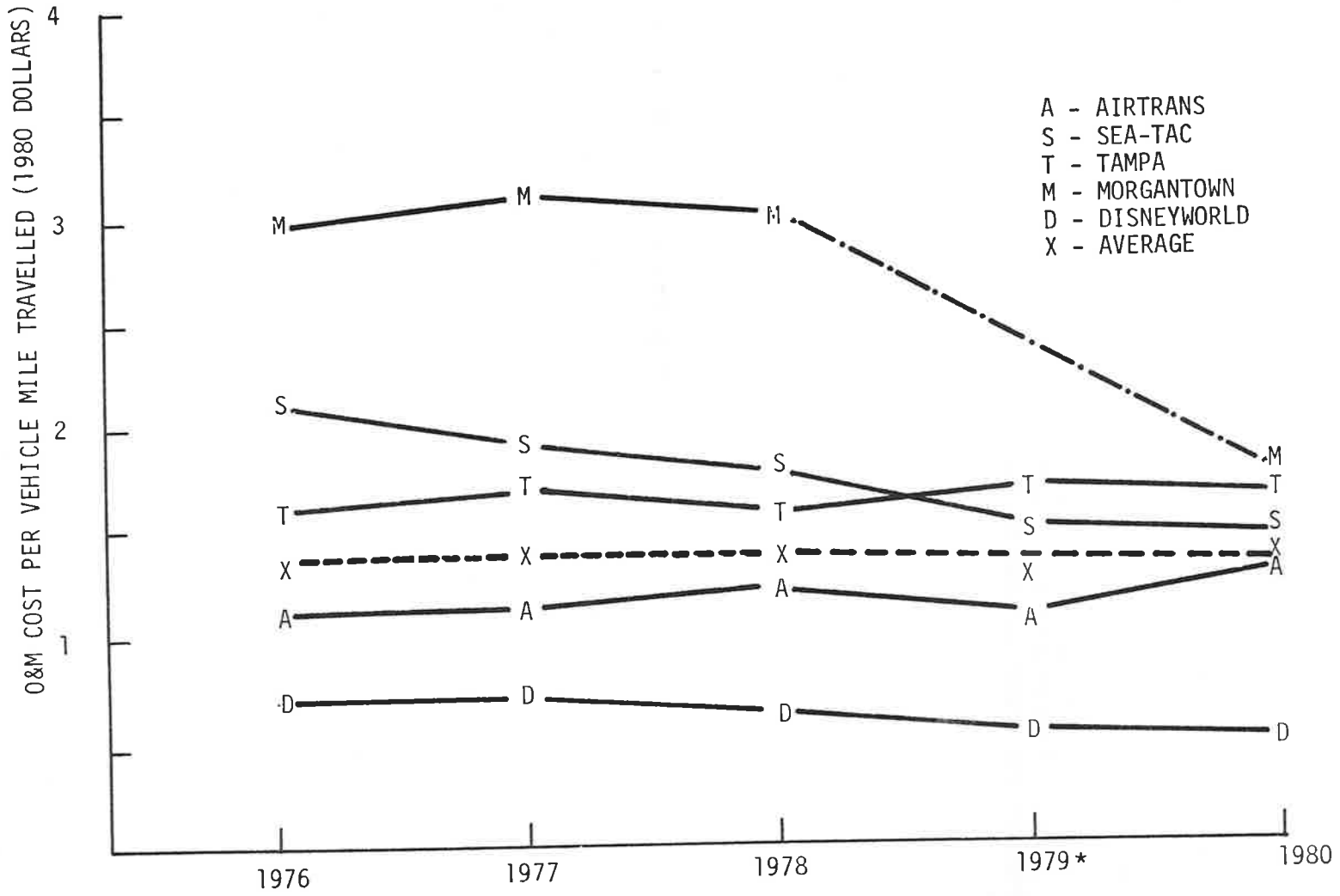
FIGURE 5-7. TREND OF TOTAL O&M COSTS OF SEVEN AGT SYSTEMS

FIGURE 5-7 NOTES:

- Absence of data for the Morgantown system for 1979 is represented by a dashed line between 1978 and 1980 data points.
- The 5 system average is shown by a straight line from 1978 to 1980 to depict the lack of Morgantown data for 1979. However, a 4 system average data point is shown.
- The average line is a five system average. Pearl Ridge (1979) and Minnesota Zoo (1980) have been added to the graph but not to the average line.
- The average O&M cost for five systems has remained approximately constant between 1976 and 1980.
- Morgantown value for 1980 reflects the expanded system with more vehicles and more vehicle miles.

