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Systems Operation Studies for Automated Guideway Transit Systems: Classification and Definition of AGT (Automated Guideway Transit) Systems

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16. Abstract

In order to examine specific Automated Guideway Transit (AGT) developments and concepts--and to build a better knowledge base for future decision-making--UMTA has undertaken a new program of studies and technology investigations called UMTA Automated Guideway Transit Technology Program. The objective of one segment of this program, the Systems Operation Studies (SOS), is to develop models for the analysis of system operations, to evaluate performance and cost, and to establish guidelines for the design and operation of AGT systems.

This final report documents the results of the System Definition Task. The report describes the development of an AGT classification structure. Five classes are defined based on three system characteristics: service type, minimum travelling unit capacity, and maximum operating velocity. The five classes defined are: Personal Rapid Transit (PRT); Small Vehicle Group Rapid Transit (SGRT); Intermediate Vehicle GRT (IGRT); Large Vehicle GRT (LGRT); and Automated Rail Transit (ART). All classes except LGRT and ART are further stratified on the basis of speed, resulting in a total of eight subclasses. Forty-four existing and proposed AGT systems are summarized and used to define ten representative systems in terms of nominal values and ranges of selected characteristics. A summary of the system information compiled and used to complete this task is presented in Appendix A of this report. This report also provides a bibliography, list of text references, and a glossary of terms.

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Indexing
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Personal Rapid Transit
Automated Rail Transit
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PREFACE

In order to examine specific Automated Guideway Transit (AGT) developments and concepts—and to build a better knowledge base for future decision-making—the Urban Mass Transportation Administration (UMTA) has undertaken a new program of studies and technology investigations called the UMTA Automated Guideway Transit Technology (AGTT) program. The objectives of one segment of the AGTT program, the Systems Operation Studies (SOS), is to develop models for the analysis of system operations, to evaluate performance and cost, and to establish guidelines for the design and operation of AGT systems. A team headed by GM Transportation Systems Division (GM TSD) has been awarded a contract by the Transportation Systems Center to pursue these objectives.

This final report was prepared by GM TSD to document the results of the System Definition Task. The report describes the development of a classification structure, definition and description of each class, classification of 44 existing and proposed systems, definition of representative systems, and identification of the ranges of system variables represented by the surveyed systems. A summary of the system information compiled and used to complete this task is presented in Appendix A.

The work reported here was completed under the direction of the SOS Program Manager at GM TSD, James F. Thompson. The research for this report was performed by Femia S. A. Alberts. Gary C. Sullo developed the Feeder System representation and characteristics for this document. Ronald A. Lee was responsible for the coordination and completion of this report.

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

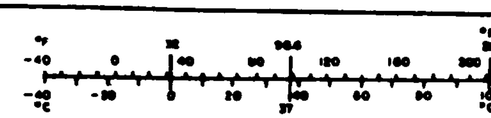


TABLE OF CONTENTS

Section	Title	Page
1.0	INTRODUCTION	1
	1.1 Objective	1
	1.2 Scope	1
2.0	SYSTEM CLASSIFICATION	2
	2.1 Classification Parameters	2
	2.2 Classification Structure	6
	2.3 Comparison With OTA Classes	9
3.0	CHARACTERISTICS OF AGT SYSTEMS	19
	3.1 Automated Systems	19
	3.2 The Feeder System	19
	3.2.1 Feeder System Representation	19
	3.2.2 Feeder System Characteristics	23
4.0	REPRESENTATIVE AGT SYSTEMS	30
	TEXT REFERENCES	43
	BIBLIOGRAPHY	44
	GLOSSARY	48
	APPENDIX A - OBSERVED SYSTEM CHARACTERISTICS	A-1
	APPENDIX B - REPORT OF INVENTIONS	B-1

LIST OF ILLUSTRATIONS

Figure	Title	Page
2-1	Histogram of Capacities	4
2-2	Histogram of Velocities	5
2-3	Unit Capacity versus Headway	7
2-4	Initial Classification Structure	8
2-5	Final Classification Structure	10
2-6	Popular Terms versus Structure	12

LIST OF TABLES

Table	Title	Page
2-1	GM TSD Classification Structure	11
2-2	Classification of Existing and Proposed Systems	
	A. Personal Rapid Transit (PRT)	13
	B. Small Vehicle GRT (SGRT)	14
	C. Intermediate Vehicle GRT (IGRT)	15
	D. Large Vehicle GRT (LGRT)	16
	E. Automated Rail Transit (ART)	16
2-3	OTA Classification Structure	17
3-1	System Characteristics for AGT Systems Data Collection	20
3-2	Feeder Model Applications	23
3-3	Feeder System Parameters and Measures	24
3-4	Fixed Route Characteristic Data	25
3-5	Demand-Responsive Characteristic Data	27
3-6	Bus Transit Capital Costs	28
3-7	Bus Transit Operational Cost Estimations	28
3-8	Bus Transit Cost Categories	29
4-1	Nominal Representative System Characteristics	32
4-2	Range of Parameter and Strategy Variation	40
4-3	Alternative Operational Control and Dispatch Policies	42

LIST OF ACRONYMS

AGRT	Advanced GRT
AGT	Automated Guideway Transit
AGTT	Automated Guideway Transit Technology
ART	Automated Rail Transit
DMT	Dual Mode Transit
FIFO	First-in, First-out
GM DMTS	General Motors Dual Mode Transit System
GM TSD	General Motors Transportation Systems Division
GRT	Group Rapid Transit
IGRT	Intermediate Vehicle GRT
LGRT	Large Vehicle GRT
LGT	Light Guideway Transit
MC-AGT	Medium Capacity Automated Guideway Transit
MRT	Mass Rapid Transit
MTBF	Mean Time Between Failures
OTA	Office of Technology Assessment (U.S. Congress)
PRT	Personal Rapid Transit
RRT	Rapid Rail Transit
SGRT	Small Vehicle GRT
SLT	Shuttle Loop Transit
SOS	Systems Operation Studies
TBD	To Be Determined

1.0 INTRODUCTION

A wide range of Automated Guideway Transit Technology (AGTT) has been proposed to serve a variety of applications ranging from low-speed people movers designed to operate on simple shuttles in activity centers, such as airport terminals; to high-speed line-haul mass transit systems designed to serve entire metropolitan areas.

1.1 OBJECTIVE

One of the initial tasks of the Systems Operation Studies (SOS) program is to develop a system classification structure based on the characteristics of AGT systems. A further objective of this initial System Definition Task is to identify the various configurations and combinations of subsystems and operational strategies defined by the variety of AGT systems which have been deployed or seriously proposed. A final objective of this task is to define the range of subsystem configurations and operational alternatives for each representative system which is to be analyzed in the Trade-Off and Comparative Analyses.

1.2 SCOPE

The report presents a system classification structure which has been developed based on consideration of the overall characteristics of existing and proposed AGT systems. The final structure, depicted in Table 2-1, includes five major classes and eight subclasses defined on the basis of service type, minimum traveling unit capacity, and maximum cruise speed. Each system class also implies a characteristic range of minimum headway.

Detailed descriptions of existing or proposed AGT systems representing each class are presented in tabular format to provide a systems data base to test the classification structure and to provide a basis for defining representative systems for detailed analysis in the SOS program. In addition, characteristics of bus transit systems which will be used to model feeder system alternatives are presented.

Finally, systems which represent each of the classes are defined in terms of ranges of design parameters and operating strategies.

2.0 SYSTEM CLASSIFICATION

The purpose of the system classification task is to define a structure within which systems can be identified for analysis. The goal of this task is to develop a classification structure which allows all existing and proposed AGT systems to be easily and unambiguously classified into a minimum set of distinct classes which emphasize major differences in the level of service provided and the general applicability of systems to various urban environments.

In this section a set of potential classification parameters are identified and evaluated for a number of AGT systems. A classification structure is then postulated and tested by classifying systems for which data have been tabulated. Finally, the classification structure is related to the structure defined by the United States Congress, Office of Technology Assessment (OTA).

2.1 CLASSIFICATION PARAMETERS

The system parameters which have been selected to define the classes were chosen from among five alternative system characteristics—service type, vehicle capacity, minimum train consist, vehicle velocity, and minimum headway. Service type distinguishes between point-to-point, nonstop service which is characteristic of PRT systems and intermediate-stop or multiple-stop service. In multiple-stop service passengers with destinations along a given route are grouped on one vehicle which makes intermediate stops along the route. This distinction represents a significant variation in service level; and, consequently, it has been selected as a classification parameter. It is recognized that systems which are designed to provide group transit service in peak periods may be configured to provide personal service during off-peak periods. However, this service parameter differentiates between systems which are primarily designed to provide point-to-point, nonstop service and those which are primarily designed to provide multiple-stop service.

Vehicle capacity provides an indication of the applicability of a system to cope with various demand situations and is also a measure of the degree of privacy afforded to individual passengers by a system. It also has some impact on the relative number of intermediate stops that passengers may expect before they reach their final destination. Since in most systems vehicle space is provided for both seated passengers and standees, the total passenger-carrying capacity of vehicles is of interest as a classification parameter. Two values of vehicle capacity are often reported. Nominal capacity (design load) is usually specified with respect to a minimum space allocation to seated and standing passengers. Crush load is a maximum vehicle capacity which is generally related to a structural or operational weight limit although it is sometimes defined in terms of maximum comfort criterion. Since vehicle capacity can be considered a measure of level of service as well as system capacity, nominal vehicle capacity is the more appropriate value for use in system classification.

Many systems permit vehicles to be operated in trains. In some cases, vehicles must be operated in trains of some minimum length. In those systems, the minimum number of cars per train (minimum train consist) affects the typical service capabilities and system capacity in much the same way that vehicle capacity does. For example, vehicles in the WEDway system as deployed at Disneyworld each accommodate six passengers. However, since they are operated in 5-car trains, the capacity of the minimum traveling unit is 30 passengers. To accurately reflect the service capabilities of systems, vehicle capacity and minimum train consist have been combined to form one classification parameter—minimum traveling unit capacity. This parameter is defined as the nominal capacity of the minimum train consist which for most systems is a single vehicle.

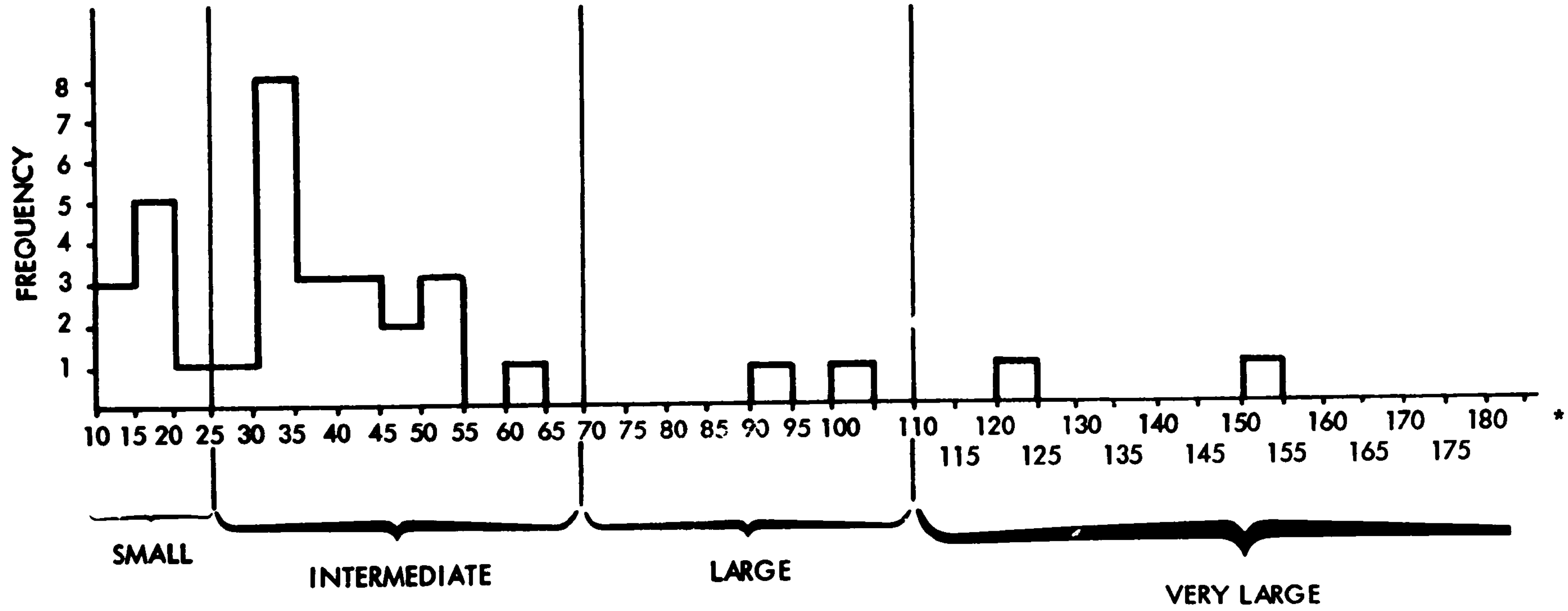
The characteristics of 44 existing and proposed AGT systems were surveyed to define the range and distribution of minimum traveling unit capacities. The minimum traveling unit capacity of the eight systems surveyed which are designed to provide non-stop service ranges from three to six passengers.

For systems which typically provide multiple-stop service, the capacities range from 10 to 416 passengers. The distribution of minimum traveling unit capacities is illustrated in Figure 2-1 which is the histogram of capacities based on a survey of 34 AGT system concepts. Based primarily on the histogram, four ranges of minimum traveling unit capacity were identified for the multiple-stop systems. Thus, five ranges of minimum traveling unit capacity have been identified for use in the system classification process as follows:

Very small	-	3 to 6 passengers
Small	-	10 to 24 passengers
Intermediate	-	25 to 69 passengers
Large	-	70 to 109 passengers
Very large	-	110 and greater

Vehicle velocity influences service level through its direct effect on travel time, especially for longer trips. Maximum speed capability also implies a range of applications for which a system may be suited. Maximum operating speed rather than cruise speed is used as a classification parameter because the former describes a system capability while the latter may refer to a network constraint or deployment option. The range of maximum operating speeds represented by the 44 AGT systems which were surveyed is from 13 km/h to 129 km/h. The distribution of these velocities is illustrated by the histograms presented in Figure 2-2. The histogram in the upper part of the figure shows the distribution of speeds for eight nonstop-type systems (personal transit). The histogram in the lower part of the figure summarizes the speed characteristics of 36 multiple-stop (group transit) systems. The distributions for the two categories of systems are not markedly different. As a result, two speed ranges, low speed and high speed, have been identified with the break point being 55 km/h.

The final potential classification parameter which was considered, minimum headway, is directly related to theoretical system capacity and is an indication of the level of control system complexity which a system requires. Minimum headway has been defined in two ways —theoretical minimum headway and practical minimum headway. Theoretical minimum headway is the shortest headway at which two vehicles can operate on a link, assuming there are no merges.



*Three systems beyond the range of this table, at 248, 340, and 416

FIGURE 2-1. HISTOGRAM OF CAPACITIES

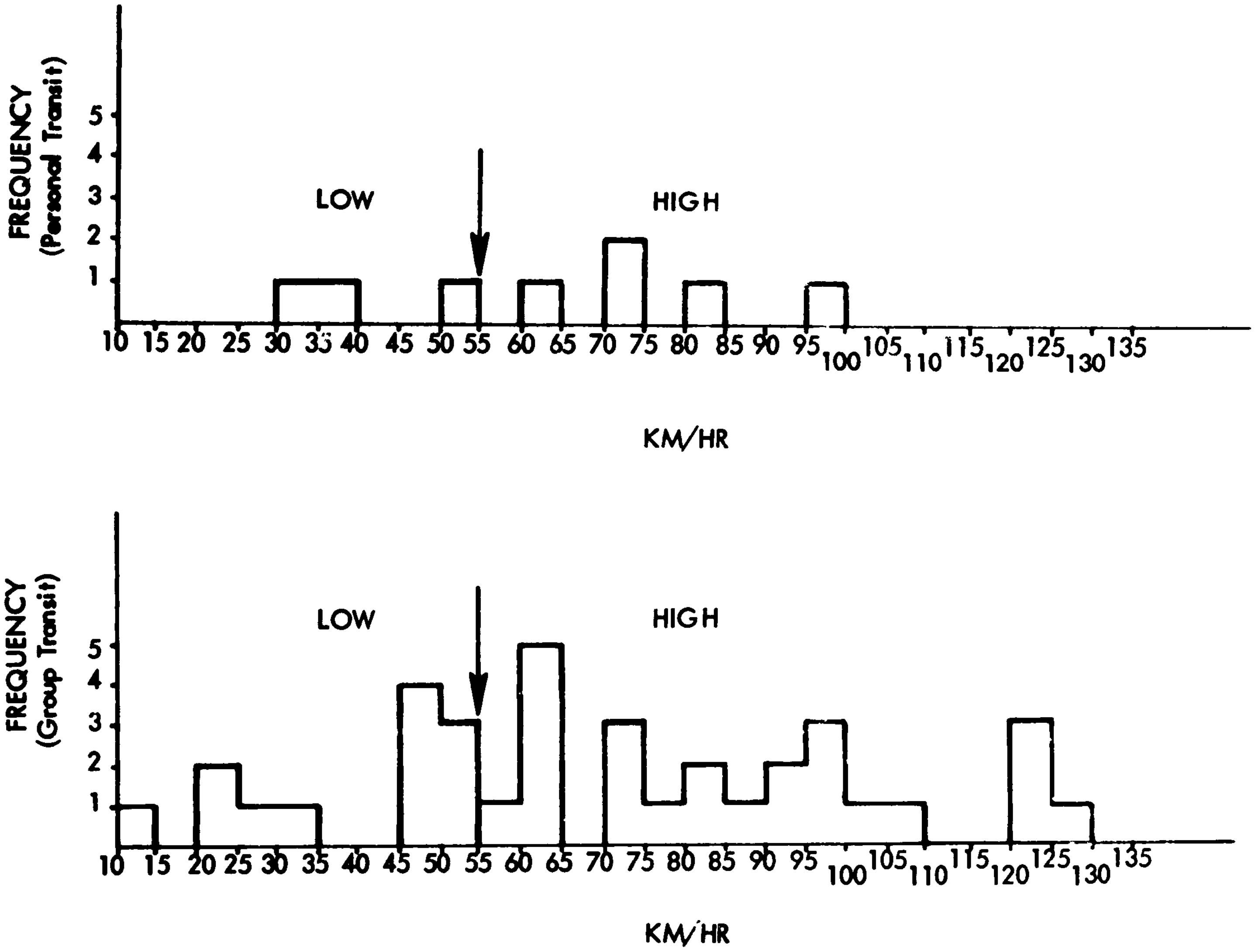


FIGURE 2-2. HISTOGRAM OF VELOCITIES

Practical minimum headway represents the minimum headway at which vehicles can operate under normal conditions on a network. Practical minimum headway appears to be a better measure of system service and applicability than the theoretical minimum headway. Therefore, whenever both values were given in the literature, the former was recorded. To evaluate the usefulness of minimum practical headway as a separate classification parameter, the correlation between minimum headway and minimum traveling unit capacity was investigated for the 44 systems that were surveyed.

Figure 2-3, minimum traveling unit capacity versus minimum (practical) headway, shows that each range of unit capacity has a characteristic, though not exclusive, range of headway. The ranges of headways overlap; but in general, they tend to increase as the traveling unit capacity increases. Systems having smaller vehicles tend to require more complex control systems; and as vehicle size increases, the requirement of sophisticated control technology to support short headways is relaxed. The correlation between these parameters is sufficient to suggest that they should not be used together to define classes. Therefore, headway is not used as an independent classification parameter, but its characteristic value will help to describe the various classes which are defined.