Data Points
System

	TOTAL O&M COSTS (MILLIONS OF 1980 DOLLARS)				
	1976	1977	1978	1979	1980
Airtrans	4.22	4.21	4.25	3.74	4.38
Sea-Tac	0.94	0.89	0.91	0.82	0.80
Tampa	0.64	0.66	0.65	0.65	0.61
Disneyworld	0.51	0.50	0.46	0.34	0.38
Morgantown	1.87	1.81	1.68	-	2.15
Average	1.64	1.61	1.59	1.39	1.66
Pearl Ridge	-	-	-	0.30	0.33
Minnesota Zoo	-	-	-	-	0.26



*1979 does not include Morgantown (the isolated point denoting the four system average is not included in the plot of the average.

FIGURE 5-8. TREND OF O&M COST PER VEHICLE MILE TRAVELLED FOR FIVE AGT SYSTEMS

FIGURE 5-8 NOTES:

- Absence of data for the Morgantown system for 1979 is represented by a dashed line between 1978-1980 data points.
- The 5 system average is shown by a straight line from 1978 to 1980 to depict the lack of Morgantown data for 1979. However, a 4 system average data point is shown.
- Average cost per vehicle mile has remained relatively constant between 1976 and 1980.
- Sharp decline in Morgantown cost per vehicle mile travelled corresponds to a large increase in vehicle miles due to system expansion.

Data Points

System	O&M Costs/Vehicle Mile Travelled				
	1976	1977	1978	1979	1980
Airtrans	1.15	1.16	1.22	1.11	1.34
Sea-Tac	2.10	1.92	1.79	1.54	1.45
Tampa	1.60	1.66	1.58	1.72	1.68
Morgantown	2.96	3.11	3.02	-	1.77
Disneyworld	0.71	0.71	0.64	0.55	0.53
Average	1.38	1.39	1.39	1.13	1.36

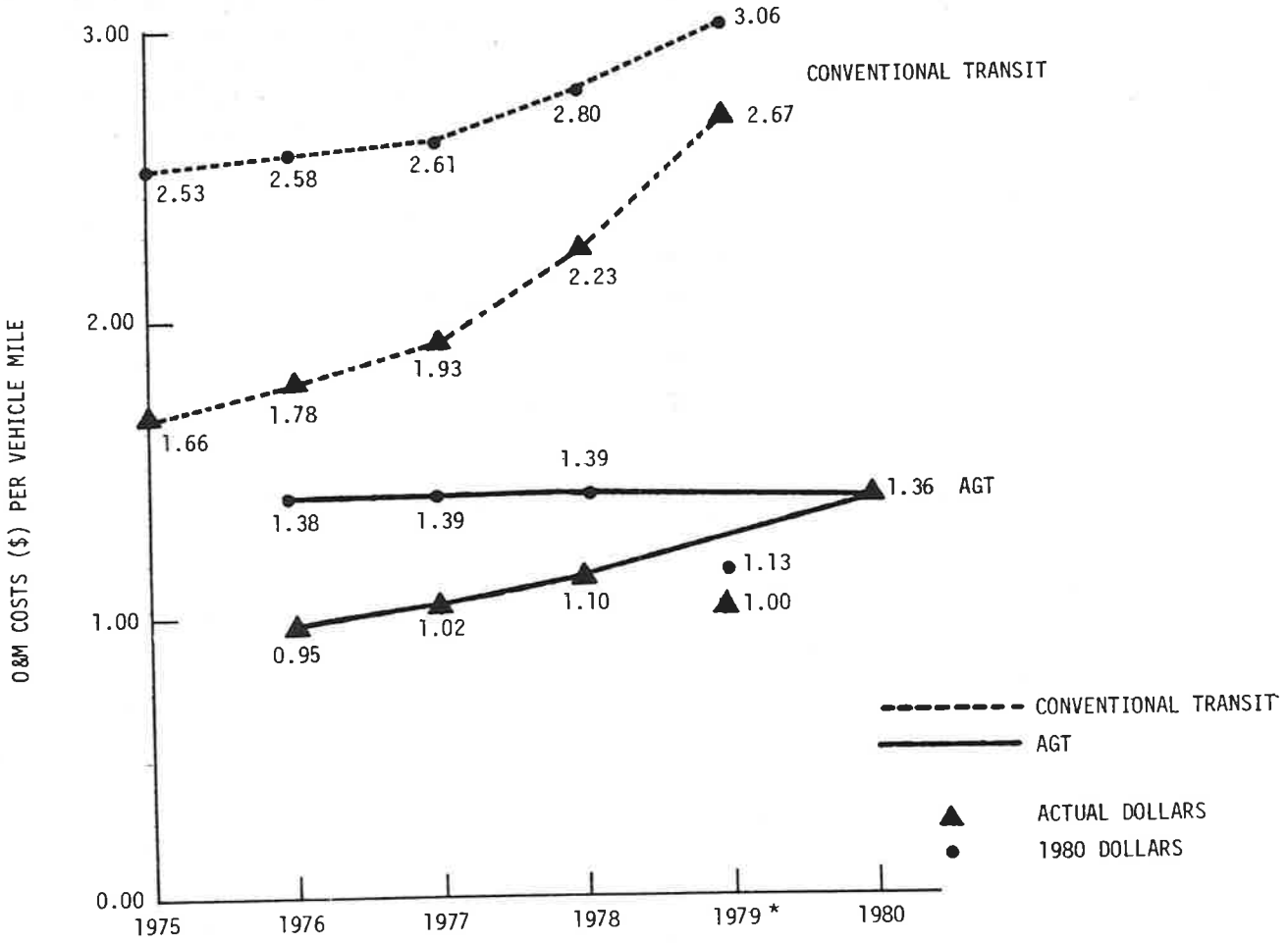
5.3 COMPARISON OF AGT AND CONVENTIONAL TRANSIT

When comparing AGT systems with conventional transportation modes in relation to operating and maintenance costs, 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 in contrast to regional or corridor service provided by existing bus and rail systems. In contrast to conventional transit systems which experience peak service periods twice a day, AGT systems provide a relatively high level of service throughout the day and tend to utilize vehicles more intensively during the day. Thus, unit vehicle operating costs are lowered for AGT due to more vehicle miles and hours being generated for their relatively small size. Therefore, it should be understood that simplified comparisons on a cost per vehicle mile basis are presented to indicate an overall contrast between the various modes.

Using available data from the American Public Transit Association for conventional transit as a yardstick, AGT system O&M unit cost data (cost per vehicle mile) compare favorably as shown in Figure 5-9. AGT cost per vehicle mile has remained constant from 1976 through 1980 while conventional transit has increased sharply. When compared on an equivalent place mile basis as seen in Figure 5-10, conventional transit between 1976 and 1979 has increased by approximately 15 percent while AGT cost per place mile has declined slightly. AGT costs per place mile are now less than conventional transit. Figure 5-11 shows the trend of O&M costs per passenger. In 1980 dollars the cost per passenger for conventional transit has remained relatively constant while AGT cost has dropped slightly. The large cost differences per passenger ($0.96 for conventional and $0.18 for AGT for 1980) may be due to the significant differences in service levels. Trip length per passenger for conventional transit is considerably longer than a trip on an AGT system.

Several factors lead to the difference shown in Figure 5-12 in O&M cost per vehicle between AGT and conventional transit. A comparison of wage rates between some of the AGT systems and conventional transit systems in the same geographic area was made and, although information was limited, the comparison showed that AGT system wages were from 17 to 24 percent lower than conventional transit wages. With labor costs comprising about 65 percent of the total O&M for AGT, use of conventional transit wage levels for AGT systems would increase the average O&M cost per vehicle mile from $1.36 to about $1.51.

Also, due to the limited length of the AGT guideways, lower maintenance cost per vehicle mile traveled would be possible. However, more frequent stops of an AGT system could lead to higher maintenance costs for the vehicle in terms of door, propulsion and brake cycles, and tire wear. In addition, the marketing, planning and advertising activity that is an essential part of urban public transportation systems, requires larger administrative staff with an associated increase in G&A expense.



*1979 does not include Morgantown (the isolated point denoting the four system average is not included in the plot of the average).

FIGURE 5-9. COMPARISON OF O&M COSTS PER VEHICLE MILE TRAVELED

FIGURE 5-9 NOTES:

- The 5 system average is shown by a straight line from 1978 to 1980 to depict the lack of Morgantown data for 1979. However, a 4 system average data point is shown.