In summary, three parameters have been selected for use in defining a classification structure for AGT: service type, minimum traveling unit capacity, and maximum operating velocity. The next section of the report describes the rationale leading to the final classification structure.

2.2 CLASSIFICATION STRUCTURE

The hierarchical classification structure depicted in Figure 2-4 was developed through an ordered consideration of the three classification parameters. The highest level classification is on the basis of the type of service provided: non-stop or multiple-stop service. In effect, the use of service type as the fundamental classification parameter distinguishes between personal and group transit systems. The second level in the hierarchy is a classification by minimum traveling unit capacity. The final subdivision is on the basis of maximum operating velocity.

A survey of the characteristics of existing and proposed AGT systems indicates that not all possible combinations of the classification parameters result in realistic classes. Only one system was identified which falls into the high speed, large vehicle, group transit class. That system, Paratran 1, is a system which is currently under development in Japan. It operates with two-car trains having a total capacity of 80 passengers (near the lower limit of large vehicle systems) and has a maximum speed capability of 60 km/h (just marginally greater than the 55 km/h limit for high-speed systems). Since the class is not well represented by AGT systems, it will be deleted as a class. Systems having very large traveling unit capacities, such as BART and WMATA, are all capable of speeds in excess of 55 km/h, and have in the past been grouped under the name Automated Rail Transit (ART).

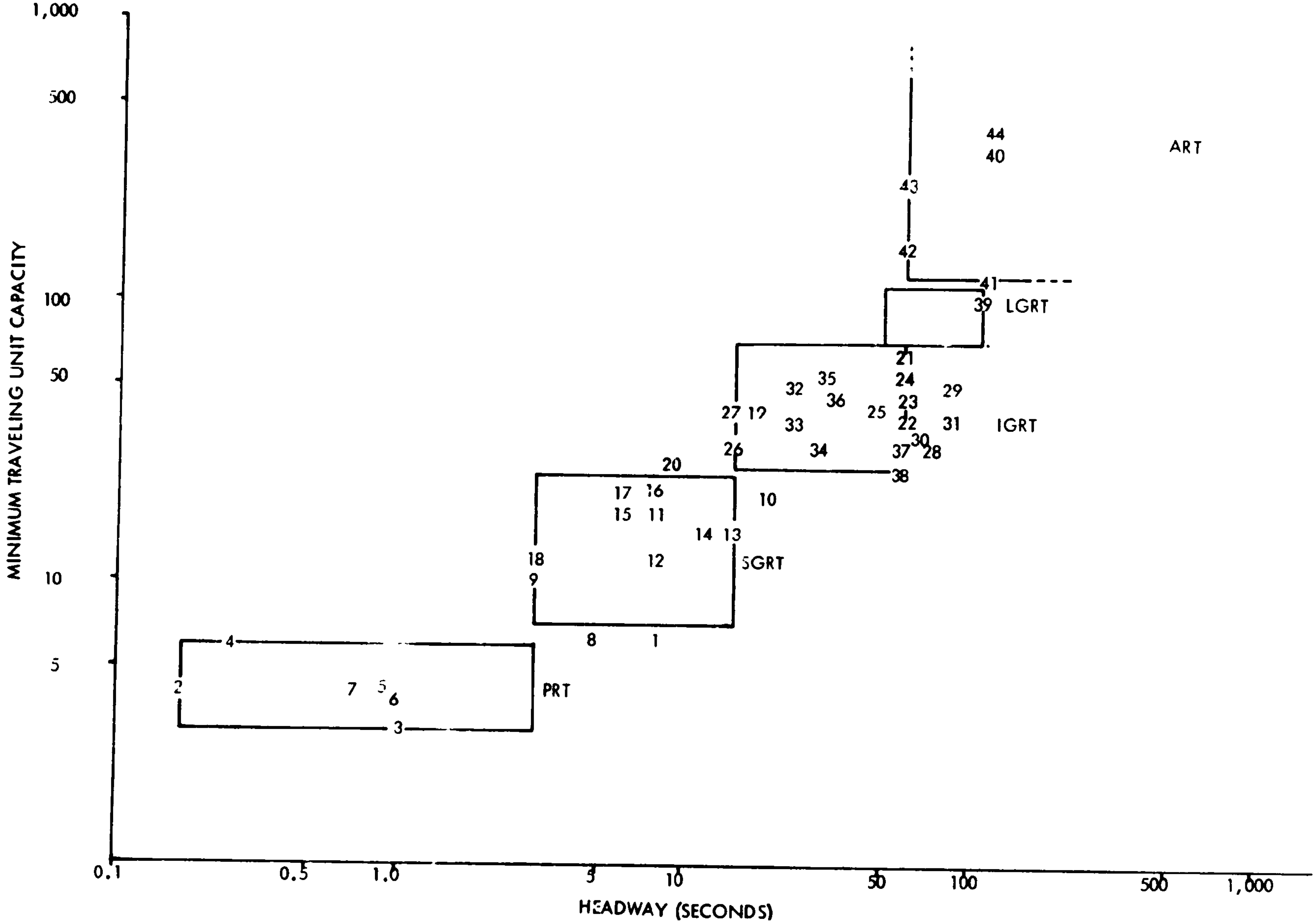


FIGURE 2-3. UNIT CAPACITY VS. HEADWAY

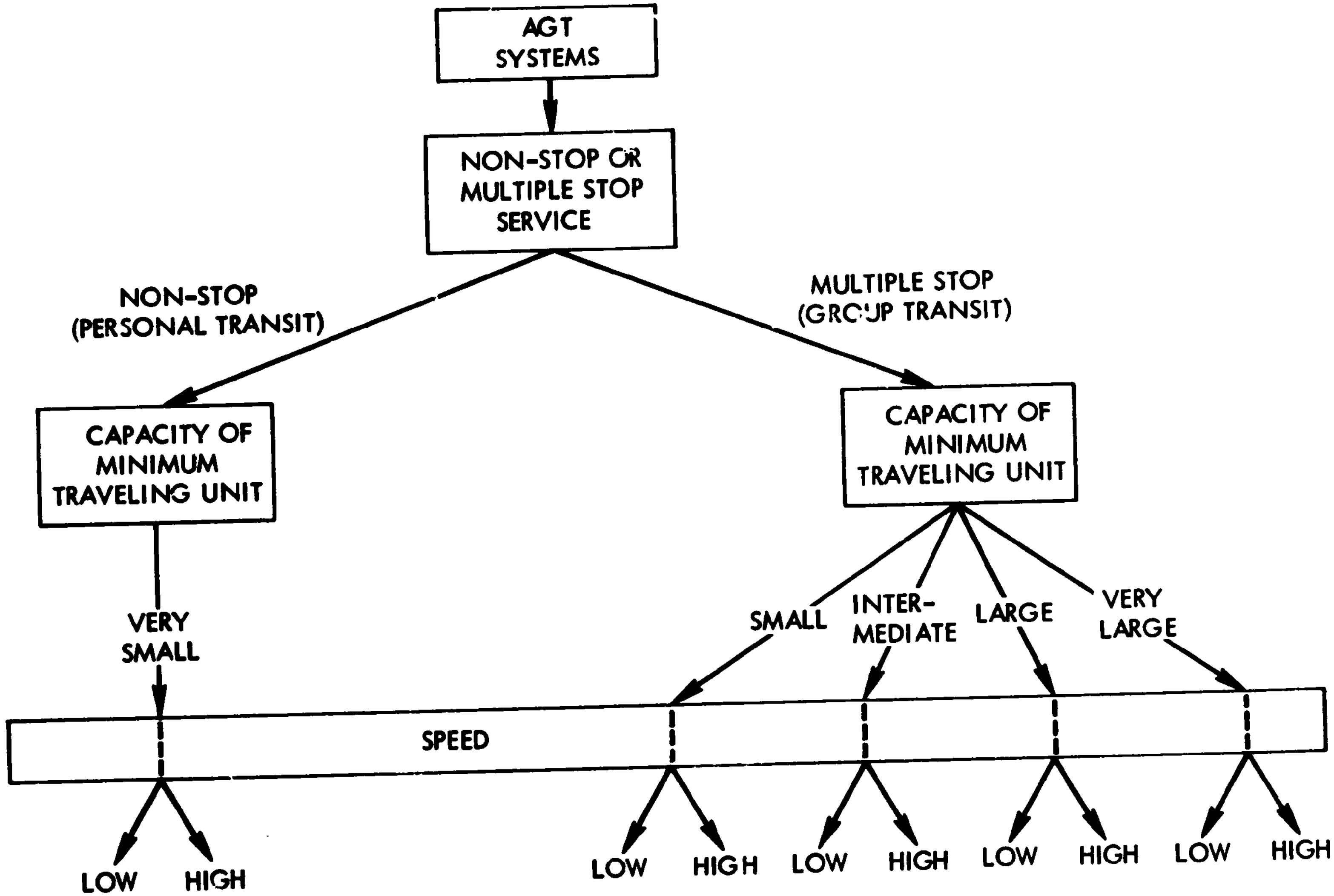


FIGURE 2-4. INITIAL CLASSIFICATION STRUCTURE

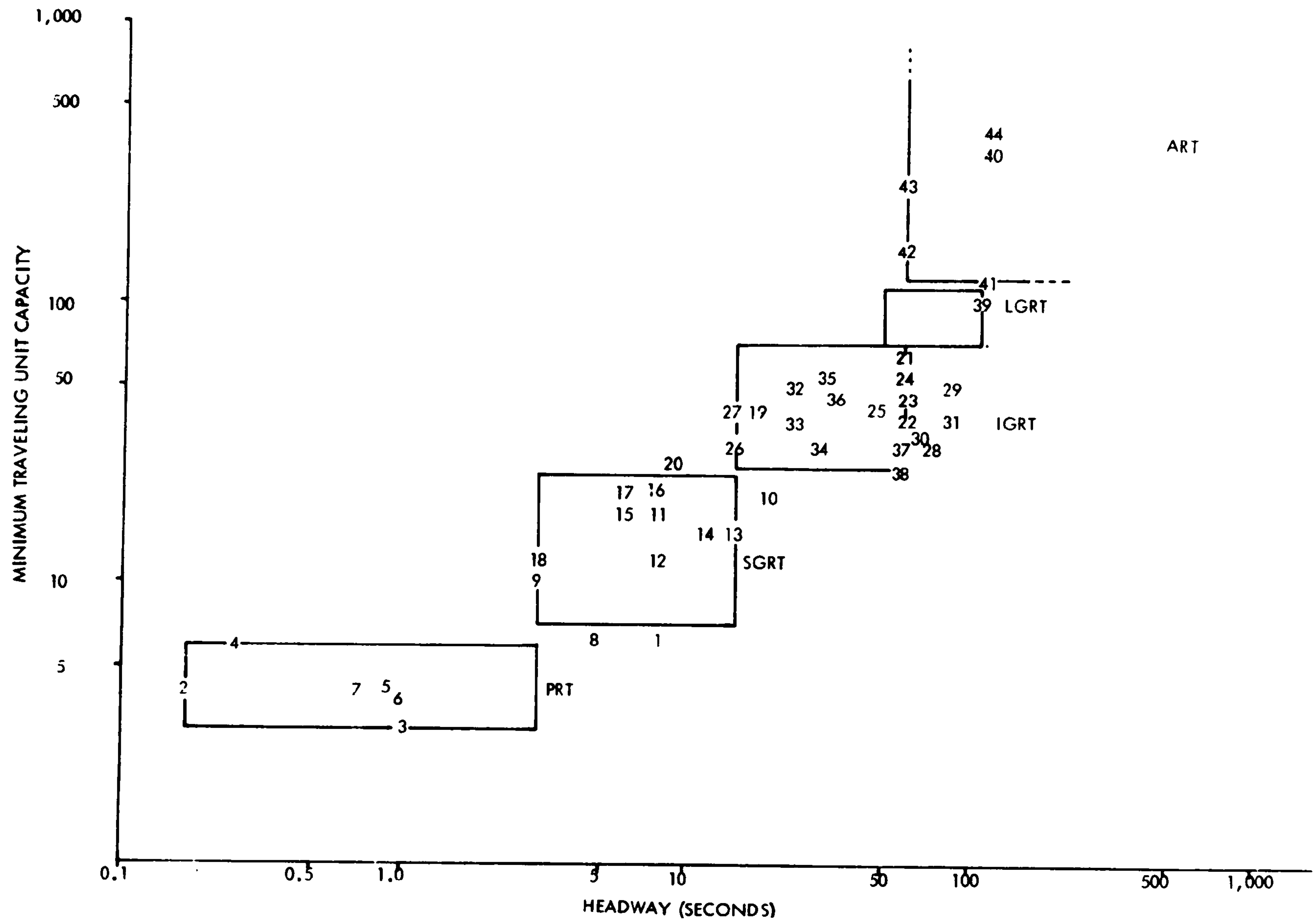


FIGURE 2-3. UNIT CAPACITY VS. HEADWAY

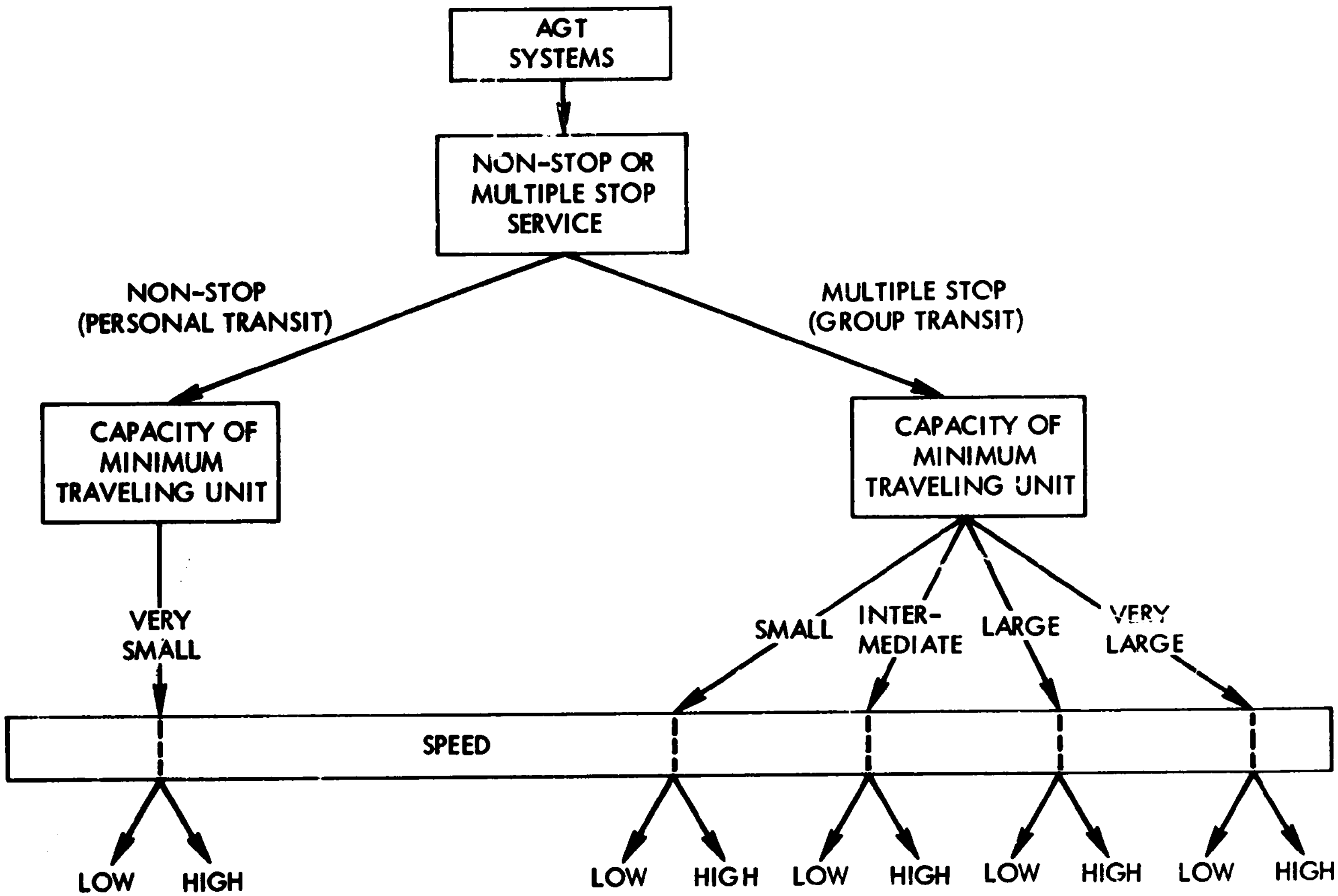


FIGURE 2-4. INITIAL CLASSIFICATION STRUCTURE

The final classification structure is illustrated in Figure 2-5. Automated Guideway Transit is divided into two main categories--personal transit and group transit--on the basis of the type of service provided (nonstop or multiple-stop). Three major categories are 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 (SGRT), Intermediate Vehicle GRT (IGRT), and Large Vehicle GRT (LGRT). The resulting five classes are further divided as appropriate into eight subclasses on the basis of maximum operating velocity. Formal definitions of the subclasses are presented in Table 2-1.

To help clarify the relationship between the classification structure presented in this report and the terminology commonly used to denote AGT systems, commonly used acronyms are associated with the appropriate subclasses in Figure 2-6. Many of the terms in general use today are so broad that the systems they denote can be considered to be members of several subclasses. The figure shows that systems commonly referred to as Shuttle-Loop Transit (SLT) can be classified as low-speed GRT systems while Dual Mode Transit (DMT) systems are members of the high-speed Small Vehicle GRT (SGRT) subclass.

A primary objective of the classification structure is to permit the logical classification of any AGT system using system information which is likely to be readily available. To test the applicability of the final structure, the characteristics of 44 existing and proposed AGT Systems, as reported in the literature, were compiled and used to classify each system. Table 2-2 displays the results of this data compilation and system classification process. In every case where sufficient information was available, it was possible to place each system into a single AGT system subclass.

2.3 COMPARISON WITH OTA CLASSES

In 1975, the United States Congress, Office of Technology Assessment (OTA) published an assessment of AGT systems.[1] The report includes one of the first documented attempts at classifying AGT systems. The OTA classification structure, which is briefly defined in Table 2-3 has become, in some respects, a standard for the industry. Therefore, it is important to note that, except for the omission of Shuttle-Loop Transit (SLT) as a system class, the classification structure described in this report essentially parallels the OTA classification and provides a more rigorous definition of the OTA classes.