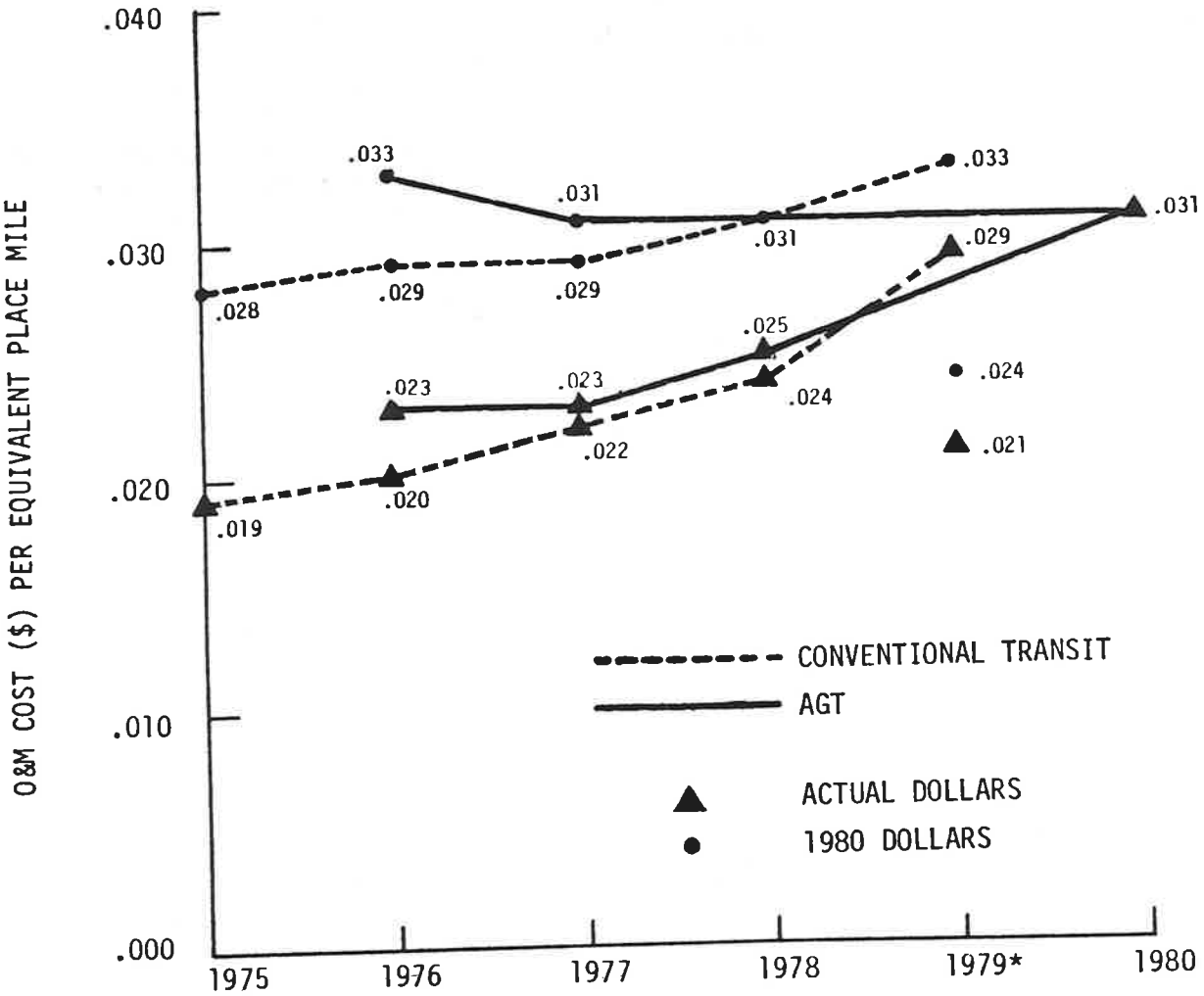
- Costs for conventional transit, i.e., bus and rail, have been adjusted to exclude amounts spent for traffic, solicitation, advertising, depreciation, amortization, taxes, licenses, rents, etc., since the AGT O&M costs do not include them. Data on conventional transit cost for 1980 were not available.

- Conventional transit figures for 1979 were obtained from the 1979 Annual Fact Book published by the American Public Transit Association.

- Both AGT and conventional transit costs have been adjusted to 1980 price levels on the basis of CPI index as follows:

	Index	Escalation Factor
1975	161.2	1.53
1976	170.5	1.45
1977	181.5	1.36
1978	195.3	1.26
1979	217.7	1.13
1980	247.0	

- AGT cost per vehicle mile has remained constant from 1976 through 1980 while conventional transit has increased sharply. This increase is probably due to rapidly rising fuel costs and high labor costs.



*1979 does not include Morgantown (the isolated point denoting the four system average is not included in the plot of the average).

FIGURE 5-10. O&M COST TRENDS PER EQUIVALENT PLACE MILE FOR FIVE AGT SYSTEMS AND CONVENTIONAL TRANSIT

FIGURE 5-10 NOTES:

- The 5 system average is shown by a straight line from 1978 to 1980 to depict the lack of Morgantown data for 1979. However, a 4 system average data point is shown.

- Cost for conventional transit, i.e., bus and rail, have been adjusted to exclude amounts spent for traffic solication, advertising depreciation, amortization, taxes, licenses, rents, etc., since the AGT O&M costs do not include them. Data on conventional transit cost for 1980 were not available.

- Conventional transit figures for 1979 were obtained from the 1979 Annual Fact Book published by the American Public Transit Association.

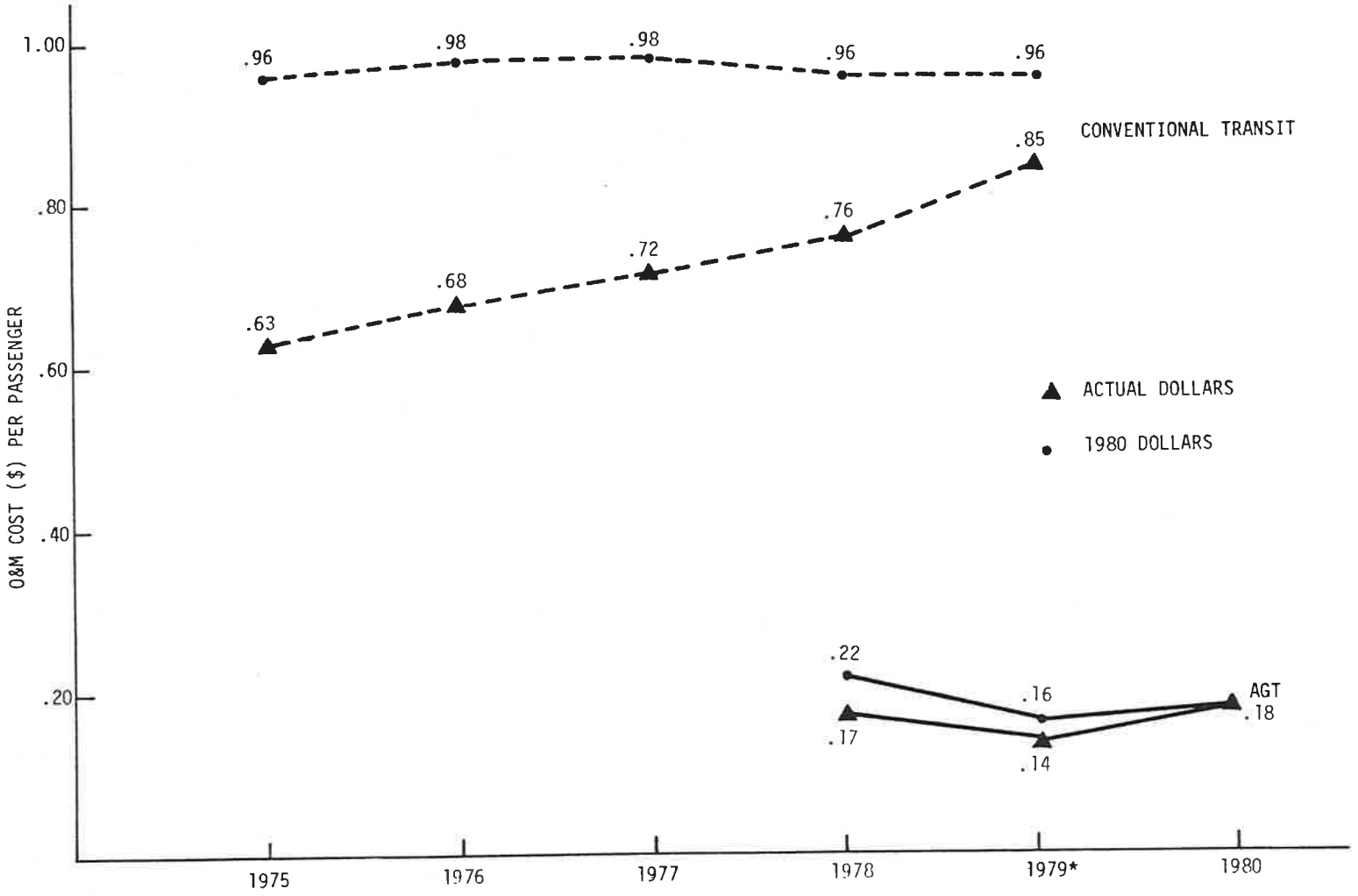
- Both AGT and conventional transit costs have been adjusted to 1980 price levels by the CPI.