One of the guidelines followed in generating the classification structure was to separate network and deployment constraints from inherent system characteristics. According to the OTA definition, SLT systems require the simplest technology and utilize few if any operational switches. Although some systems employ relatively slow guideway active switching techniques, nearly all systems that have been examined to date are capable of some degree of operational switching; and most of them could be deployed on a limited grid network with relatively minor modifications. Obviously, systems designed for operation on grid networks could be deployed on shuttle or loop

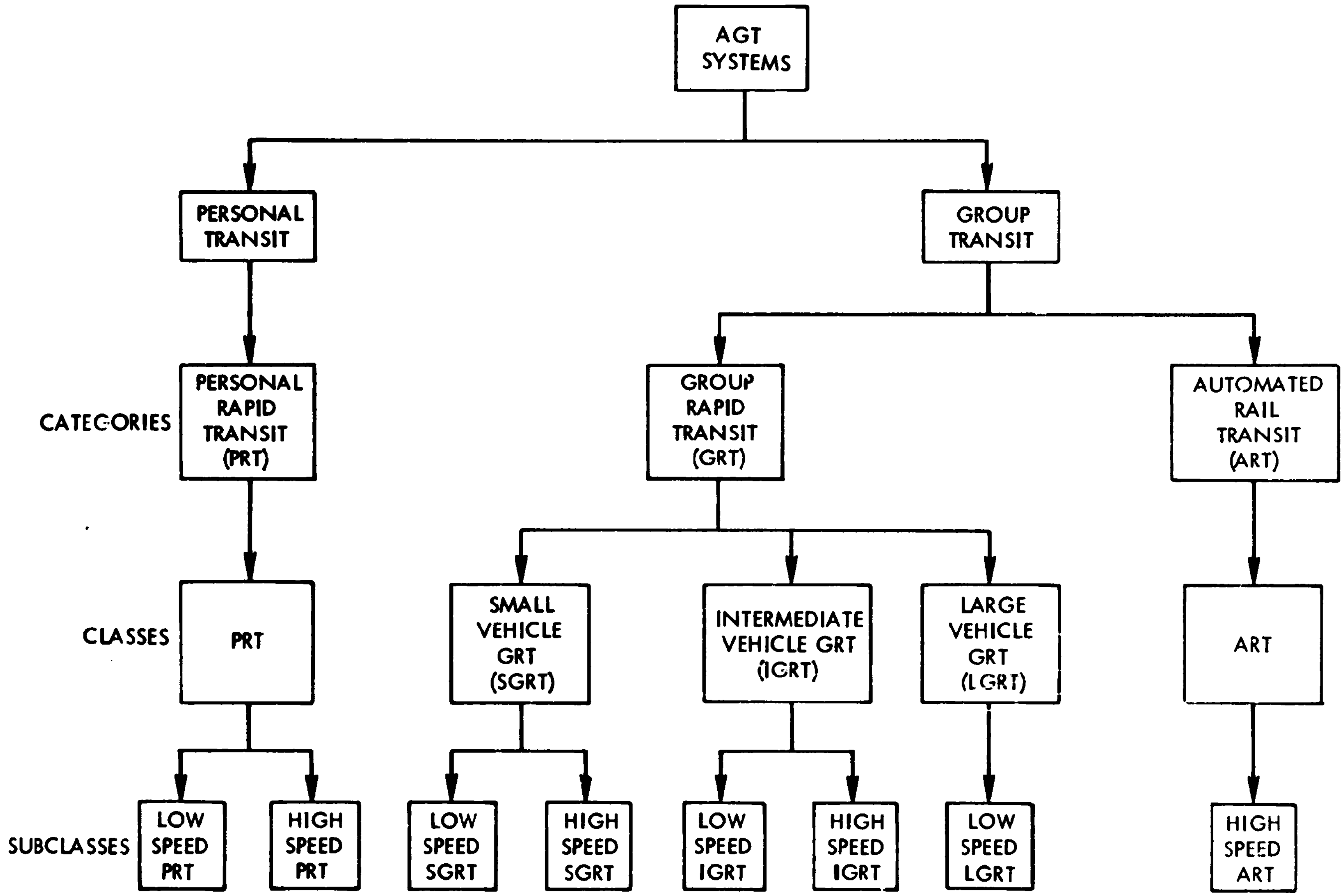


FIGURE 2-5. FINAL CLASSIFICATION STRUCTURE

TABLE 2-1. GM TSD CLASSIFICATION STRUCTURE

Category	Class	Subclass	Service Type	Minimum Traveling Unit Capacity (Passengers)	Maximum Operating Speed (km/hr)	Characteristic Minimum Headway (s)
PRT	PRT	low speed	non-stop	3-6	13-54	3 or less
		high speed	non-stop	3-6	55+	3 or less
GRT	SGRT	low speed	multiple-stop	7-24	13-54	3-15
		high speed	multiple-stop	7-24	55+	3-15
	IGRT	low speed	multiple-stop	25-69	13-54	15-60
		high speed	multiple-stop	25-69	55+	15-90
	LGRT		multiple-stop	70-109	13-54	50-109
ART	ART		multiple-stop	110+	55+	60+

Legend:

PRT - Personal Rapid Transit
GRT - Group Rapid Transit
SGRT - Small Vehicle GRT
IGRT - Intermediate Vehicle GRT
LGRT - Large Vehicle GRT
ART - Automated Rail Transit

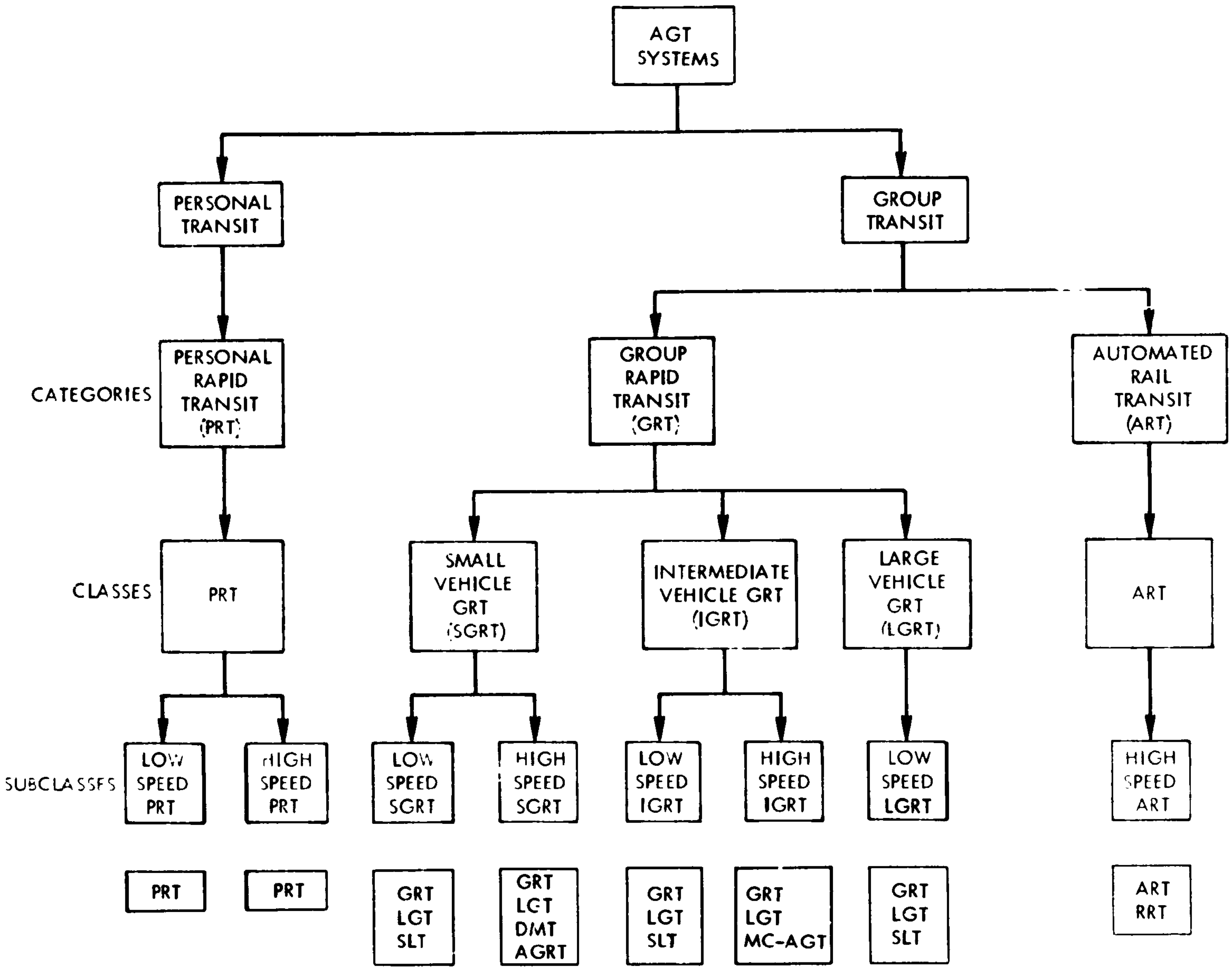


FIGURE 2-6. POPULAR TERMS VS. STRUCTURE

TABLE 2-2A. CLASSIFICATION OF EXISTING AND PROPOSED SYSTEMS - PERSONAL RAPID TRANSIT (PRI

SYSTEM	VEHICLE CAPACITY		TRAVELING UNIT	MINIMUM TRAVELING UNIT CAPACITY	VEHICLE VELOCITY (KM/H)	MINIMUM HEADWAY (SEC)
	SEATED	STANDING				
LOW SPEED						
1. Aerial Transit System	6	0	Single	6	32	8.0
2. Aramis	4	0	Single, up to 40/Platoon	4	50	60 between 0.17 within
3. Cabinentaxi	3	0	Single	3	36	1.0
HIGH SPEED						
4. Aerospace	6	0	Single	6	97	0.25
5. Cabtrack	4	0	Single	4	72	0.9
6. CVS	4	0	1-10 Veh.	4	80	0.95
7. Elan-Sig	4	0	Single	4	64	0.7
8. Monocab	6	0	Single	6	72	5.0

TABLE 2-2B. CLASSIFICATION OF EXISTING AND PROPOSED SYSTEMS - SMALL VEHICLE GRT (SGRT)

SYSTEM	VEHICLE CAPACITY		TRAVELING UNIT	MINIMUM TRAVELING UNIT CAPACITY	VEHICLE VELOCITY (KM/H)	MINIMUM HEADWAY (SEC)
	SEATED	STANDING				
LOW SPEED						
9. Alden StaRRcar	6-10	14-0	Single	10	48	3
10. Ford ACT	10	14	1-3 Veh.	24	48	20
11. H-Bahn	8	9	1-2 Veh.	17	50	8
12. Minitram	6	6	1-3 Veh.	12	54	10
13. Morgantown	8	7	Single	15	48 (operational)	15
HIGH SPEED						
14. GEC Minitram	6	9	1-3 Veh.	15	90	12
15. GM DMTS	17	0	Single	17	90	6
16. Rohr Dual Mode	21	0	Single	21	104	7-8
17. TTD/Otis Dual Mode	17	0	Single	17	80	6
18. UMTA AGRT	12	0	Single	12	64	3

TABLE 2-2C. CLASSIFICATION OF EXISTING AND PROPOSED SYSTEMS - INTERMEDIATE VEHICLE GRT (IGRT)

SYSTEM	VEHICLE CAPACITY		TRAVELING UNIT	MINIMUM TRAVELING UNIT CAPACITY	VEHICLE VELOCITY (KM/H)	MINIMUM HEADWAY (SEC)
	SEATED	STANDING				
LOW SPEED						
19. Airtrans	16	24	1-2 Veh.	40	31	18
20. KRT - 100	10	15	1-3 Veh.	25	50	9
21. Rohr "J" Series	60*	0	Trains	60	24	60
22. Rohr "K" Series	36 or 60*	0	Trains	36	48	60
23. Rohr "M" Series	0-30	72-15	1-4 Veh.	45	48	60
24. Rohr "P" Series	8	10	3-9 Veh.	54	13	60
25. Unimobile, Type II	14	6	2-10 Veh.	40	29	45
26. WEDway People Mover	6	0	5 Veh.	30	22	14
HIGH SPEED						
27. Dashaveyor, Family I	12-40	60-0	1-4 Veh.	40	64	15
28. KCV	16-24	14-26	1-6 Veh.	30	75	75
29. Kompactbahn	24	24	1-5 Veh.	48	70	90
30. MAT	16	16	1-8 Veh.	32	60	75
31. Mini-Monorail	4,8	9,17	2-12 Veh.	38	60	90
32. NTS	24	26	1-6 Veh.	50	60	25
33. Project 21 RTS	22	15	1-4 Veh.	37	89	25
34. Transurban	14	16	1-5 Veh.	30	80-120	30
35. Tridim Aerotrain	36	16	1 or more	52	105	19
36. Unimobil, Transporter	10-20	24-14	1-5 Veh.	34	56	45
37. URBA 30	30	0	1-8 Veh.	30	70	60
38. VONA	11	14	1-12 Veh.	25	72	60

* Train Capacity

TABLE 2-2D. CLASSIFICATION OF EXISTING AND PROPOSED SYSTEMS - LARGE VEHICLE GRT (LGRT)

SYSTEM	VEHICLE CAPACITY		TRAVELING UNIT	MINIMUM TRAVELING UNIT CAPACITY	VEHICLE VELOCITY (KM/H)	MINIMUM HEADWAY (SEC)
	SEATED	STANDING				
39. Westinghouse	0-12	100-90	1-2 Veh.	100	48 (operational)	70-150*

* Derived from the four Westinghouse Systems.

TABLE 2-2E. CLASSIFICATION OF EXISTING AND PROPOSED SYSTEMS - AUTOMATED RAIL TRANSIT (ART)

40. BART	72	98	2-10 Veh.	340	129	120
41. Lindenwold	72	48	1-6 Veh.	120	120	120
42. Rohr "N" Series	72 & 78	0	Married Pairs	150	80	60
43. VAL	44 or 68	116 or 56	2 or 4 Veh.	248	80	60
44. WMATA	80	128	2-8 Veh.	416	120	120

TABLE 2-3. OTA CLASSIFICATION STRUCTURE

SLT - SHUTTLE LOOP TRANSIT

- Simplest Technology
- Vehicle Size Varies
- Little or No Switching
- Long Headways - 60 s or More
- Speeds from 13 to 48 km/h

GRT - GROUP RAPID TRANSIT

- Usually 10 to 50 Riders
- Switching to Shorten En-Route Delays
- Intermediate Headways - 3 to 60 s
- Can Operate in Trains

PRT - PERSONAL RAPID TRANSIT

- One to Six Riders
- No En-Route Delays or Transfers
- Short Headway - Less than 3 s

SOURCE: U. S. Congress, Office of Technology Assessment, Automated Guideway Transit, An Assessment of PRT and Other New Systems, June 1975 networks which do not require sophisticated control technology. Therefore, the amount of switching required of a system is more dependent on network configuration than on inherent system capability.

Since any of the systems represented by the classes defined in Table 2-1 could be deployed in a shuttle-loop network, a separate class for SLT systems is not provided in the structure. However, the Application Area Definition report[2] defines eleven SLT deployment scenarios which will be analyzed in detail in the Systems Operation Studies Program. These scenarios include various shuttle and loop deployments of GRT systems in CBD, university, and airport demand environments.

3.0 CHARACTERISTICS OF AGT SYSTEMS

In this section, relevant characteristics for a number of AGT systems in each of the eight subclasses are identified. In addition, the particular characteristics of feeder systems which are necessary to model this aspect of transit system operations are identified and evaluated for several fixed-route/fixed-schedule and dial-a-ride systems.

3.1 AUTOMATED SYSTEMS

An extensive literature search and direct contact with various agencies and organizations has resulted in the acquisition of a substantial set of data on AGT systems. Evaluation of this data set coupled with the future needs of the analyses to be performed within the SOS program, has led to the generation of a list of system characteristics which describe AGT systems (see Table 3-1). Appendix A contains the raw data collected during the literature search and personal contacts. Several trips were made to interview transportation systems planners, operators, and manufacturers; and a summary of the information obtained by these contacts is recorded in the Data Collection Trip Reports document.[10]

The set of characteristics for which data have been recorded includes items for which no direct analytical use is expected, but they are included in the interest of completeness. However, many items considered to be necessary for the planned analyses were not available from the literature or from our Contacts. Finally, since many of the systems are defined only in the context of a specific deployment, some of the data compiled is more closely associated with specific application needs than with general system capabilities. Therefore, in several areas, particularly cost and reliability, the collected information must be analyzed and supplemented with data from other sources to yield the input data required to perform system analyses.

3.2 THE FEEDER SYSTEM

3.2.1 Feeder System Representation

Feeder service is represented as a support system to the primary automated guideway transit network. It provides the means for direct comparison of alternate automated transit system concepts deployed against the same demand models.

TABLE 3-1. (SHEET 1 of 3) SYSTEM CHARACTERISTICS FOR AGT SYSTEMS DATA COLLECTION

System Name

Developer

Deployment Status

Vehicle Characteristics
- No. of Seats Per Vehicle
- Design Load Per Vehicle
- Crush Load Per Vehicle
- Vehicle Length
- Vehicle Width
- Vehicle Height
- Interior Area Per Seated Passenger
- Interior Area Per Standing Passenger
- Empty Vehicle Weight
- Load/Unload Rate Per Door
- Door Width
- Number of Doors Per Vehicle
- Guideway Interface
- Lateral Control Interface
- Switching Mechanism
- Switch Actuation Time
- Minimum Turning Radius
- Coupler
- Minimum Traveling Unit
- Maximum Train Consist
- "A" and "B" Vehicles
- Platooning Capability
- Propulsion Type
- Power Rating Per Unit
- Number of Propulsion Units
- Acceleration
- Cruise Speed
- Maximum Speed
- Service Brake Type
- Service Deceleration
- Emergency Brake Type
- Emergency Deceleration
- Emergency Brake Reaction Time
- Maximum Grade Capability
- Reverse Capability (Bi-Directionality)
- Precision Stopping Tolerance
- Exterior Noise
- Energy Consumption (Acceleration, Decel., Cruise)
- Emissions

Typical Network Configuration

Maximum Grade

Guideway Type

Guideway Dimensions
- Outside Width
- Height
- Running Surface Width
- Elevated Span Length

Construction Material

Weather Protection (Snow/Ice)

Power Distribution
- AC or DC
- Voltage
- Number of Substations Per Lane Kilometer

Lateral Control Equipment

Switching Equipment

Station Configuration
- Number of Parallel Platforms
- Number of Berthing Lanes
- Length of Platform
- Berth Configuration
- Number of Berths Per Platform
- Capacity of Vehicle Queues
- Empty Vehicle Storage Capacity
- Average Vehicle Dwell Time
- Vehicle Throughput (Vehicles Per Hour)
- Turnaround Capability

TABLE 3-1. (SHEET 2 of 3) SYSTEM CHARACTERISTICS FOR AGT SYSTEMS DATA COLLECTION

- Station Configuration (continued)
  - Off-Line Acceleration/Deceleration Lane Length
  - Operational Control Strategy
  - Dispatch Policy
- Headway Protection
  - Fixed Block
    - Block Lengths
    - No. of Blocks Between Vehicles
  - Moving Block
    - Communication Sample Rate
- Merge Strategy
- Minimum Headway
- Merge Throughput
- Service Policy
- Service Goals
- Routing Strategy
- Empty Vehicle Management
- Station Management
  - Separate vs Common Board/Deboard
  - Ripple vs Platoon Movement
- Fleet Management
  - Total Fleet
  - Peak Operating Fleet
  - Base Operating Fleet
- Failure Management
  - Push/Pull Capability
  - Emergency Equip. & Crew Location
  - Redundant Prop. or G'way Power
  - Redundant Local Control
  - Redundant Vehicle Electronics
- Mean Time Between Failures
  - System
  - Vehicle
  - Guideway
  - Station
  - Central Control
- Mean Time to Restore Service
  - System
  - Vehicle
  - Guideway
  - Station
  - Central Control
- System Availability Number
- Availability Definition
- System Responses to Failures
- System Capital Cost
  - Vehicle Cost
    - Expected Life
    - System Fleet Size
  - Guideway Cost
    - Expected Life
    - System Lane Kilometers
  - Power Distribution Cost
    - Expected Life
  - Station Cost
    - Expected Life
    - Number of Stations
  - Maintenance and Storage Facilities
    - Expected Life
    - Number of Facilities
  - Communication and Controls
    - Expected Life
- System Operating Cost
  - Operating Hours/Day
  - Vehicle Kilometers/Day
  - Vehicle Hours/Day
- Energy Cost

TABLE 3-1. (SHEET 3 of 3) SYSTEM CHARACTERISTICS FOR AGT SYSTEMS DATA COLLECTION

Maintenance Cost
Vehicles
Stations
Facilities
Personnel Costs
Maintenance
Vehicle
Station
Facilities
Operations
Central Control
Stations
General
General and Administrative Costs

In the analysis of representative system deployments, the feeder system model is used as a tool in mapping zone-to-zone demand onto the automated guideway network at the stations. As explained in the report, Representative Application Areas for AGT,[2] the demand for both the activity center application areas is given in a station-to-station format, so application of the feeder system model is not required. The central business district deployments to be analyzed are considered to serve internal circulation trips where access to the AGT stations is assumed to be entirely via the walk mode. Thus, the definition and analysis of feeder system alternatives applies only to the metropolitan area deployments described in Reference 2. Table 3-2 summarizes the types of feeder service modeled in each of the representive application areas.