- For purposes of comparing AGT systems to conventional transit, the capacities of vehicles were calculated on a uniform basis as follows:

gross area (length x width) ÷ 4 sq ft/passenger
= Places

- Capacity for conventional transit: An average number of places for each mode (bus, rapid rail, and light rail) is multiplied by the vehicle miles travelled by the corresponding mode to compute total place miles.

- AGT cost per place mile has declined slightly between 1976 and 1980 while conventional transit has increased by approximately 15% probably due to higher fuel and labor costs. AGT costs per place mile are now less than conventional transit.



*Morgantown is not included.

FIGURE 5-11. TREND OF TOTAL O&M COST PER PASSENGER CARRIED FOR CONVENTIONAL TRANSIT AND FIVE AGT SYSTEMS

FIGURE 5-11 NOTES:

- Costs for conventional transit, i.e., bus and rail, have been adjusted to exclude amounts spent for traffic, solicitation, advertisting, depreciation, amortization, taxes, licenses, rents, etc., since the AGT O&M costs do not include them. Data on conventional transit cost for 1980 were not available.

- Conventional transit figures for 1979 were obtained from the 1979 Annual Fact Book published by the American Public Transit Association.

- Both AGT and conventional transit costs have been adjusted to 1980 price levels on the basis of the CPI index.

- Data on passengers carried were not available until 1978 for AGT.

- The decline of cost per passenger between 1978 and 1979 is due to the lack of data on Morgantown for 1979.

- Large differences in cost per passenger may be due to significant differences in service levels (AGT passenger trips are considerably shorter than conventional transit trips).

- Conventional transit cost per passenger has remained relatively constant while AGT cost per passenger has declined.

- Five AGT Systems -

  Airtrains
  Sea-Tac
  Tampa
  Morgantown
  Disneyworld

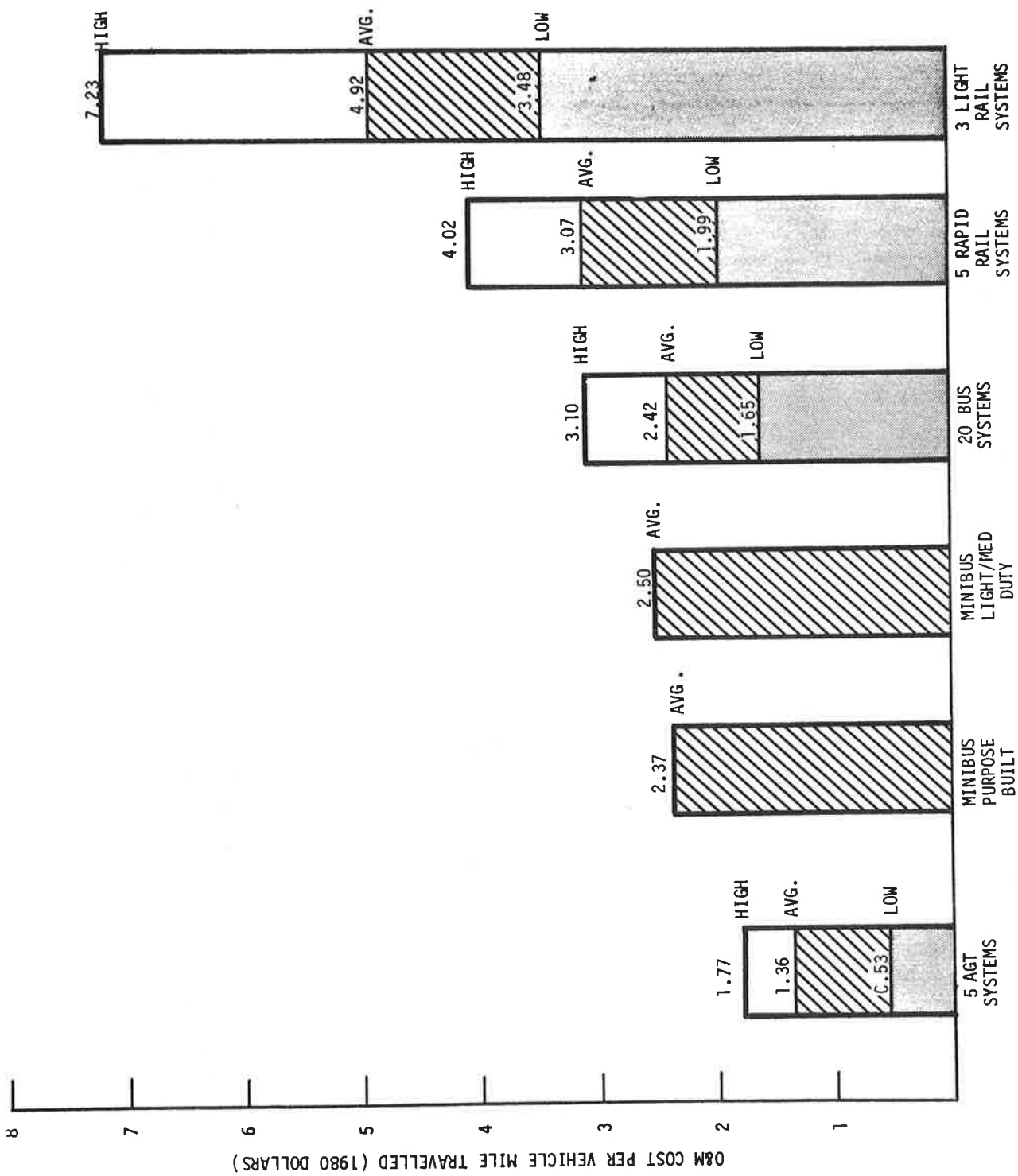


FIGURE 5-12. COMPARISON OF O&M COST PER VEHICLE MILE TRAVELLED

FIGURE 5-12 NOTES:

- The average line indicated on each bar represents a weighted average of the system included in the particular data set.

- The rail and bus data was derived from the 1980 APTA "Operating Statistical Report" and "Expense Recovery Ratio Report." Since no appropriate NYC transit data was included in these reports NYC transit is not included in the data sets. The minibus data was taken from SG Associates report "Operating Cost and Characteristics of Minibus," January 1981.

- The ranges for O&M costs per vehicle mile are as follows:

	AGT	BUS	Rapid Rail	Light Rail
High	1.77 Morgantown	3.10 Wash.DC	4.02 Philadelphia	7.23 Philadelphia
Low	0.53 Disneyworld	1.65 Dallas	1.99 Toronto	3.48 Toronto

- Conventional transit figures (bus, rapid rail and light rail) are for 1979 operations escalated to 1980 figures while AGT costs represent 1980 experience.

- Selection of bus systems in the data set covers a range of bus properties in regards to fleet size so that costs are not biased by fleet size factor.

- A distribution of conventional transit costs show 52% for operations, 20% for vehicle maintenance, 8% for non-vehicle maintenance and 20% for general and administrative.

- The five system AGT average is $1.36 with Morgantown high at $1.77 and Disneyworld low at $0.53. AGT costs (which are for 1980) are significantly lower than 1979 costs for all other modes.

- Heavy Rail

  SEPTA (Philadelphia)
  PATCO (Philadelphia)
  BART (San Francisco)
  WMATA (Washington, D.C.)
  Toronto

- Light Rail

  SEPTA (Philadelphia)
  New Orleans
  Toronto

- Bus

  Dallas
  Buffalo
  New Orleans
  Los Angeles
  Miami
  Long Beach
  Milwaukee
  St. Louis
  Richmond, Va.
  East Meadow, N.Y.
  Washington, D.C.
  San Diego
  Kansas City
  Phoenix
  Salt Lake City
  Maplewood, N.J.
  Philadelphia
  Atlanta
  Pittsburgh
  Sacramento

APPENDIX A

GENERAL CHARACTERISTICS

System	Manufacturer	Site Description	Initial Operation	Hours of Operation	Days Per Year	System Configuration
Airtrans	Vought	Airport	1/74	24 hrs/day	365	Single-lane Multi-loop
Atlanta	Westinghouse	Airport	9/80	24 hrs/day	365	Reverse turn back loop
Busch Gardens	Westinghouse	Recreation Center	5/75	11 hrs/day	143	Single-lane loop
Disneyworld (Wedway)	Walt Disney Productions	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
Houston	Disney	Airport	7/81*	——	——	Single-lane loop
King's Dominion	UMI	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	UMI	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	7/81*	——	——	2 Dual-lane shuttles
Pearl Ridge	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 1 Single-lane shuttle
Tampa	Westinghouse	Airport	4/71	18-24 hrs/day	365	4 Dual-lane shuttles