While the primary subsystems of automated transit operations are analyzed by identifying individual element dynamics or discrete events, the feeder system is modeled at a higher level, considering overall flow rates and regional characteristics. The feeder service parameters to be evaluated are those which are indicative of the ease of access and the level of performance offered to the remote passenger.

Two feeder system service types can be analyzed: fixed-route and demand-responsive. Fixed-route feeder service operates on predetermined routes and headways, and users of the feeder service are assumed to walk between the route and their ultimate origins and destinations. Demand-responsive service provides door-to-door service on routes generated from demand. Two types of demand-responsive service are available--dial-a-ride service or subscription service. Dial-a-ride service vehicles are dispatched or rerouted when a request or group of requests in an area is received. Consequently, users are subjected to a wait time which is defined as the time between their phoned trip request and the vehicle's arrival. In subscription service, demand is stratified into tour regions where the average wait time is thus half the time it takes the vehicle to make the "tour."

TABLE 3-2. FEEDER MODEL APPLICATIONS

Application Area	Feeder Service Models
Activity Centers - circulation - and line haul University	None
CBD - low demand CBD - high demand	Walk
Metro - high demand in Metro - high demand out Metro - high demand both	Combined service of: walk mode auto usage fixed route bus demand responsive bus

In dual mode systems the feeder function is integrated with the automated guideway line-haul function so that the need for passenger transfers between transit modes is minimized. To accomplish this in an efficient manner, it is necessary to aggregate passengers having similar destinations within each feeder bus service region. This may result in relatively less efficient off-guideway operation in dual-mode systems.

The separation of the on- and off-guideway operations of a dual mode system into independent models presents several modeling complexities since the transition of vehicles as well as passengers from one model to the other must be represented. These complexities have not yet been fully evaluated, but they do not appear to introduce insurmountable modeling difficulties.

3.2.2 Feeder System Characteristics

Characteristics identified as being necessary to represent a feeder system in terms of performance and accessibility are presented in Table 3-3. A distinction is made between parameters which are used in defining the feeder system to be represented, and measures which are the resultant operational characteristics that will be used for various analyses.

The characteristics identified as being either fixed route or demand responsive parameters, constitute the necessary information to be input into the feeder system model (for more detail, consult the functional specifications report[3]). They serve as a first order indication of the ease of access offered by a feeder system, and thus its convenience, which has been identified as a significant factor in transit usage.[4] Data pertaining to current bus transit operations and urban planning studies, as found in Tables 3-4 and 3-5, was used to determine the typical value ranges for the parameters reported in Table 3-3. These ranges are the bounds within which the feeder systems for each representative metropolitan area will be configured.

Feeder system time performance, used as a measure of effectiveness of the off-guideway portion of the interzonal travel[5], is represented in the model (as output) by deriving the statistics identified as performance measures in Table 3-3. Consistent with the level of resolution of the feeder system modeling, these statistics are presented as the average values for all applicable passenger demand over the specified time interval. Implicit in using these time measures as indicators of performance, is the assumption that individual bus capacities will not be exceeded. Standard 53-passenger coaches are considered adequate for fixed routes, while vehicles as small as 17-passenger buses are acceptable for demand responsive service in order to be consistent with the performance model used.[6]

To determine the cost of the required feeder service, characteristics indicative of the physical extent of the entire feeder system are needed. The utilization measures listed in Table 3-3 are those associated with the primary items of which bus transit costs are a function (time, distance, number of vehicles).[7] Drawing on, but not limited to, the cost and utilization data gathered in Tables 3-4 through 3-7, bus transit costs will be estimated by modeling the effects of mileage, hours, and fleet size in each of the categories listed in Table 3-8.

TABLE 3-3. FEEDER SYSTEM PARAMETERS AND MEASURES

Fixed Route Parameters	Value Ranges
Headway - peak	5-20 min.
Headway - base	7-60 min.
Route Spacing	1-3 miles
Velocity	5-15 mph
Demand Responsive Parameters	**Value Ranges**
Response Time	15-30 min.
Area of Service	1-11 sq. mi.
Velocity	9-21 mph
Performance Measures	
On-Vehicle Feeder Access Time	
Off-Vehicle Feeder Access Time	
On-Vehicle Feeder Egress Time	
Off-Vehicle Feeder Egress Time	
Utilization Measures	
Fleet Size (including spares)	
Annual Vehicle Mileage Traveled	
Annual Vehicle Hours Elapsed	

TABLE 3-4. FIXED-ROUTE CHARACTERISTIC DATA (1 of 2)

	Chicago	Manhattan & Bronx	Brooklyn	Philadelphia	San Francisco	Cleveland	Toronto	Montreal	Detroit
Headway - Peak	6 min.	6 min	7 min	--	--	14 min	6 min	5	8 min
Base	13 min.	8 min	7 min	--	--	32 min	15 min	18 min	22 min
Spacing	--	--	--	--	--	--	--	--	--
Velocity	8.81 mph	5.17 mph	7.96 mph	--	--	11.27 mph	12.06 mph	9.4 mph	13.11 mph
Fleet Size	2,653	2,040	2,854	1,462	22	702	1,166	1,905	1,024
Vehicle Miles	88,177,790	43,624,640	68,484,749	34,984,557	6,332,056	18,284,670	39,530,620	46,477,289	30,890,193
Vehicle Hours	10,005,957	8,434,565	8,604,614	--	--	1,623,201	3,278,884	5,027,475	2,356,175
Driver's Cost	$72.673 mill	$58.683 mill	$62.206 mill	$26.602 mill	$4.390 mill	$11.082 mill	$20.591 mill	$36.615 mill	$20.561 mill
Maintenance	$31.095 mill	$34.313 mill	$37.256 mill	$13.475 mill	--	$4.545 mill	$9.770 mill	--	$6.309 mill
Fuel, Oil, Etc.	$9.071 mill	$4.599 mill	$6.349 mill	$2.906 mill	$433,760	$1.648 mill	$2.159 mill	$4.326 mill	$2.894 mill
Administrative	$9.330 mill	$22.492 mill	$42.196 mill	$17.440 mill	--	--	--	--	$22.607 mil
Licensing	$16,058	--	--	$50,662	--	--	$285,596	$591,786	$4,016
Insurance	$11.049 mill	$4.301 mill	--	$4.570 mill	--	--	--	--	With Admin.
Advertising	0	$57,202	--	$431,166	--	--	--	--	With Admin.

SOURCE: APTA Annual Report, 1974

TABLE 3-4. FIXED-ROUTE CHARACTERISTIC DATA (2 of 2)

	Washington, D.C.[1]	Cincinnati[1]	Baltimore[1]	Houston[1]	Atlanta[1]	Detroit 1990 Plan[2]	Detroit SEMTA Study[3]	Boyd et al[4]	De Leuw Cather[5]
Headway - Peak	--	17 min	--	--	19 min	6 min	Urb. 15 min	--	--
Base	--	47 min	--	--	56 min	12 min	Sub. 30 min	--	--
Spacing	--	--	--	--	--	1-2 miles	1,2,3 miles	--	--
Velocity	--	12.46 mph	10.35 mph	13.35 mph	13.46 mph	Urb. 14 mph Sub. 21 mph	CBD Frng Sub Pk. 12 14 21 Bs. 13 15 21	--	--
Fleet Size	2,065	527	988	376	870	--	876	--	--
Vehicle Miles	46,288,944	10,410,905	25,734,974	13,358,458	22,738,821	--	36,146,845	29,400/ veh	--
Vehicle Hours	--	835,406	2,486,948	1,000742	1,829,983	--	2,831,757	--	--
Driver's Cost	$34.642 mill	$5.481 mill	$15.722 mill	$5.585 mill	$11.922 mill	--	$23.390 mill	--	$0.57/vm
Maintenance	$14.980 mill	$2.567 mill	$5.891 mill	$2.409 mill	--	--	$6.410 mill	$0.158/vm	$0.180/vm
Fuel, Oil, Etc.	$3.727 mill	$963,349	$2.429 mill	$1.070 mill	--	--	$1.305 mill	$0.072/vm	With Driver
Administrative	$12.088 mill	$2.554 mill	$4.368 mill	$1.599 mill	--	--	$9.352 mill	$0.099/vm	$0.11/vm
Licensing	--	--	--	$13,612	--	--	$192,411	$2646/veh	$0.06/vm
Insurance	$2.938 mill	--	$1.921 mill	$564,343	--	--	$33,724	W/Lic.	$0.06/vm
Advertising	$1.328 mill	--	$662,535	$104,168	--	--	$184,693	$0.05/vm	$0.02/vm

SOURCE:

1 APTA Annual Report, 1974
2 A Preliminary Proposal for High- and Intermediate-Level Transit in the Detroit Metropolitan Area; SEMTA, 1974
3 SEMTA Mass Transit Study; URS/Coverdale & Colpitts, Inc., 1975
4 Evaluation of Rail Rapid Transit & Express Bus Service in Urban Commuter Market; Boyd, Asher, Wetzler; 1973
5 Characteristics of Urban Transportation Systems; De Leuw Cather & Co., 1974

TABLE 3-5. DEMAND-RESPONSIVE CHARACTERISTIC DATA

	Ann Arbor, Michigan Plan(1)	Batavia, New York(2)	Bay Ridges, Ontario(2)	Haddonfield, New Jersey(4)	Mansfield, Ohio(2)	Peoria, Illinois(2)	Regina, Saskatchewan(2)	San Diego Guidelines(5)
Response Time	25 min(3)	22 min(3)	--	20 min	--	--	15 min(3)	15-30 min
Late Arrival	--	--	--	--	--	--	--	± 10 min
Service Area	--	4.75 mi^2	1.34 mi^2	10.9 mi^2	1.0 mi^2	2.75 mi^2	2.75 mi^2	--
Velocity	--	12-13 mph	12 mph	9.8 mph	18-21 mph	13.20 mph	9.2 mph	--
Fleet Size	40	5	10(3)	19(3)	1	10	12(3)	--
Vehicle Miles	3,082,000	--	--	656,810	--	--	--	--
Vehicle Hours	180,000	--	--	67,000	11/day	--	44.8/day	--
Productivity (pass/veh hr)	--	7-15	11-21	6.6	--	30	19	--
Driver's Cost	$786,000	--	--	$729,600	--	--	--	--
Maintenance	$287,000	--	--	$204,350	--	--	--	--
Fuel, Oil, Etc.	$85,000	--	--	$46,900	--	--	--	--
Administrative	Dispatch $122,000 Other $678,000	--	--	$337,730	--	--	--	--
Licensing	--	--	--	--	--	--	--	--
Insurance	$67,000	--	--	$39,560	--	--	--	--
Advertising	$5,000	--	--	$4,000	--	--	--	--

SOURCES:
1 Plan for Public Transportation; Ann Arbor Transportation Authority, 1974
2 Dial-A-Bus Manual; Transport Canada; 1974
3 Paratransit Dispatch Systems; Transport Development Agency of Transport Canada; 1976
4 Summary Evaluation of the Haddonfield Dial-A-Ride Demonstration; MITRE Corporation; 1975
5 Guidelines for San Diego Transit, Wilber Smith & Assoc., 1976

TABLE 3-6. BUS TRANSIT CAPITAL COSTS

VEHICLE SIZE		UNIT COST[3]
8 seats		$ 6,000
11 seats[4]		12,000
17-25 seats		18,000
19 seats[4]		23,000
31 seats		29,000
33 seats		30,000
35 seats[4]		43,000
41 seats		36,000
45 seats		39,000
51 seats		40,000
53 seats		42,000
53 seats[4]		67,000
Additional Cost, Demand-Responsive Radio[5]		1,000
Garage & Maintenance Facilities	Ref. 5	7,850/veh
	Ref. 2	13,700/veh
Demand-Responsive Dispatch Equipment[6] (40-vehicle system)		$400,000

TABLE 3-7. BUS TRANSIT OPERATIONAL COST ESTIMATIONS

First-Order Formulae Developed by:	Cost Rates $/VM $/VH $/V
Detroit - SEMTA Study[1]	$0.236 (VM) + 9.59 (VH) + 57,291 (V)
Typical - Bhatt Paper[2]	$0.39 (VM) + 5.30 (VH)
Additional Cost, Demand-Responsive Dispatch[7]	$100,000 - 200,000 annually

SOURCES:

1. SEMTA Mass Transit Study; URS/Coverdale & Colpitts, Inc., 1975
2. A Comparative Analysis of Urban Transportation Costs; TRB Working Paper No. 5002-5, The Urban Institute; Kiran Bhatt; January 1975
3. Characteristics of Urban Transportation; De Leuw Cather & Co., 1974
4. Urban Densities for Public Transportation; Tri-State Regional Planning Commission (New York, New Jersey, Connecticut); 1976
5. Elderly & Handicapped Service Plan; Triner, Turski, Wild, GM TSD, 1976
6. Plan for Public Transportation; Ann Arbor Transportation Authority, 1974
7. R&D in Demand-Responsive Transportation; TRB Special Report 154; Murphy & Siersema; 1975

TABLE 3-8. BUS TRANSIT COST CATEGORIES

CAPITAL COSTS	
	VEHICLE PURCHASE
	MAINTENANCE & STORAGE FACILITIES
	DEMAND-RESPONSIVE CONTROL FACILITIES
OPERATIONAL COSTS	
	DRIVER LABOR
	FUEL COST
	ROUTINE SERVICING (Oil, Tires, Cleaning, Etc.)
	HEAVY MAINTENANCE (Parts & Labor)
	DISPATCHING FUNCTIONS (Demand-Responsive Only)
	ADMINISTRATIVE (Clerical, Insurance, Licensing, Etc.)

4.0 REPRESENTATIVE AGT SYSTEMS

The eight subclasses defined in Section 2.0 and the raw data described in Appendix A provide a basis upon which to define representative systems. Each subclass, as defined in Table 2-1, represents a range of systems that have similar operating characteristics and provide common levels of service. Therefore, the subclasses will be employed to provide a starting point for defining representative systems. However, it is necessary to identify more than eight representative systems in order to adequately represent high speed SGRT, which includes dual mode transit systems. Three representative systems are defined for this subclass: two for dual mode systems, one with pallets and the other without, and a conventional AGT system. Consequently, a total of ten representative systems are defined in this section.

The system characteristics for which data are summarized in the tables of Appendix A have been reduced to a set of characteristics which is sufficient to initially define the representative systems for the purpose of conducting the various analyses in the SOS program. The characteristics which are used to define representative systems include the following:

- vehicle characteristics
- guideway characteristics
- system management strategies
- station characteristics
- reliability characteristics
- cost characteristics

Table 4-1 lists the nominal values for the various characteristics used as representative descriptors. The nominal values of all parameters presented in Table 4-1 were determined from the information contained in Appendix A. Whenever possible, deployed system characteristics were used as nominal values since they represent the current state-of-the-art. An attempt was made to maintain an internal consistency between the characteristics. For example, vehicle capacity corresponds with vehicle dimensions, guideway dimensions correspond with vehicle dimensions, and propulsion power is consistent with the nominal performance of the vehicle.

In cases where the available data is incomplete, particularly the cost and reliability areas, it will be necessary to develop representative values and ranges through appropriate methods of estimation as delineated in the Analysis Requirements[9]. Characteristics which seem to be largely application dependent include station configurations, system management strategies, and failure management strategies. While representative cases of these are identified for systems, in general, the final set for each system application type will be developed during the design trade-off process described in the Analysis Plan.[11]

Since reliability data are not well documented in the literature, no nominal values are given in Table 4-1. Rather, an analysis process is specified in the Analysis Plan for determining a nominal mean time between failures (MTBF) for each item listed in the section of the table pertaining to MTBF's. In addition, a set of failure management strategies will be determined by analysis for the various deployments of each representative system. The set will include a strategy for dealing with the failure of each system component for which a failure rate (MTBF) is determined.

Alternative failure management strategies for managing vehicle failures which result in a vehicle stoppage on the guideway at various locations in a network and at various times during the day will be considered in a trade-off analysis as described in the Analysis Plan. The alternative failure management strategies which will be considered in that analysis are:

- Reroute vehicles around the blocked link.
- Reverse the leading vehicle, and tow the disabled vehicle to the nearest station for passenger disembarkation, and subsequently push it to the nearest maintenance spur.
- Advance the trailing vehicle to push the disabled vehicle to the next station for passenger disembarkation, and subsequently push the failed vehicle to the nearest maintenance spur.
- Dispatch a tow truck upstream of the disabled vehicle, and proceed as is the case for rescue by the leading vehicle. The location of the tow vehicles and maintenance spurs will be varied.

Elements of capital and operating costs which define representative systems are indicated in Table 4-1. The unit cost values will be determined in a detailed cost analysis phase to be conducted for each representative application.

One class, high speed SGRT, is best represented by the AGRT system development which is being supported by UMTA. However, due to the competitive nature of the program, little or no information on the characteristics of the systems is available to the general public. Therefore, the nominal characteristics selected to define this representative system correspond closely to the guideway characteristics of the GM DMTS concept. It is assumed that the characteristics of AGRT are not significantly different from the GM DMTS specifications, and information on this system is readily available. When information on the AGRT system concepts becomes available in the future, and if the characteristics are significantly different from those specified, then the nominal definition of this representative system will be modified.

The DMT Pallets representative system is based on the Otis/TTD Dual Mode concept since this is the only palletized dual mode system for which conceptual design and performance specifications have been identified.

TABLE 4–1 (SHEET 1 OF 7) NOMINAL REPRESENTATIVE SYSTEM CHARACTERISTICS

Representative System Name	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLETS	HIGH SPEED IGRT	APT
Number of Seats Per Vehicle	4	8	16	12	4	17	17	17	24	80
Design Load Per Vehicle	4	15	40	100	4	17	17	17	50	208
Crush Load Per Vehicle	4	21	60	100	4	29	29	29	65	240
Vehicle Length	2.3 m	4.72 m	6.4 m	11.3 m	3.3 m	8.1 m	8.1 m	6.9 m (Pallet)	9.35 m	
Vehicle Width	1.3 m	2.03 m	2.1 m	2.8 m	1.6 m	2.4 m	2.4 m	4.0 m (Pallet)	2.4 m	3.09 m
Vehicle Height	1.4 m	2.67 m	3.0 m	3.3 m	1.8 m	2.5 m	2.5 m	3.5 m (Pallet and vehicle)	3.15 m	2.3 m
Empty Vehicle Weight	650 kg	3900 kg	6349 kg	11,600 kg	770 kg	4,865 kg	4,865 kg	10,258 kg	13,500 kg	32,900 kg
Load/Unload Rate Per Door	1.5 s/psss	1.5 s/psss	1.5 s/pass	1.0 s/pass	1.5 s/pass	1.5 s/pass	1.5 s/pass	1.5 s/pass	1.5 s/pass	1.0 s/pass
Number of Doors Per Vehicle	1	1	1	2 each side	1	1	1	1	1	2 each side
Guideway Interface	Pneumatic tires	Pneumatic tires	Pneumatic tires	Pneumatic tires	Pneumatic tires	Pneumatic tires	Pneumatic tires	Air levitation	Pneumatic tires	Steel wheel
Lateral Control Interface	Rubber tires on sidewall	Rubber tires on sidewall	Rubber guidewheels	Rubber guidewheels	Rubber guidewheels	Mag. field around wire in guideway	Senses mag. field around wire in g'way	Four guidewheels	Guidewheels	Steel rail
Switching Mechanism	Guidewheels engage guiderails	Guidewheels entrapped	Guiderail moves to entrap wheels	None on vehicle	Guidewheels entrapped	Two wires at switch	Senses one of two wires at switch	Two switch arms per side	Guideway wall moves	vehicle is passing
Minimum Turning Radius	5 m	10 m	10 m	25 m	5 m	10 m	10 m	38 m (Pallet)	20 m	68.6 m
Coupler	None	Manual	Manual	Manual	None	None	None	None	Manual	Automatic
Minimum Traveling Unit	1	1	1	1	1	1	1	1	1	2
Maximum Train Consist	1	3	4	2	1	1	1	1	6	8
"A" and "B" Vehicles	All "A"	"A" & "B" veh.	"A" & "B" veh.	All "A"	All "A"	All "A"	All "A"	All "A"	"A" and "B"	"A" and "B"
Propulsion Type	DC motor	DC motor	DC motor	DC motor	DC motor	DC motor	Gasoline engine DC motor hybrid	LIM	DC motor	DC motor
Power Rating Per Unit	10 kw	52 kw	44.7 kw	39 kw	16 kw	200 kw	194 kw (4000 rpm) 22 kw per mtr.	70 kw	50 kw	131 kw

TABLE 4–1 (SHEET 2 OF 7) NOMINAL REPRESENTATIVE SYSTEM CHARACTERISTICS

Representative System Name	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLETS	HIGH SPEED IGRT	[illegible]RT
Number of Propulsion Units	2	1	1	1	1	1	1 engine 2 motors	2	2	4
Acceleration	2.2 m/s²	1.0 m/s²	1 m/s²	1.0 m/s²	2.2 m/s²	2.2 m/s²	2.2 m/s²	1.0 m/s²	1.0 m/s²	1.0 m/s²
Cruise Speed	40 km/h	48 km/h	27 km/h	48 km/h	60 km/h	90 km/h	90 km/h auto 43 km/h man.	80 km/h auto 48 km/h man.	65 km/h	65 km/h
Service Brake Type	Friction	Friction	Friction	Friction	Dynamic	Dynamic	Friction	Dynamic	Dynamic	Friction
Service Deceleration	2.2 m/s²	1.0 m/s²	1.0 m/s²	1.0 m/s²	2.2 m/s²	2.2 m/s²	2.2 m/s²	1.5 m/s²	1.0 m/s²	1.0 m/s²
Emergency Brake Type	Friction	Friction	Friction	Friction	Friction	Friction	Friction	Skid pads	Friction	Friction
Emergency Deceleration	5.0 m/s²	2.2 m/s²	2.2 m/s²	2.2 m/s²	5.0 m/s²	5.0 m/s²	5.0 m/s²	5.0 m/s²	2.2 m/s²	1.0 m/s²
Reverse Capability (Bi-Directionality)	No	No	Yes	Yes	No	No	No	No	Yes	Yes
Precision Stopping Tolerance	± 10 cm	± 10 cm	± 15 cm	± 15 cm	± 15 cm	± 15 cm	± 15 cm		± 15 cm	± 30 cm
Exterior Noise	70 dBA at 7.5 m	60 NCA at 7.6 m	60 dBA at 7.6 m	NCA 60 at 30.5 m (70 below way)	70 dBA at 15.2 m	70 dBA at 7.5 m	82 dBA	70 dBA at 7.5 m	70 dBA at 7.5 m	84 dBA at 15 m
Energy Consumption (Accel, Decel, Cruise)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Emissions	None	None	None	None	None	None	16 gm/hp-h (HC & NO_x) 40 gm/hp-h (CO)	None	None	None
Guideway Dimensions Outside Width	2.0 m single 3.2 m dual	3.8 m	2.74 m	2.59 m	2.4 m single	7.84 m double	7.84 m double	3.6 m single	3.12 m single 6.12 m double	2.5 m single
Height	1.0 m	1.68 m	0.81 m	0.89 m	1.0 m	1.65 m	1.65 m	1.47 m	0.95 m	0.2 m
Running Surface Width	1.3 m	0.6 m wheel path 1.58 m centers	2.49 m	2.59 m	1.3 m	2.94 m	2.94 m	3.23 m	0.4 m each tire	1.7 m
Elevated Span Length	40 m (max)	40 m (max)	35 m (max)	37 m	35 m (max)	25 m (max)	25 m (max)	30 m	30 m	30 m
Construction Material	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete with steel rails
Weather Protection (Snow, Ice)	Fluid heating	Fluid heating	Fluid heating	Fluid heating	Fluid heating	Fluid heating	Fluid heating	Fluid heating	Fluid heating	None

TABLE 4–1 (SHEET 3 OF 7) NOMINAL REPRESENTATIVE SYSTEM CHARACTERISTICS

Representative System Name	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLETS	HIGH SPEED IGRT	ART
Power Distribution	500 Vac	500 Vac	500 Vac	500 Vac	500 Vac	500 Vac	N.A.	500 Vac	500 Vac	500 Vac
Lateral Control Equipment	Sidewall	Sidewall	Sidewall	Steel guidebeam	Sidewall	Wires in guideway	Wires in guideway	Sidewall	Sidewall	Rails
Switching Equipment	Guiderail at switches	None	Guideway switch rail moves	Transfer table	Guiderail at switches	Wires plus slot in guideway	Wires plus slot in guideway	Guiderails at switches	Guidewall moves vertically	Rails move
Operational Control Strategy	Asynchronous	Synchronous	Asynchronous	Asynchronous	Quasi-synchronous	Asynchronous	Synchronous	Asynchronous	Asynchronous	Asynchronous
Vehicle Control Strategy	Vehicle follower	Point follower	Block speed control	Block speed control	Point follower	Vehicle follower	Point follower	Vehicle follower	Block speed control	Block speed control
Dispatch Policy	Non-deterministic	Deterministic	Non-deterministic	Non-deterministic	Non-deterministic	Non-deterministic	Deterministic	Non-deterministic	Non-deterministic	Non-deterministic
Headway Protection	Moving block	Fixed block	Fixed block	Fixed block	Moving block	Moving block	Moving block	Moving block	Fixed block	Fixed block
Minimum Headway	2 s	15 s	18 s	90 s	1 s	3 s	6 s	6 s	60 s	120 s
Merge Strategy	FIFO	Scheduled	FIFO	N.A.	FIFO	FIFO	Scheduled	FIFO	FIFO	FIFO
Pathing Strategy	Scheduled real time	Prescheduled	Prescheduled	Prescheduled	Scheduled real time	Scheduled real time	Scheduled real time	Scheduled real time	Prescheduled	Prescheduled
Primary Path Selection Criterion	Minimum time	N.A.	N.A.	N.A.	Minimum time	Minimum time	Minimum time	Minimum time	N.A.	N.A.
Path Alterability	On network	None	On network	None	On network	On network	Before departure	On network	On network	None
Route Alteration Criteria	Link loading	N.A.	Compatible request for demand stop	N.A.	Link loading	Link loading	Link loading	Link loading	Compatible request for demand stop	N.A.
Service Policy Peak Off-Peak	Demand responsive Demand responsive	Prescheduled Demand activated	Prescheduled Demand activated	Prescheduled Demand activated	Demand responsive Demand responsive	Demand stop Demand activated	Demand stop Demand activated	Demand stop Demand activated	Prescheduled Demand stop	Prescheduled Prescheduled
Empty Vehicle Management Peak Off-Peak	Station storage hist., Same as peak	N.A. Station storage hist.	N.A. Station storage hist	N.A. Station storage hist.	Station storage hist., Same as peak	N.A. Station storage hist.	N.A. Station storage hist.	N.A. Station storage hist	N.A. N.A.	N.A. N.A.
Station Configuration	Off-line	On-line	On line and Off-line	On line	Off-line	Off-line	Off-line	Off-line	On-line	On-line
Berthing Configuration	Serial	Serial	Serial	Serial	Serial	Parallel (sawtooth)	Parallel (sawtooth)	Parallel (dock)	Serial	Serial
Station Lane Configuration	Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
Load/Unload Configuration	Separate	Common	Common	Common	Separate	Common	Common	Common	Common	Common

TABLE 4–1 (SHEET 4 OF 7) NOMINAL REPRESENTATIVE SYSTEM CHARACTERISTICS

Representative System Name	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLETS	HIGH SPEED IGRT	ART
Station Queues	Entry, exit	N.A.	None	N.A.	Entry, exit	Entry, exit	Entry, exit	Entry, exit	N.A.	N.A.
Turn Around Capability	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No
Exit Merge Resolution Strategy	Mainline priority	N.A.	Mainline priority	N.A.	Mainline priority	Mainline priority	Mainline priority	Mainline priority	N.A.	N.A.
Mean Time Between Failures										
Vehicle Propulsion										
Vehicle Body/Chassis										
On-Board Control and Communications										
Guideway Structure										
Guideway Power										
Guideway Weather Protection										
Wayside Control Computer										
Wayside Communicatns										
Station Ticketing Equipment										
Station Platform Doors										
Station Dock Mechnsm.										
Station Controller										
Central Management Computer										
Central Mgmt. Comm.										
Steady State % of Veh Fleet Out of Service for Maint.										

TABLE 4–1 (SHEET 5 OF 7) NOMINAL REPRESENTATIVE SYSTEM CHARACTERISTICS

Representative System Name	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLETS	HIGH SPEED IGRT	ART
System Capital Cost										
Vehicle Cost										
AGT Vehicles										
Expected Life										
Service Vehicles										
Expected Life										
Guideway Cost										
Structure										
At Grade										
Elevated										
Below Grade										
Switch										
Expected Life										
Power Distribution										
Expected Life										
Weather Protection										
Expected Life										
Wayside Controls and Communication										
Expected Life										

TABLE 4—1 (SHEET 6 OF 7) NOMINAL REPRESENTATIVE SYSTEM CHARACTERISTICS

Representative System Name	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLETS	HIGH SPEED IGRT	ART
Station Cost										
Structure										
Expected Life										
Passenger Mgt. Equipt.										
Expected Life										
Control										
Expected Life										
Maintenance and Storage Facilities										
Expected Life										
Central Control Cost										
Facility										
Expected Life										
Computer										
Expected Life										
Comm. and Control Equip.										
Expected Life										
Spare Parts Inventory Cost										
System Operating Cost										
Operating Personnel										

TABLE 4–1 (SHEET 7 OF 7) NOMINAL REPRESENTATIVE SYSTEM CHARACTERISTICS

Representative System Name	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLETS	HIGH SPEED IGRT.	ART
System Operating Cost (cont'd) Maintenance										
Vehicle										
Station										
Facilities										
Energy										
Vehicle										
Guideway Heating										
Station										
Facilities										
Insurance										
General and Administrative										

A limited set of variables has been identified to define the range of system mechanization alternatives which will be considered in system trade-off analyses during the SOS program. The set of variables to be considered are listed in Table 4-2 and include system design parameters and management alternatives which are expected to have significant effects on system performance and cost.

The parameter data given in the table indicate the range of observed values of the selected parameters for each representative system. These parameter ranges will serve to define the bounds of parametric variation for the system trade-off analysis.

Presently, deployed AGT systems use very simple, unsophisticated system management approaches and thus do not serve as a good reference for definition or selection of strategies to be employed in more complex applications. Therefore, the comprehensive set of alternative strategies compiled by Priver[8] was considered in the context of each of the deployment scenarios identified in the Representative Application Areas report[2] to determine reasonable alternatives for each representative system. Table 4-2 identifies the station and system management alternatives to be considered in the trade-off analysis of each representative system. In addition, each of the alternative operational control and dispatch policies identified in Table 4-3 will be considered in the detailed operational control analysis as described in the Analysis Plan[9] for the following representative systems:

- Low Speed PRT
- Low Speed SGRT
- Dual Mode Transit
- High Speed IGRT

TABLE 4–2 (SHEET 1 OF 2) RANGE OF PARAMETER AND STRATEGY VARIATION

Representative System Name / System Parameters	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLET	HIGH SPEED IGRT	ART
No. of Seats/Vehicle	3-6	6-10	(0) - (60) 6-16	0-12	4-6	6-17	6-17	6-17	4-40	44-80
Nominal Vehicle Capacity	3-6	10-20	6-72	70-109*	4-6	12-21	12-21	12-21	25-75	120-208
Crush Load/Vehicle	3-6	12-26	6-72	70-109	4-6	12-34	12-34	12-34	30-75	208-240
Minimum No. of Cars Per Train	1	1	1-9	1	1	1	1	1	1-2	1-2
Maximum No. of Cars Per Train	1	1-3	2-9	2	1-10	1-3	1-3	1-3	4-12	4-10
Cruise Velocity	32-50	20-54	(13) 24-50	20-54*	32-97	48-90	48-90	48-90	33-89	60-80
Service Acceleration	1.3-2.45 m/s^2	0.61-1.25 m/s^2	0.6-1.34 m/s^2	0.89 m/s^2	1.22-2.5 m/s^2	0.9-2.2 m/s^2	0.9-2.2 m/s^2	0.9-2.2 m/s^2	0.56-1.73 m/s^2	0.9-1.34 m/s^2
Service Deceleration	1.3-2.45 m/s^2	0.98-1.25 m/s^2	0.6-1.34 m/s^2	0.67 m/s^2	1.22-2.5 m/s^2	1.25-2.2 m/s^2	1.25-2.2 m/s^2	1.25-2.2 m/s^2	0.83-1.73 m/s^2	0.9-1.34 m/s^2
Emergency Deceleration	2.2-4.9 m/s^2	2.5-2.9 m/s^2	1.46-2.96 m/s^2	2.2 m/s^2	4-7.8 m/s^2 (one up to 20)	5.0 m/s^2	5.0 m/s^2	5.0 m/s^2	1.25-3.92 m/s^2	1.0-2.0 m/s^2
"A" & "B" Cars	All A	If train, A & B	All A & B	All A	All A	All A	All A	All A	All A & B	All A & B
Bi-Directionality	No	No, Yes	Yes	Yes	No	No	No	No	No	Yes
Service Policy	Demand responsive	Prescheduled (peak, off-peak) Demand activated (off-peak)	Prescheduled (Peak, off-peak) Demand stop (off-peak), Demand activated	Prescheduled (peak, off-peak), Demand Activated (off-peak)	Demand responsive	Prescheduled, Demand stop, demand activated	Prescheduled, demand stop, demand activated	Prescheduled, demand stop, demand activated	Prescheduled, demand stop	Prescheduled
Pathing Strategy	Scheduled real time	Prescheduled	Prescheduled	Prescheduled	Scheduled real time	Prescheduled, scheduled real time	Prescheduled, scheduled real time	Prescheduled, scheduled real time	Prescheduled	Prescheduled
Merge Strategy	Priority, FIFO	Scheduled	Priority, FIFO	N.A.	Priority, FIFO	Priority, FIFO	Scheduled	Priority, FIFO	Priority, FIFO	Priority, FIFO
Primary Path Selection Criteria	Minimum time	Minimum time	Minimum time	Minimum time	Minimum time	Minimum time	Minimum time	Minimum time	N.A.	N.A.
Path Alterability	None, on network	None	None, before departure, on network	None	None, on network	None, before departure, on network	None, before departure	None, before departure, on network	None, before departure, on network	None
Criterion For Route Alteration	Link loading	N.A.	Request for demand stop at off-line station	N.A.	Link loading	o Link loading o Demand stop at off-line station	o Link loading o Demand stop at off-line station	o Link loading o Demand stop at off-line station	Demand stop at off-line station	N.A.
Empty Vehicle Management	Station storage: historical	Station storage. real time, historical	Station storage: real time, historical	Station storage: real time, historical	Circulate, station storage historical	Circulate, station storage historical	Circulate, station storage historical	Circulate, station storage historical	N.A.	N.A.

* Range associated with the AGT class includes observed values of 100 passengers/vehicle and 48 km/h.

TABLE 4–2 (SHEET 2 OF 2) RANGE OF PARAMETER AND STRATEGY VARIATION

Representative System Name	LOW SPEED PRT	LOW SPEED SGRT	LOW SPEED IGRT	LGRT	HIGH SPEED PRT	HIGH SPEED SGRT	DMT	DMT PALLET	HIGH SPEED IGRT	ART
Station Configuration Alternatives	Off-line	On-line/Off-line	On-line/Off-line	On-line	Off-line	Off-line	Off-line	Off-line	On-line/Off-line	On-line
Berthing Configuration	Serial	Parallel (sawtooth) Serial	Serial	Serial	Serial	Parallel (sawtooth) Serial	Parallel (sawtooth) Serial	Parallel (dock) Serial	Serial Parallel	Serial
Lane Configuration	Single/multiple	Single/multiple	Single/multiple	Single	Single/multiple	Single/multiple	Single/multiple	Single	Single/multiple	Single
Unload/Load Configuration	Separate Common	Separate Common	Separate Common	Common	Separate Common	Common	Common	Common	Separate Common	Common
Queues	Entry, exit	Entry, exit	None Entry, exit	N.A.	Entry, exit	None Entry, exit	Entry, exit	None Entry, exit	None Entry, exit	N.A.
Turnaround Capability	No	No	No	No	Yes, no	Yes, no	Yes, no	Yes, no	Yes, no	No
Exit Merge Resolution	Priority–mainline	Priority–mainline	Priority (for off-line station) • Mainline • Exiting over mainline • Exiting over mainline empty • Loaded over empty	N.A.	Priority • Mainline • Exiting over mainline • Exiting over mainline empty • Loaded over empty	Priority • Mainline • Exiting over mainline • Exiting over mainline empty • Loaded over empty	Priority–mainline	Priority	Priority • Mainline • Exiting over mainline • Exiting over mainline empty • Loaded over empty	N.A.

Table 4-3 Alternative Operational Control and Dispatch Policies

Operational Control	Dispatch
Synchronous	Deterministic
Quasisynchronous	Deterministic
Quasisynchronous	Quasideterministic
Quasisynchronous	Non-deterministic
Asynchronous	Quasideterministic
Asynchronous	Non-deterministic

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GLOSSARY

Asynchronous

Operation of vehicles under velocity control or in the vehicle-follower mode with speed changes allowed to prevent potential merge conflicts.

Automated Guideway Transit (AGT)

Computer-controlled transit system operating in demand or scheduled service on a fixed, exclusive guideway.

Automated Rail Transit (ART)

A class of AGT systems which provides multiple-stop service, carries at least 100 passengers in its minimum train consists, operates at speeds equal to or greater than 55 km/h, and generally runs at headways of more than 1 minute.

Availability-Factor Relationships

The sensitivity of the vehicle and passenger availability measures to changes in parameters which affect either system reliability or failure management strategy.