*Planned

APPENDIX B

GUIDEWAY CHARACTERISTICS

System	Guideway Length (mi.) Single lane/ Double lane	Guideway Elevation (%) Elevated/At Grade/ Below Grade	Guideway cross-Section Shape	Guideway Materials	Guideway Power	Guideway Switches #/Type	Guideway Grade (max. %)	All Weather Provisions
Airtrans	12.8/0	20/80/0	U-Shape	Concrete	3ϕ 480 VAC, 60Hz	71/MBE	8	Guideway Ice Removal Vehicle
Atlanta	1.89/0.20	0/0/100	Box-Beam	Concrete	3ϕ 600 VAC, 60Hz	13/HPG	Level	None (Below Grade)
Busch Gardens	1.33/0	40/60/0	I-Beam	Concrete, Steel	3ϕ 600 VAC, 60Hz	None/TT	10	None
Disneyworld	0.87/0	100/0/0	Y-Shape	Concrete, Steel	3ϕ 240 VAC, 60Hz	2/RT	Level	None
Duke	0.11/0.23	20/45/35	U-Shape	Concrete	3ϕ 480 VAC, 60Hz	2/LDM	4	None
Fairlane	0.38/0.11	100/0/0	U-Shape	Concrete	3ϕ 480 VAC, 60Hz	2/SWA	2.5	Electric Heating Cables
Houston	1.48/0	0/0/100	Rail	Steel	3ϕ 240 VAC, 60Hz	None	Level	None (Below Grade)
King's Dominion	2.06/0	5/95/0	Box-Beam	Steel	3ϕ 440 VAC, 60Hz	1/HSS	8	None
Miami	0/0.26	100/0/0	I-Beam	Concrete, Steel	3ϕ 480 VAC, 60Hz	None	4	None
Minnesota Zoo	1.36/0	90/10/0	Box-Beam	Steel	3ϕ 440 VAC, 60Hz	1/HSS	3	Electric Heated Rails
Morgantown	0/4.30	60/40/0	U-Shape	Concrete, Steel	3ϕ 575 VAC, 60Hz	57/OBS	10	Heated Pipes
Orlando	0/0.74	100/0/0	I-Beam	Concrete, Steel	3ϕ 600 VAC, 60Hz	None	1	None
Pearl Ridge	0.23/0	90/10/0	Box-Beam	Steel	1ϕ 480 VAC, 60Hz	None	4.5	None
Sea-Tac	1.71/0	0/0/100	Box-Beam	Concrete	3ϕ 600 VAC, 60Hz	None/TT	4.5	None (Below Grade)
Tampa	0/0.68	100/0/0	I-Beam	Concrete, Steel	3ϕ 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

APPENDIX C

STATION CHARACTERISTICS

System	Number of Stations On-Line/Off-Line	Number of Stations Elevated/At Grade/ Below Grade	Type of Construction	Fare Collection	Elevators/ Escalators	Platform Configuration**
Airtrans*	4/10	1/13/0	5 Free Standing 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 Free-Standing	No	Yes/No	Dual Side Platforms
Disneyworld	1/0	1/0/0	Free Standing	Yes	No/Yes	Single Side Platform
Duke	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	9/0	0/0/9	Joint Use	No	Yes/Yes	Single Side Platform
King's Dominion	1/0	0/1/0	Free-Standing	Yes	No/No	Dual Side Platforms
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	Free Standing	Yes	Yes/No	Island and Single Side Platforms
Orlando	8/0	8/0/0	Joint Use	No	No/No	Island Platform
Pearl Ridge	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

*Only airline passenger stations shown, Airtrans has a total of 53 stations (including 25 utility, 14 employees)
**Dual indicates two platforms, one on each side

APPENDIX D

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)	Vehicle Suspension	Vehicle Steering	Vehicle Propulsion	Vehicle Control
Airtrans	51	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	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 trains)	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	RTDC, SPDR	SGW	DCTM	PF, FB
Houston	6(3 car trains)	12.0/5.8/8.0	N/A	18/18*	15/6	SWOS, SPDR	SGW	SLIM	VF, FB
King's Dominion	6(9 car trains)	14.0/6.0/7.4	18,700/31,500	96/0*	18/6	RTOS, SPMR	SGW	DCTM	VF, FB
Miami	4	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 trains)	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
Pearl Ridge	1(4 car trains)	60.0/6.7/8.5*	29,200/40,800*	32/32*	8/7	RTOC, SPDR	CGB	DCTM	PF, FB
Sea-Tac	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

Sterring (All Have Rubber Guide Wheel)

- CGB - Center Guide Beam
- RGW - Rubber Guide Wheel
- SGW - Side Guidance Surface
- SWF - Side Wall Follower/On-Board Switch

*Train