Average Queue Transit Time (TQ)

Average time required to move through a platform boarding queue during a period of congestion such as the peak hour. For a particular station the value is calculcted as the difference between the average wait time and one-half the average route headway.

Capital Cost (base year)

The initial cost of deploying a system expressed in base year (1977) dollars. Capital cost is the sum of guideway construction cost, passenger station construction and equipment cost, AGT vehicle cost, central control construction and equipment cost, maintenance facility construction and equipment cost, power distribution system installation cost, and feeder system costs including vehicles, maintenance facilities, and control facilities.

Catalogued Procedure

A pre-coded set of Job Control Language (JCL) statements that is assigned a name, placed in a data set, and may be retrieved and executed by one JCL statement.

Central Business District (CBD)

The downtown retail trade area of a city. As defined by the Census Bureau, the CBD is an area of very high land valuation characterized by a high concentration of retail business offices, theaters, hotels, and service businesses, and by a high traffic flow.

Central City (CC) of an SMSA

The largest city in an SMSA. One or two additional cities may be secondary Central Cities in the SMSA.

Central City (CC) of an Urbanized Area (UA)

A city of at least 50,000 persons within closely settled incorporated and unincorporated areas that meet the criteria for urbanized ring (fringe) areas. A few UA's contain twin cities with a combined population of at least 50,000.

Central City Ring (CCR)

The portion of a Central City not included in the CBD.

Checkpoint File

A file created at a user-specified time by the Model Processor and containing all data necessary to restart the MP from that time.

Closed-Loop Control

Advancement of vehicles under generated control based upon the estimated system state.

Control Block

A specific section of guideway corresponding to a single control segment of a fixed block vehicle regulation and/or headway protection system.

Cruise Speed

The constant velocity at which a vehicle travels after acceleration and prior to braking. This velocity is usually less than the maximum design speed, but can be equal to it.

Crush Load Capacity

The maximum total capacity which a vehicle is designed to accommodate. This limitation is defined by either a vehicle weight limitation or a passenger comfort criterion.

Demand Activated Service Policy

A service policy in which routes, which may include intermediate station stops, are generated in real time on the basis of passenger demand, i.e., point-to-point routing with demand stop.

Demand Responsive Service Policy

A service policy in which non-stop routes are generated in real time on the basis of passenger demand, i.e., point-to-point routing with no intermediate stops.

Demand Stop Service Policy

A service policy in which vehicles travel on predetermined routes but stop at stations along the route only in response to specific passenger demand.

Demand Type

A system deployment parameter which specifies the demand environment on which a detailed demand model will be specified. Three metropolitan area demands and four activity center demand types are identified:

1. Metropolitan area - high CBD, high reverse commutation
2. Metropolitan area - high CBD, low reverse commutation
3. Metropolitan area - low CBD, low reverse commutation

1. Activity Center Line-Haul
2. Activity Center Circulation
3. Activity Center in High Demand CBD
4. Activity Center in Low Demand CBD

Design Load per Vehicle

The nominal passenger capacity of each vehicle.

Deterministic

A strategy by which all merge conflicts are resolved before launch, and barring failures, each vehicle is assured of traversing the network in a predetermined time.

Dial-A-Ride Service

Transit service operated by generating vehicle paths in continual response to demand.

Downtown People Mover (DPM)

An AGT system deployed in a CBD environment, or the UMTA demonstration program to implement such systems.

Empty Vehicle Management (EVM)

A set of strategies which govern the disposition of active, empty vehicles not assigned to a fixed route nor enroute to service a passenger demand. Alternative strategies include:

Circulation

Vehicles are circulated on the network until needed to satisfy a demand. The distribution of circulating vehicles may be based on historical demand or on current demand patterns.

Station storage - historical

Vehicles are routed to stations for storage based on historical demand data.

Station storage - real time

Vehicles are either stored in the station when they become empty or are routed to other stations and stored based on current demand patterns.

Event Model

A representation of an entity (a subsystem or process) in terms of discrete states of the entity and the time required to change from one state to another for use in a discrete event simulation.

Fixed Block

A longitudinal control or headway protection mechanization wherein blocks are hardwired to the guideway and each block transmits velocity or braking commands to the vehicle based on the occupancy of preceding blocks. For longitudinal control, the commands may be altered by central or local control. For headway protection the blocks transmit either braking or velocity limit commands to vehicles which establish upper bounds for any other commands.

Fixed Route Service

Transit service operated on predetermined paths.

Flow Capacity (ρ_c)

A measure of system capacity in terms of passenger spaces per second past a point; the ratio of traveling unit capacity to average route headway.

Fully Connected Grid (FG)

A grid network in which vehicles proceed directly from one station to any other station without retracing any one- or two-directional portion of the guideway.

Global Variables

Variables stored in a common area and known by one name to all segments included in the program.

Grid

Any guideway on which vehicles are presented with a choice of paths during normal operation.

Grid Transit (GT)

A transit system deployed in any demand environment which uses an FG or PG network and has more extensive operational switching capability than an MSLT. Generally shorter headways result than in MSLT. This category includes PRT systems and many systems which are often referred to as Group Rapid Transit (GRT).

Guideway Interface

The vehicle components which contact the guideway for support. Usually the interface is wheels but in some cases it is an air or magnetic levitation force.

Headway

A frequency of service measure: the mean time between vehicles passing a point along a route of known configuration.

Headway Equation

An analytic function which expresses the relationship between minimum headway and system parameters such as traveling unit (vehicle or train) length, cruise speed, acceleration, communication delay, and expected position error.

Intermediate Vehicle Group Rapid Transit (IGRT)

A class of AGT systems which provides multiple-stop service and carries from 25 to 69 passengers in its minimum train consist. Low speed IGRT systems have a maximum operating speed of 13 to 54 km/h and tend to run at 15 to 60 s headways. High speed IGRT systems operate at speeds greater than 54 km/h and at headways which usually fall between 15 and 90 s.

Intersection

An X-type merge with 2 input links, 2 output links, 4 ramp links, 4 through paths, and either 2 or 4 queuing areas.

Large Vehicle Group Rapid Transit (LGRT)

A class of AGT systems which provides multiple-stop service, has a minimum train consist capacity of 70 to 109 passengers, operates at a maximum speed of 13 to 54 km/h, and usually runs at headways of 30 to 90 s.

Lateral Control Interface

Vehicle and guideway components that interface to control the vehicle's lateral movement.

Loop

A guideway on which motion is unidirectional during normal operation (except possibly at short station segments or at ends of runs) and which is defined by a closed path.

Loop of Closed Geometry (S)

A simple loop as defined above which encircles no area.

Macro

A standard code segment that is generated in-line at compile time by specification of single statement.

Maximum Operating Speed

The maximum speed at which a vehicle can travel. This limit is imposed by vehicle and propulsion system design constraints.

Merge Strategy

A strategy for resolving merge conflicts. Three strategies are considered.

1. FIFO (first-in, first-out)
2. Prescheduled
3. Priority

Metro Shuttle Loop Transit (MSLT)

A transit system deployed in a metropolitan environment and having high speed capability but no or limited operational switching capability. The network may be of any type. If it is a grid network, however, the switching is of limited capability. This category includes most guideway transit systems currently deployed in metropolitan areas.

Minimum Traveling Unit

The minimum number of vehicles with which a train can operate. For some systems the minimum traveling unit is a single vehicle.

Minimum Traveling Unit Capacity

The nominal capacity (not crush capacity) of a single vehicle times the number of vehicles in a minimum train consist.

Moving Block

A headway protection mechanization wherein an emergency protection zone which moves along with the vehicle is established around each vehicle. Emergency braking commands are issued to the traveling vehicle whenever its emergency protection zone infringes upon that of a leading vehicle.

Multiple Loop (ML)

Any network consisting of two or more loops and requiring that passengers transfer from a vehicle constrained to one loop to a vehicle constrained to another loop if they wish to travel between two points not served by a single loop.

Network Element

Either a link, merge, or an intersection modeled in the DCCM.

Network Type

A system deployment parameter which specifies network configuration. Seven network types are identified:

1. Shuttles (S)
2. Loop of closed geometry (L)
3. Open loop, one-way (L1)
4. Open loop, two-way (L2)
5. Multiple loop (ML)
6. Partially connected grid (PG)
7. Fully connected grid (FG)

Nominal Capacity

Vehicle capacity including seated and standing passengers as specified by the manufacturer according to a passenger comfort criterion. The average area allotted to each standee is generally at least 2.5 square feet.

Non-deterministic

A strategy by which potential conflicts at merges are not considered before launch but are resolved locally in the vicinity of each merge.

Off-Vehicle Feeder Travel Time for Access

The mean time per person enroute to a specific AGT station for delay or non-vehicle travel (including any walking to feeder route or waiting for feeder bus, transferring between vehicles, parking a car, or walking all the way), while going from zone centroids to a specific station.

Off-Vehicle Feeder Travel Time for Egress

The mean time per person enroute from a specific AGT station for delay or non-vehicle travel (including waiting at stations for bus, walking from route to destination, transferring between vehicles, or walking all the way), while going from a specific station to zone centroids.

On-Vehicle Feeder Time for Access

The mean time per person enroute to a specific AGT station spent aboard a feeder vehicle (including feeder bus or private auto), while going from zone centroids to a specific station.

On-Vehicle Feeder Travel Time for Egress

The mean time per person enroute from a specific AGT station spent aboard a feeder vehicle (including the feeder bus or private auto), while going from a specific station to zone centroids.

Open-Loop Control

Advancement of vehicles by user-specified control independent of system state.

Open Loop, One-Way (L1)

A single loop encircling an area and providing one-way circulation.

Open Loop, Two-Way (L2)

Two loops deployed side-by-side encircling an area and providing two-way circulation.

PARAFOR

A superset of FORTRAN utilizing PL/1 macros to add structured programming facilities to standard FORTRAN.

Partially Connected Grid (PG)

A grid network which does not qualify as a Fully Connected Grid (FG).

Partitioned Data Set

A type of file organization in which independent groups of sequentially organized records, called members, are on direct-access storage.

Path

A sequence of guideway links used by a vehicle to travel between two points on a network.

Personal Rapid Transit (PRT)

A class of PRT systems which provides non-stop point-to-point service, has a minimum traveling unit capacity of 3 to 6 passengers, and runs at very short headways, usually 3 s or less. Low speed PRT has a maximum operating speed of 13 to 54 km/h, while high speed PRT has a maximum operating speed exceeding 54 km/h.

Platoon Movement

Simultaneous advancement of a row of vehicles or trains.

Practical Minimum Headway

The minimum headway at which vehicles can operate under normal conditions.

Prescheduled Pathing

A vehicle pathing strategy in which the primary path from origin to destination is predetermined and specified for all station pairs.

Precision Stopping Tolerance

The tolerance within which a vehicle can stop at a given point.

Quasi-deterministic

A strategy by which merge conflicts are not resolved prior to launch, but information about the future state of the network is used to launch vehicles at times that provide a high probability of efficient merging.

Quasi-synchronous

Operation of vehicles under point-follower control but with change of control points allowed to resolve potential merge conflicts by advancing or slipping one or more slots.

Reliability Block Diagram

A diagram that illustrates what equipment or combinations of equipment are required for successful system operation.

Representative System

A collection of values for the following system characteristics and strategies·

1. Vehicle characteristics
2. Guideway characteristics
3. System management strategies
4. Reliability characteristics
5. Cost characteristics

The range of values are chosen to be interrelated in such a way as to represent a general class of state-of-the-art systems for the purpose of conducting system analyses within the SOS program.

Representative System Deployment

A specific combination of a representative system, demand type, and network configuration defined for the purpose of conducting system analyses within the SOS program.

Response Time

A frequency of service measure the mean time between a request for and the arrival of a dial-a-ride service vehicle.

Ripple Movement

Advancement of vehicles and trains one at a time for a row of stationary vehicles/trains.

Route

A designated set of destinations, usually defined by stations, to which a vehicle must travel. The path, or links, to be traversed between any two destinations is not specified.

Routing Strategy

A strategy which identifies routes for vehicles/trains. Two alternatives are fixed routing and real time select routing. Real time routing is used only with demand responsive service and demand activated service, while fixed routing is employed for demand stop and fixed route service policies.

Rural and Scattered Urban (R&SU)

The remaining rural and urban portions of counties not included as part of the urbanized ring of the UA, but still within the boundaries of the SMSA. Thus, with the exception of the New York and Los Angeles SMSA's the SMSA consists of two components — the UA and the Rural and Scattered Urban. Both New York and Los Angeles Urbonized Areas (UA's) extend into counties outside the boundaries of the SMSA.

Scheduled, Real Time Pathing

A vehicle pathing strategy in which the primary path from origin to destination is selected from among specified alternatives just prior to departure from the origin station on the basis of current traffic conditions on the network.

Sector

An area serviceable by one vehicle in subscription service during a prescribed time interval for a specific demand density.

Service Type

Either non-stop (personal transit) or multiple-stop (group transit) service.

Shuttles (S)

A guideway on which bi-directional motion occurs during normal operation and which is defined by a single curve connecting two distinct end points. Also, any network consisting of two or more simple shuttles, either following the same path or different paths.

Shuttle Loop Transit (SLT)

A low speed AGT system deployment in an activity center demand environment having any non-grid type of network. Thus, SLT system deployments require no operational switching but may require passenger transfers.

Small Vehicle Group Rapid Transit (SGRT)

A class of AGT systems which provides multiple-party service, has a capacity of 7 to 24 passengers in its minimum train consist, and usually operates at headways between 3 and 15 s. Low speed SGRT has a maximum operating speed of 16 to 54 km/h, and high speed SGRT a maximum of over 54 km/h.

Standard Metropolitan Statistical Area (SMSA)

A county or group of counties containing at least one city (or twin cities) with a population of 50,000 or more, plus adjacent counties which are metropolitan in character and integrated economically and socially within the central city.

Switching Mechanism

The mechanism, located either on the vehicle or the guideway, by which vehicles/trains are switched.

Synchronous

Operation of vehicles under point-follower control with no changes allowed in control points during a given guideway trip.

Theoretical Minimum Headway

The minimum headway at which two vehicles can travel, assuming there are no merges or on-line stations.

Total Value Capital Cost

The sum of all capital costs except interest expense over the life cycle period expressed in base year dollars.

Urbanized Area (UA)

An area containing a central city (or twin cities) of 50,000 or more population, plus the surrounding closely settled incorporated and unincorporated areas which meet certain criteria of population size and density (urbanized ring). UA's differ from SMSA's in that UA's exclude the rural portions of counties composing the SMSA's, as well as places that were separated by rural territory from the densely populated fringe around the central city. The components of the UA's include the central city, as defined above, and the urbanized rings, as defined below.

Urbanized Ring (UR)

Various areas contiguous to a central city or cities, which together constitute its urbanized ring, or "urban fringe," as termed by the Census Bureau.

Variable Cost (base year)

The annual cost of operating and maintaining a system expressed in base year (1977) dollars. Variable costs include maintenance costs, energy costs, and administrative costs for both the AGT and feeder systems.

Vehicle Capacity

When used in correlations of vehicle dimensions and cost to capacity, nominal vehicle capacity is assumed. However, the system simulations interpret vehicle capacity as the maximum number of passengers which can occupy a vehicle at one time.

APPENDIX A

OBSERVED SYSTEM CHARACTERISTICS

Appendix A contains the results of an intensive data collection effort on AGT systems. The forty-four systems surveyed are divided into the eight subclasses defined in Section 2.0 of this report. The eight sets, comprised of ten charts each, contain the relevant and available data on the forty-four systems.

A reference list of the sources used for completion of the charts is included at the front of the appendix. In most cases, the data on individual systems were obtained from one major source. That source is identified by number in the last row of the first chart. System information obtained from a source other than the major reference is noted with a superscripted reference number.

LIST OF REFERENCES FOR APPENDIX A

a. Obtained through direct contact with transportation system manufacturers and/or operations.

b. Obtained through direct contact with TSC.

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TABLE A–1 (SHEET 1 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
Developer	Demag Mbb	S.A. Engins Matra	Pullman Inc.				
Deployment Status	Test track	Test track (Orly Airport, Paris)	Development curtailed				
Vehicle Characteristics No. of Seats Per Vehicle	3	4	6				
Design Load Per Vehicle	3	4	6				
Crush Load Per Vehicle	3	4	6				
Vehicle Length	2.3 m	2.3 m	3.65 m				
Vehicle Width	1.6 m	1.3 m	1.68 m				
Vehicle Height	1.5 m	1.4 m	1.58 m				
Interior Area Per Seated Passenger	$3\ m^3$		0.457 m wide 0.381 m knee space				
Interior Area Per Standing Passenger	N.A.	N.A.	N.A.				
Empty Vehicle Weight	700 kg	650 kg	2,180 kg				
Load/Unload Rate Per Door							
Door Width		630 mm					
Number of Doors Per Vehicle	1	2 (one each side)	2 (one each side)				
Major Reference (except as noted)	Reference 2		Reference 1				

TABLE A–1 (SHEET 2 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
Vehicle Characteristics (cont'd) Guideway Interface	Solid rubber tires	Rubber tires on metal sheet (pneu.)	Urethane coated steel wheels on rails				
Lateral Control Interface	Horiz. solid rubber guidewheels	Four horizontal rubber tires on side rail	Flanged steel wheels on steel rails				
Switching Mechanism	4 switching arms, 2 per side (a)	Transverse bolster on vehicle engages guiderail	On-board horiz. guidewheels steer axles				
Switch Actuation Time	0.7 s (a)		3 s				
Minimum Turning Radius	30 m		15.24 m				
Coupler	None	None	None				
Minimum Traveling Unit	1	1	1				
Maximum Train Consist	1		1				
"A" and "B" Vehicles	N.A.	N.A.	N.A.				
Platooning Capability	None	Yes, 300 mm (0.168 s)	None				
Propulsion Type	Double-sided LIM	Variable reluctance DC motors (15)	DC traction motor				
Power Rating Per Unit	23 kg/kg motor wt. at 30 km/h	10 kw (15)	37.4 kw				
Number of Propulsion Units	2, one each side of vehicle	2, coupled to rear wheels (15)	1				

TABLE A–1 (SHEET 3 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
Vehicle Characteristics (cont'd) Acceleration	2.45 m/s^2	1.3 m/s^2 (15)	1.34 m/s^2				
Cruise Speed	36 km/h	50 km/h (15)	32 km/h				
Maximum Speed	36 km/h	50 km/h (15)	56 km/h				
Service Brake Type	Dynamic	Friction (14)	Regenerative				
Service Deceleration	2.45 m/s^2	1.3 m/s^2 (15)	1.34 m/s^2				
Emergency Brake Type	Same as service	One electrical, one mechanical (15)	Friction disk				
Emergency Deceleration	4.9 m/s^2		2.24 m/s^2				
Emergency Brake Reaction Time	20ms		0.2 s				
Maximum Grade Capability	15%	4% full speed 10% reduced speed	5%				
Reverse Capability (Bi-Directionality)	No						
Precision Stopping Tolerance	± 10 cm		±15.2 cm				
Exterior Noise	60-65 dBA at 7.5 m	70 dBA at 7.5 m	63 dBA				
Energy Consumption (Acceleration, Decel., Cruise)	0.03 kwh/veh-km		1.24 kwh/veh-km				
Emissions	No direct emissions	No direct emissions	No direct emissions				

TABLE A–1 (SHEET 4 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
Typical Network Configuration		Grid or loops					
Maximum Grade		10%					
Guideway Type		Open structure	Steel rails				
Guideway Dimensions Outside Width	1.6 m	2.0 m single lane 3.2 m double lane	1.62 m				
Height	1.75 m		0.710 m				
Running Surface Width		1.3 m					
Elevated Span Length	40 m max.		15.2 m - 18.3 m				
Construction Material	Steel and/or concrete	Cement sandwich between bonded metal sheets	Structural steel				
Weather Protection (Snow/Ice)	None, suspended veh. configuration (a)						
Power Distribution AC or DC	AC	DC	AC 60 Hz, 1 phase				
Voltage	500 V	400 V					
Number of Substations Per Lane Kilometer							
Lateral Control Equipment		Side rail	Rails				
Switching Equipment		Guiderail at switches	None at wayside				

TABLE A–1 (SHEET 5 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
Station Configuration	Off-line	Off-line	Off-line				
Number of Parallel Platforms		1					
Number of Berthing Lanes	1 per platform	2 per platform					
Length of Platform							
Berth Configuration	Serial	Serial	Serial				
Number of Berths Per Platform		2	3				
Capacity of Vehicle Queues							
Empty Vehicle Storage Capacity							
Average Vehicle Dwell Time		30 s	10–15 s				
Vehicle Throughput (Vehicles Per Hour)	4,500 pass/hr/platform						
Turnaround Capability							
Off-Line Acceleration/Deceleration Lane Length							
Operational Control Strategy	Vehicle follower, asynchronous	Vehicle follower within platoons, blk and command (14)	Point follower, quasi-synchronous				
Dispatch Policy	Non-deterministic	Deterministic					

TABLE A–1 (SHEET 6 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
Headway Protection Fixed Block							
Block Lengths	N.A.	Fixed block between platoons	N.A.				
No. of Blocks Between Vehicles	N.A.		N.A.				
Moving Block	Moving block	N.A.	Moving block				
Communication Sample Rate							
Merge Strategy	FIFO						
Minimum Headway	1 s	0.168 s within platoons: 60 s between platoons	8 s (2)				
Merge Throughput							
Service Policy	Demand responsive	Scheduled in peak, demand responsive in off peak	Demand responsive				
Service Goals							
Routing Strategy							
Empty Vehicle Management							

TABLE A-1 (SHEET 7 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
Station Management							
Separate vs Common Board/ Deboard							
Ripple vs Platoon Movement			Platoon				
Fleet Management Total Fleet							
Peak Operating Fleet							
Base Operating Fleet							
Failure Management Push/Pull Capability	Being developed (a)						
Emergency Equip. & Crew Location	Tow vehicle at station	At central control facility					
Redundant Prop. or G'way Power							
Redundant Local Control							
Redundant Vehicle Electronics	Redundant headway control (b)						

TABLE A-1 (SHEET 8 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
Mean Time Between Failures							
System			3 days				
Vehicle	1,920 h (10 h/day) (a)		1,400 h				
Guideway							
Station	320 h (10 h/day) (a)		3 days				
Central Control							
Mean Time to Restore Service							
System							
Vehicle							
Guideway							
Station							
Central Control							
System Availability Number	98.8% (a)						
Availability Definition							
System Responses to Failures							

TABLE A–1 (SHEET 9 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
System Capital Cost			$81,830,000 (1973)				
Vehicle Cost	100 - $33K, 1000 - $20K 33% ea.:bogie, cabin, control	$24,000					
Expected Life		•	15 years (2)				
System Fleet Size			300				
Guideway Cost	$2.4 M/km	$3.98 M/km					
Expected Life			40 years				
System Lane Kilometers			35 km				
Power Distribution Cost							
Expected Life							
Station Cost							
Expected Life							
Number of Stations			20				
Maintenance and Storage Facilities							
Expected Life							
Number of Facilities							
Communication and Controls	Appr. 15% of total						
Expected Life							

TABLE A–1 (SHEET 10 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED PRT

System Name	Cabinentaxi	Aramis	Aerial Transit System				
System Operating Cost			$6,000,000				
Operating Hours/Day							
Vehicle Kilometers/Day							
Vehicle Hours/Day							
Energy Cost							
Maintenance Cost			$2,000,000				
Vehicles							
Stations							
Facilities							
Personnel							
Maintenance							
Vehicle							
Stations							
Facilities							
Operations							
Central Control							
Stations							
General							
General and Administrative							

TABLE A–2 (SHEET 1 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace Corp. High Capacity PRT	Cabtrack	CVS	ELAN-SIG	Monocab		
Developer	Aerospace Corp.	Transportation & road research lab.	Japan society for the promotion of machine industry	SIG Swiss Industrial Co.	Rohr Industries Inc.		
Deployment Status	1/10th scale model operational	1/5th scale model	5 km demo. & 1.6 km system at an exposition	suspended pending increased demand	Las Vegas proposal, transpo 72, test track ; Discontinued		
Vehicle Characteristics No. of Seats Per Vehicle	6	4	4	4	6		
Design Load Per Vehicle	6	4	4	4	6		
Crush Load Per Vehicle	6	4	4	4	6		
Vehicle Length	3.05 m	3.05 m	3.35 m	3.1 m	2.92 m		
Vehicle Width	1.52 m	1.37 m	1.6 m	1.8 m	1.68 m		
Vehicle Height	1.52 m	1.68 m	1.85 m	1.38 m	2.02 m		
Interior Area Per Seated Passenger	0.46 m^2		2.6 m^2		0.41m^2		
Interior Area Per Standing Passenger	N.A.	N.A.	N.A.	N.A.	N.A.		
Empty Vehicle Weight	818 kg	600 kg	1000 kg (a)	795 kg	1,820 kg		
Load/Unload Rate Per Door	720 pass/hr/berth		1.24 (a)				
Door Width			0.8 m (a)		920 mm		
Number of Doors Per Vehicle	1	2, 1 on each side (load, unload)	1	1	2, 1/side		
Major Reference (except as noted)	Reference 1	Reference 1	Reference 2	Reference 1	Reference 1		

TABLE A–2 (SHEET 2 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace Corp. High Capacity PRT	Cabtrack	CVS	ELAN-SIG	Monocab		
Vehicle Characteristics (cont'd) Guideway Interface	2 vertical rubber tires in tandem	4 pneumatic rubber tires	4 pneumatic rubber tires	2 pneumatic rubber tires	foam-filled rubber tires		
Lateral Control Interface	lateral guidewheels	rubber tired guidewheels	Ackerman steering actuated by front steering arm (2/veh)	bogie constrained to ride inside overhead guide beam	lateral guidewheels on center blade		
Switching Mechanism	electromagnetic, backed up by mech. locks on vehicle	hydraulic actuated guidewheel retraction mechanism	mechanical positive entrapment rollers (4/veh)	vehicle active	positive entrapment switch on vehicle		
Switch Actuation Time	0.5 ms		mechanism operates advance of switch	0.15 s	1 s		
Minimum Turning Radius	4.6m at reduced speeds	6.1 m	5 m at 10 km/h	73 m	7.6 m at 7.65 km/h		
Coupler	N.A.	N.A.	equipped on freight vehicle (a)	N.A.	N.A.		
Minimum Traveling Unit	1	1	1	1	1		
Maximum Train Consist	1	1	10	1	1		
"A" and "B" Vehicles	N.A.	N.A.		N.A.	N.A.		
Platooning Capability	none	none	yes (a)	none	none		
Propulsion Type	DC linear electric	slipring induction or DC motor	rotary DC electric	rotary DC electric	DC shunt electric		
Power Rating Per Unit	137 kg thrust	25 kw	13 kw (a)	15 kw	30 kw		
Number of Propulsion Units	1, riding inside guideway	1/veh	1/veh under floor	1/veh	1/veh		

TABLE A-2 (SHEET 3 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace	Cabtrack	CVS	ELAN-SIG	Monocab		
Vehicle Characteristics (cont'd) Acceleration	2.5 m/s^2	2.5 m/s^2	2 m/s^2	2.5 m/s^2	1.22 m/s^2		
Cruise Speed	32 - 97 km/h	36 km/h	40 - 60 km/h	60 km/h	56 km/h		
Maximum Speed	97 km/h	72 km/h	80 km/h	64 km/h	72 km/h		
Service Brake Type	dynamic, regenerative, mechanical for holding	dynamic with disc brakes at low speed	electrodynamic & mechanical at low speed	dynamic	dynamic regenerative		
Service Deceleration	2.5 m/s^2	2.5 m/s^2	2 m/s^2	2.5 m/s^2	1.22 m/s^2		
Emergency Brake Type	dynamic electric & back-up mechanical	hydraulic disk	hydraulic	mechanical	mechanical		
Emergency Deceleration	7.85 m/s^2		5 - 20 m/s^2	5 m/s^2	4 m/s^2		
Emergency Brake Reaction Time	0.1 s		0.09 s	1 s			
Maximum Grade Capability	as required	10 %	6% (a)	20%	10%		
Reverse Capability (Bi-Directionality)			none (a)	No (a)			
Precision Stopping Tolerance	±76 mm		±300 MM		±152 mm		
Exterior Noise			NCA 50 at 10m		70 dBA at 15.2 m		
Energy Consumption (Acceleration, Decel., Cruise)	0.21 kwh/veh-km		0.2 kwh/veh-km (a)	0.09 kwh/veh-km	empty vehicle 0.69 kwh/veh-km; design capacity - 8.1 kwh/veh-km		
Emissions	no direct	no direct	no direct	no direct	no direct		

TABLE A–2 (SHEET 4 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace	Cabtrack	CVS	ELAN-SIG	Monocab		
Typical Network Configuration							
Maximum Grade			10% (a)				
Guideway Type	closed concrete structure	closed structure	closed structure	running surface with elevated guidebeam	suspension		
Guideway Dimensions Outside Width	0.813 m		1.8 m + 0.6 m (sidewalk) single lane	2.3 m	0.8 m		
Height	0.914 m		0.8 m	2.3 m	0.9 m		
Running Surface Width		1.98 m	0.43 m (a)		0.2 m		
Elevated Span Length	max. 18.3 m		max. 30 m	max. 48 m	max. 37 m		
Construction Material	prestressed concrete	steel & concrete	prestressed concrete & steel	concrete or steel road-bed & steel guidebeam	steel or concrete		
Weather Protection (Snow/Ice)			possible (a)		None		
Power Distribution AC or DC	DC	AC	AC	DC	AC		
Voltage	1,000	415, 3 phase	210 volt (a)	600	480, 3 phase		
Number of Substations Per Lane Kilometer			1 (a)				
Lateral Control Equipment	bogie rides in guideway	guideway sidewall	slot in guideway	guidebeam	vehicle rides in guide-way		
Switching Equipment	electromagnets on guideway	on vehicle	guideway is passive	guideway is passive	guideway is passive		

TABLE A-2 (SHEET 5 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace	Cabtrack	CVS	ELAN-SIG	Monocab		
Station Configuration	off-line	off-line	off-line	off-line	on or off-line		
Number of Parallel Platforms		variable	1 (a)				
Number of Berthing Lanes		variable	1 (a)				
Length of Platform	18.3 m for 6 berths 6.1 m for 2 berths		20 m (a)				
Berth Configuration	serial	serial	serial				
Number of Berths Per Platform		variable	2 (a)				
Capacity of Vehicle Queue			N.A. (a)				
Empty Vehicle Storage Capacity			None (a)				
Average Vehicle Dwell Time			Appr. 20 s	30 s	20 s		
Vehicle Throughput (Vehicles Per Hour)		board-76 carloads/hr/berth.; deboard-60 carloads/hr/berth	150 veh/hr/berth (a)	480 pass/hr/berth	720 pass/hr/berth		
Turnaround Capability			yes (a)				
Off-Line Acceleration/Deceleration Lane Length			13 m (a)				
Operational Control Strategy	quasi-synchronous	quasi-synchronous	synchronous-point follower	quasi-synchronous			
Dispatch Policy	centralized	non-deterministic	demand responsive (a)				

TABLE A–2 (SHEET 6 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace	Cabtrack	CVS	ELAN-SIG	Monocab		
Headway Protection Fixed Block			(Okinawa)				
Block Lengths			20 m (a)				
No. of Blocks Between Vehicles			2 (a)				
Moving Block			(Higashi-Murayama)				
Communication Sample Rate			0.3–0.5 (a)				
Merge Strategy							
Minimum Headway	0.25 s (2)	0.9 s (2)	0.95 s	0.7 s (2)	5.0 s		
Merge Throughput							
Service Policy	demand-responsive	demand-responsive	demand-responsive	demand-responsive	scheduled and/or demand-responsive		
Service Goals							
Routing Strategy	variable						
Empty Vehicle Management							

TABLE A–2 (SHEET 7 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace	Cabtrack	CVS	ELAN-SIG	Monocab		
Station Management							
Separate vs Common Board/ Deboard		separate	Common (a)				
Ripple vs Platoon Movement			ripple (a)				
Fleet Management Total Fleet							
Peak Operating Fleet							
Base Operating Fleet							
Failure Management Push/Pull Capability	Yes		No		No		
Emergency Equip. & Crew Location							
Redundant Prop. or G'way Power			Battery in case of power failure		Auxiliary power		
Redundant Local Control							
Redundant Vehicle Electronics							

TABLE A–2 (SHEET 8 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace	Cabtrack	CVS	ELAN-SIG	Monotrack		
Mean Time Between Failures			(Okinawa)				
System	10,000 hr		25 h (a)	10,000 hr			
Vehicle			95 h (a)	1,000 hr			
Guideway			900 h (a)				
Station				10,000 hr			
Central Control			45 h (a)				
Mean Time to Restore Service	20 min.			1 hr			
System			0.46 h (a)				
Vehicle			0.71 h (a)				
Guideway			0.24 h (a)				
Station							
Central Control			0.34 h (a)				
System Availability Number			98.2% (a)				
Availability Definition							
System Responses to Failures							

TABLE A–2 (SHEET 9 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace	Cabtrack	CVS	ELAN-SIG	Munocab		
System Capital Cost	Based on 161 km, 200 stations, and 10,000 vehicles		Based on 450 km, 800 sta, 4000 veh/980,000 veh/km/day, 27,200 veh-hr/day, 24 hr/oper		Based on 35.5 km, 21 sta, 140 veh. 692 veh-km/day, 20 veh-hr/day, 24 hr oper		
Vehicle Cost			$17,000		$80,000		
Expected Life	10 yr		5 yr				
System Fleet Size							
Guideway Cost	$808,000/km		$1 m/km (single lane)		$0.74 m/km (single lane		
Expected Life			50 yr (a)				
System Lane Kilometers			450		35.5		
Power Distribution Cost			$11.25 M (a)		$0.37 m/km		
Expected Life			30 yr. (a)				
Station Cost	$215,000 each		$150,000 each (a)		$150,000 each		
Expected Life			30 yr. (a)				
Number of Stations							
Maintenance and Storage Facilities	$5 m		(M & S plus power dist. & substa.) - $50 m		$1.0 m		
Expected Life			30 yr. (a)				
Number of Facilities							
Communication and Controls	$28 m (comp., software & control cente)				0.68 m/km		
Expected Life							

TABLE A–2 (SHEET 10 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED PRT

System Name	Aerospace	Cabtrack	CVS	ELAN-SIG	Monocab		
System Operating Cost	3.3¢ per occupied veh-km		Fixed: $[illegible]0K/wkdy Variable: $15K/wkdy $0.30/veh-h, $0.2/veh-km		Fixed: $6K/weekday Var: $10K/weekday $4.76/veh-h, $0.17/veh-km		
Operating Hours/Day			24				
Vehicle Kilometers/Day							
Vehicle Hours/Day							
Energy Cost							
Maintenance Cost							
Vehicles							
Stations							
Facilities							
Personnel							
Maintenance							
Vehicle							
Stations							
Facilities							
Operations							
Central Control							
Stations							
General							
General and Administrative							

TABLE A–3 (SHEET 1 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram - HSD	Starrcar	Ford Act	H - Bahn Type 1/1	Morgantown		
Developer	Hawker Siddeley Dynamics Ltd.	Alden Self-Transit Systems, Corp.	Ford	Siemens Aktiengesellschaft and Duwag Waggonfabrid Uerdingen	Boeing - Prime Contractor to UMTA		
Deployment Status	Drawing board--terminated research	Morgantown proposal	Deployment, Fairlane Towne Centre	Experimental switch demonstration: Dusseldorf	Phase I operational		
Vehicle Characteristics No. of Seats Per Vehicle	6	6 - 10	10	8	8		
Design Load Per Vehicle	12	10 - 20	24	17	15		
Crush Load Per Vehicle	23	12 - 23	30	26 (a)	23 (a)		
Vehicle Length	4.6 m	3.8 - 4.3 m	7.54 m	3.45 m	4.72 m		
Vehicle Width	2.0 m	2.04 m	2.03 m	2.30 m	2.03 m		
Vehicle Height	2.6 m	2.74 m	2.64 m	2.30 m	2.67 m		
Interior Area Per Seated Passenger			0.36 m^2	0.44 m^2	0.45 m^2 (a)		
Interior Area Per Standing Passenger			0.32 m^2	0.25 m^2	0.17 m^2 (a)		
Empty Vehicle Weight	2,540 kg	2,770 - 3,162 kg	6,485 kg	4,450 kg	38,900 Nt (a)		
Load/Unload Rate Per Door			1,800 pass/hour/berth overall (2 s/pass)		0.67 s/boarding passenger (a)		
Door Width				1.6 m (a)	0.97 m (a)		
Number of Doors Per Vehicle			2	2 (a)	2 (a)		
Major Reference (except as noted)	Reference 2	Reference 1	Reference 2	Reference 2	Reference 2		

TABLE A-3 (SHEET 2 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram - HSD	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
Vehicle Characteristics (cont'd) Guideway Interface	Rubber tires	Rubber tires, concrete surface	Rubber tires, concrete surface	Suspended by rubber coated steel wheels from concrete surface	Rubber tires, concrete surface (a)		
Lateral Control Interface	Guiderail	Guide tire	Foam filled rubber tires	Steel wheel/guiding pulley	Side wall follower on mainline		
Switching Mechanism	Move rail	Active steer	On-board mechanical entrapment wheels	Electromagnet or mechanical grab	On-board vehicle passive guideway		
Switch Actuation Time		0.2 s	2 s	8 s headway	1.2 s (incl. verification)(a)		
Minimum Turning Radius		9.1 m	15.3 m	30 m (a)	9.2 m at 18 km/h (a)		
Coupler			Not yet designed (a)	automatic (a)	None		
Minimum Traveling Unit	1	1	1	1	1 (b)		
Maximum Train Consist	3	1	3	2	1 (b)		
"A" and "B" Vehicles			Yes (a)		No (b)		
Platooning Capability	None	None	None	None	None		
Propulsion Type	Electric traction motor	Asynchronous rotary electric	DC rotary	Linear induction motor or DC motor	DC motor		
Power Rating Per Unit	40 kw	74.6 - 93.2 kw	44.8 kw	Asynchr. 44 kw DC 17 kw	52.2 kw		
Number of Propulsion Units	1	1	2	1 Asynchr. 2 DC	1		

TABLE A-3 (SHEET 3 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram - HSD	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
Vehicle Characteristics (cont'd) Acceleration	1.25 m/s^2	0.98 m/s^2	0.98 m/s^2	1.25 m/s^2	0.61 m/s^2		
Cruise Speed	54 km/h	48 km/h	48 km/h	20-28 km/h	48 km/h		
Maximum Speed			48 km/h	50-60 km/h (a)	48 km/h (a)		
Service Brake Type		Hydraulic drive unit	Friction and regenerative	Regenerative (a) Dynamic	Redundant friction		
Service Deceleration	1.25 m/s^2	0.98 m/s^2	0.98 m/s^2	1.25 m/s^2	0.61 (a)		
Emergency Brake Type		Disc with feedback control	Friction	Friction	Friction		
Emergency Deceleration	2.50 m/s^2	2.90 m/s^2	2.70 m/s^2	2.50 m/s^2	3.33 m/s^2 (a)		
Emergency Brake Reaction Time				1 s	200 ms		
Maximum Grade Capability	10%	10%	6%	15% Async. (a) 7.5% DC	10%		
Reverse Capability (Bi-Directionality)			Yes	Yes (a)	No (a)		
Precision Stopping Tolerance		± 76mm	± 152 mm	± 100 mm	± 152 mm (a)		
Exterior Noise				62 dBA (a)	60 NCA @ 7.6 m		
Energy Consumption (Acceleration, Decel., Cruise)		1.16 kwh/veh-km overall	1.87 kwh/veh-km cruise	110 Wh/t km (a)	0.62 kwh/veh-km (a) cruise		
Emissions	None direct	None direct	None direct	None direct	None direct		

TABLE A–3 (SHEET 3 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram - HSD	Starcar	Ford Act	H-Bahn Type 1/1	Morgantown		
Vehicle Characteristics (cont'd) Acceleration	1.25 m/s^2	0.98 m/s^2	0.98 m/s^2	1.25 m/s^2	0.61 m/s^2		
Cruise Speed	54 km/h	48 km/h	48 km/h	20-28 km/h	48 km/h		
Maximum Speed			48 km/h	50-60 km/h (a)	48 km/h (a)		
Service Brake Type		Hydraulic drive unit	Friction and regenerative	Regenerative (a) Dynamic	Redundant friction		
Service Deceleration	1.25 m/s^2	0.98 m/s^2	0.98 m/s^2	1.25 m/s^2	0.61 (a)		
Emergency Brake Type		Disc with feedback control	Friction	Friction	Friction		
Emergency Deceleration	2.50 m/s^2	2.90 m/s^2	2.70 m/s^2	2.50 m/s^2	3.33 m/s^2 (a)		
Emergency Brake Reaction Time				1 s	200 ms		
Maximum Grade Capability	10%	10%	6%	15% Async. (a) 7.5% DC	10%		
Reverse Capability (Bi-Directionality)			Yes	Yes (a)	No (a)		
Precision Stopping Tolerance		± 76mm	± 152 mm	± 100 mm	± 152 mm (a)		
Exterior Noise				62 dBA (a)	60 NCA @ 7.6 m		
Energy Consumption (Acceleration, Decel., Cruise)		1.16 kwh/veh-km overall	1.87 kwh/veh-km cruise	110 Wh/t km (a)	0.62 kwh/veh-km (a) cruise		
Emissions	None direct	None direct	None direct	None direct	None direct		

TABLE A-3 (SHEET 4 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram - HSD	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
Typical Network Configuration	Loop, line haul, grid	Loop, grid	Shuttle (potential grid)		Grid, line haul (a)		
Maximum Grade			10%	15% (a)	10%		
Guideway Type	Closed concrete structure	Closed concrete structure	Closed concrete structure	Closed concrete structure	Open concrete structure		
Guideway Dimensions Outside Width (single/double)	2.0 m	2.74m/6.10 m	3.04–3.66 m/ 6.70–7.90 m	0.78 m	3.25/5.86 m (a)		
Height		0.61 m	0.68 m	1.125 m	1.68 m		
Running Surface Width		2.38 m	2.30 m	0.25 m (a)	0.65 m wheel paths, (a) 1.58 m centers		
Elevated Span Length	20 m	21.3 m	36.6 m	30 m	20.88 m (a)		
Construction Material	Concrete or steel	Steel and/or reinforced concrete	Prestressed concrete/ steel/combination	Steel or reinforced concrete	Reinforced concrete		
Weather Protection (Snow/Ice)		Snow/ice melting	Electric heating (a)	None (enclosed)	Fluid heating (a)		
Power Distribution AC or DC	3-phase AC	3-phase AC	3-phase AC	50 Hz AC	3-phase AC		
Voltage	415 V	208–575 V	480 V	660 V (a)	575 V		
Number of Substations Per Lane Kilometer				~2 (a)	2.9 (a)		
Lateral Control Equipment	Guide beam	Wall follower			Sidewall follower (a)		
Switching Equipment	Moving rail	Vehicle steering	Side mounted guiderail at switches	mechanical (a)	On board vehicle via steering mechanism		

TABLE A–3 (SHEET 5 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram - HSD	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
Station Configuration	On-line	Off-line	On-line/off-line	On-line/off-line	2 on-line and 10 off-line		
Number of Parallel Platforms	Series			1 (a)	2 (middle station)		
Number of Berthing Lanes			1/station (a)		2/platform (A) (a) 4/platform (B)		
Length of Platform							
Berth Configuration					Serial		
Number of Berths Per Platform					8-A (a) 14-B		
Capacity of Vehicle Queues					3 entrance (a) 1 exit		
Empty Vehicle Storage Capacity					4/platform (and stations)		
Average Vehicle Dwell Time	15 s	15-25 s	30 s (a)	30 s	21-30 s		
Vehicle Throughput (Vehicles Per Hour)				60 (a)	240 (a)		
Turnaround Capability	Apparently not	Yes			Yes		
Off-Line Acceleration/Deceleration Lane Length				80m (a)	240/hr (a)		
Operational Control Strategy		Synchronous	Fixed Block		Synchronous		
Dispatch Policy			Nondeterministic decentralized		Centralized		

TABLE A–3 (SHEET 6 OF 10) OBSERVED SYSTEM CHARACTERISTICS — LOW-SPEED SGRT

System Name	Minitram - HSD	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
Headway Protection Fixed Block		Fixed block	Fixed block		Fixed block (b)		
Block Lengths				12 m (a)			
No. of Blocks Between Vehicles				12 (a)	2 (a)		
Moving Block							
Communication Sample Rate							
Merge Strategy					Mainline priority		
Minimum Headway	10 s	3 s	20 s	8 s	15 s		
Merge Throughput							
Service Policy	Scheduled, demand stop, or demand responsive	Demand responsive	Schedule, demand stop, or demand responsive	Scheduled, demand stop, or demand responsive	Scheduled (peak) demand responsive (off-peak)		
Service Goals					5 min wait (scheduled) 2 min wait (demand)		
Routing Strategy	Fixed or variable		Fixed or real time		Fixed, with rerouting in case of emergency (a)		
Empty Vehicle Management					Circulation; store in station where emptied (a)		

TABLE A–3 (SHEET 7 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram–HED	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
Station Management							
Separate vs Common Board/ Deboard	Common		Both [a]		Separate [a]		
Ripple vs Platoon Movement							
Fleet Management Total Fleet					45 - Phase I [a] 79 - Phase II		
Peak Operating Fleet					29 vehicles Phase I [a] 65 vehicles Phase II		
Base Operating Fleet							
Failure Management Push/Pull Capability	Push [a]	Yes (push)			No [a]		
Emergency Equip. & Crew Location					Maintenance station [a]		
Redundant Prop. or G'way Power					No [a]		
Redundant Local Control					Backup Station [a] Computers		
Redundant Vehicle Electronics	Braking [a]				Yes [a]		

TABLE A–3 (SHEET 8 OF 10) OBSERVED SYSTEM CHARACTERISTICS -- LOW SPEED SGRT

System Name	Minitram-HSD	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
Mean Time Between Failures							
System					9 (a)		
Vehicle					11.9 (a)		
Guideway					355 h (incl. power) (a)		
Station							
Central Control					74 h (incl. station) (a)		
Mean Time to Restore Service							
System		5 min			12 min (a)		
Vehicle					10.6 min (a)		
Guideway					22.8 min (a)		
Station							
Central Control					12.8 min (a)		
System Availability Number			98% (a)		94% conveyance dependability (a)		
Availability Definition			Total time with any vehicle operating ÷ scheduled operating time (a)		System availability x system reliability x vehicle availability (a)		
System Response to Failures		Vehicle fail: push	Tow vehicle to station with passengers aboard	Blocked link: shuttle blocked station: bypass computer fail: linear service; vehicle fail: tow	Software headway control failure: fixed block; stalled vehicle: remote restart, local restart, tow; ticketing failure: open station (a)		

TABLE A-3 (SHEET 9 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram-HSD	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
System Capital Cost			$6.3M, including 1.0 M replacement since June 1976 (a)	$4.3 M/km double lane, including vehicles & stations	$65 M (a)		
Vehicle Cost				380,000 DM (a) (Marks)	$180,000 (a)		
Expected Life			10 yr	20-25 yr	10 yr		
System Fleet Size					45 – Phase I (a) 73 – Phase II		
Guideway Cost				6,704,732 DM/km (a)	$13.7 M/km double lane including electrification		
Expected Life				75 yr. (a)	20 yrs. (a)		
System Lane Kilometers					8.85 km		
Power Distribution Cost				DM 362,400/km (a)			
Expected Life				40 yr. (a)	20 yrs. (a)		
Station Cost				DM 697,000 (a)	$0.4-1.0 M		
Expected Life				75 yr. (a)	20 yrs. (a)		
Number of Stations					3		
Maintenance and Storage Facilities							
Expected Life				10-75 yr. (a)	20 yrs. (a)		
Number of Facilities					1		
Communication and Controls					$3.5 M		
Expected Life				10 yr. (a)	20 yrs. (a)		

TABLE A–3 (SHEET 10 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED SGRT

System Name	Minitram–HSD	Starrcar	Ford Act	H-Bahn Type 1/1	Morgantown		
System Operating Cost		$0.12/veh-km overall		(all labor) (a) 47.2%	$1,400,000 (a)		
Operating Hours/Day					13.25 (a)		
Vehicle Kilometers/Day					240 (a)		
Vehicle Hours/Day					210 (a)		
Energy Cost			$95,000 (a)	20.9% (a)	$170,000 (a)		
Maintenance Cost			$74,000 supplier (a)	26.7% (a) (excl. labor)			
Vehicles							
Stations							
Facilities							
Personnel			$305,000 (a)		51 persons		
Maintenance							
Vehicle							
Stations							
Facilities							
Operations							
Cont... al							
Stations							
General							
General and Administrative			$15,000 (a) $10,000 Ins. & tax	5.2% (a)			

TABLE A–4 (SHEET 1 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GEC/Minitram	UMTA-AGRT	GM DMTS	Rohr DMTS	TTD-DMTS		
Developer	Sacems Ltd.		GMTSD	Rohr Ind.	TTD Otis		
Deployment Status	Test Track	Conceptual	Conceptual	Conceptual, discontinued	Conceptual		
Vehicle Characteristics No. of Seats Per Vehicle	6	12	17	21	17		
Design Load Per Vehicle	15	12	17	21	17		
Crush Load Per Vehicle	34	12	29	32			
Vehicle Length	3.55 m		8.1 m	8.3 m	6.9 m pallet 6.0 m veh. only		
Vehicle Width	1.9 m		2.4 m	2.4 m	4.0 m pallet 2.1 m veh. only		
Vehicle Height	2.8 m		2.5 m	2.7 m	3.5 m pallet and veh. 2.9 m veh. only		
Interior Area Per Seated Passenger	1.8 m^2 (min.)						
Interior Area Per Standing Passenger	4.4 m^2 (8 standees)			0.23 m^2			
Empty Vehicle Weight	3,380 kg		4,865 kg	6,704 kg			
Load/Unload Rate Per Door			1.5 pass/s				
Door Width			91 cm				
Number of Doors Per Vehicle			1	1	1		
Major Reference (except as noted)	Reference 1		Reference 12		Reference 16		

TABLE A–4 (SHEET 2 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GEC/Minitram	UMTA-AGRT	GM DMTS	Rohr DMTS	TTD-DMTS		
Vehicle Characteristics (cont'd) Guideway Interface	Steel wheels, steel rails		Pneumatic rubber tires	Rubber tires	Hovair		
Lateral Control Interface	Flanged wheels		Lateral ref-mag. field around wire in guideway	Horizontal wheel on guideway sidewall	Four guidewheels (one at each corner)		
Switching Mechanism	Guideway active mechanical switch		Two wires at switch pt. mech. switch arm	Veh. switch wheel extends to wall	Two switch arms each side of pallet		
Switch Actuation Time	3 s						
Minimum Turning Radius	12 m		10 m	9.1 m	38.1 m (pallet)		
Coupler			none				
Minimum Traveling Unit	1	1	1	1	1		
Maximum Train Consist	3		1				
"A" and "B" Vehicles			All "A"				
Platooning Capability	None	None	None	None	None		
Propulsion Type	Series wound DC traction motor		Gasoline engine DC motor auxiliary	Diesel	LIM		
Power Rating Per Unit	70.4 kw		194 kw at 4800 rpm 22 kw per motor	187 kw	70 kw		
Number of Propulsion Units	1		1 engine, 2 motors	1	2 (one each side of veh.)		

TABLE A–4 (SHEET 3 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GBC/Minitram	UMTA-AGRT	GM-DMTS	Rohr-DMTS	TTD-DMTS		
Vehicle Characteristics (cont'd) Acceleration	1.25 m/s^2		2.2 m/s^2	0.98 m/s^2	0.9 m/s^2		
Cruise Speed	54 km/h	64 km/h (8)	90 km/h corridor 43.2 km/h CBD		80 km/h corridor 48 km/h CBD		
Maximum Speed	90 km/h			104 km/h	80.4 km/h		
Service Brake Type	Air actuated friction brakes		Closed-loop friction brakes	Friction brakes	Dynamic		
Service Deceleration	1.25 m/s^2		2.2 m/s^2	1.47 m/s^2	1.47 m/s^2		
Emergency Brake Type	Electro-magnetic friction brake		Same as service brakes		Friction skid pads		
Emergency Deceleration	1.25 m/s^2		5.1 m/s^2	5.1 m/s^2	5.2 m/s^2		
Emergency Brake Reaction Time			0.1 s	1.0 s			
Maximum Grade Capability	10%		6% at 90 km/h 24% at 10 km/h	6%	6%		
Reverse Capability (Bi-Directionality)			No				
Precision Stopping Tolerance	± 15 cm		± 15 cm				
Exterior Noise	70 dbA at 7.5 m		82 dbA	90 dbA at 7.6 m	70 dbA at 7.6 m (75 dbA off guideway)		
Energy Consumption (Acceleration, Decel., Cruise)	1.9 kwh/km accel 0.8 kwh/km cruise				1.87 kwh/km (5.75 km/l off guideway)		
Emissions	No direct emissions		16 gm HC & NO_x per bhp-h [illegible] gm CO per bhp-h	5 gm HC & NO_x per hp-h 25 gm CO per hp-h			

TABLE A–4 (SHEET 4 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GEC/Minitram	UMTA-AGRT	GM-DMTS	Rohr-DMTS	TTD-DMTS		
Typical Network Configuration	Loop		Grid				
Maximum Grade	10%		6%				
Guideway Type	Closed concrete structure		Closed concrete structure		Closed concrete structure		
Guideway Dimensions Outside Width	2.375 m single 4.75 m double		7.84 m double	4.06 m single 6.07 m double	3.6 m		
Height	1.37 m		1.65 m		1.47 m		
Running Surface Width	1.067 m		2.94 m	3.2 m	3.23 m		
Elevated Span Length	30 m		25 m		30 m		
Construction Material	Reinforced concrete		Pre-cast, pre-stressed concrete or steel	Reinforced concrete	Concrete or concrete and steel		
Weather Protection (Snow/Ice)	Electric heating		Fluid heating		Manual removal		
Power Distribution AC or DC			None	DC for vehicle control only	AC, 3 phase		
Voltage			N.A.		575 V		
Number of Substations Per Lane Kilometer			N.A.		Guiderails at switches		
Lateral Control Equipment	Rails		Wire in guideway	Sidewalls	Sidewalls		
Switching Equipment	Mechanical lock		Slot in guideway entraps veh, switch arm	Sidewall with rail as back-up			

TABLE A–4 (SHEET 5 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GEC/Minitram	UMTA-AGRT	GM-DMTS	Rohr-DMTS	TTD-DMTS		
Station Configuration	Off-line		Off-line	Off-line	Off-line		
Number of Parallel Platforms	2		1	1 (18)			
Number of Berthing Lanes			1	1 (18)			
Length of Platform			62 m	36.6 m (18)			
Berth Configuration			Sawtooth	Serial	Dock		
Number of Berths Per Platform			3				
Capacity of Vehicle Queues			1 entrance, 1 exit				
Empty Vehicle Storage Capacity							
Average Vehicle Dwell Time	15 s		58 s (corridor)				
Vehicle Throughput (Vehicles Per Hour)			188 (CBD) 125 (corridor)				
Turnaround Capability			Yes	No	Yes		
Off-Line Acceleration/Deceleration Lane Length			77 m diverge lane 234 m merge lane		213.3 m decel lane 304.8 m accel lane		
Operational Control Strategy	Synchronous		Synchronous	Asynchronous	Asynchronous		
Dispatch Policy			Deterministic				

TABLE A–4 (SHEET 6 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GBC/Minitram	UMTA–AGRT	GM–DMTS	Rohr–DMTS	TTD–DMTS		
Headway Protection Fixed Block	Moving block		Moving block	Moving block			
Block Lengths							
No. of Blocks Between Vehicles							
Moving Block							
Communication Sample Rate			100 ms/veh				
Merge Strategy			Predetermined FIFO				
Minimum Headway	12 s	3s	5.68 s	7.3 - 7.7 s	6.1 s		
Merge Throughput							
Service Policy	Scheduled		Demand reponsive	Scheduled and demand responsive	Scheduled and demand responsive		
Service Goals							
Routing Strategy			Variable	Variable			
Empty Vehicle Management			Store in station near anticipated demand	Maintain prescribed inventory in network			

TABLE A–4 (SHEET 7 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GBC/Minitram	UMTA-AGRT	GM-DMTS	Rohr DMTS	TTD-DMTS		
Station Management							
Separate vs Common Board/Deboard			Common board/deboard ripple movement		Common board/deboard		
Ripple vs Platoon Movement							
Fleet Management Total Fleet							
Peak Operating Fleet							
Base Operating Fleet							
Failure Management Push/Pull Capability			No				
Emergency Equip. & Crew Location	Tow vehicles		Tow vehicle in stations at 6.4 km intervals				
Redundant Prop. or G'way Power			Back-up propulsion		Back-up propulsion		
Redundant Local Control			Each local computer monitors next sector				
Redundant Vehicle Electronics							

TABLE A–4 (SHEET 8 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GBC/Minitram	UMTA–AGRT	GM–DMTS	Rohr–DMTS	TTD–DMTS		
Mean Time Between Failures							
System							
Vehicle	2,000 h		4,348 h (control equipment)	12,872 km	1,250 h		
Guideway					3,700 h (power distribution)		
Station			17,543 (control equipment)		1,900 h		
Central Control			1,264 h		3,500 h		
Mean Time to Restore Service							
System	0.75 h						
Vehicle					0.5 h		
Guideway					0.75 h (power distribution)		
Station					0.75 h		
Central Control					0.5 h		
System Availability Number			.998				
Availability Definition			Vehicle up-time / Total time				
System Response to Failures			Continue to next station at reduced speed. Stopped vehicle towed to next station by tow vehicle.				

TABLE A-4 (SHEET 9 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GEC/Minitram	UMTA-AGRT	GM-DMTS (13)	Rohr-DMTS	TTD-DMTS		
System Capital Cost			$357,546,600 (1974)				
Vehicle Cost			$ 36,355	$ 25,750 (19)	$115,000 (pallet)		
Expected Life	20 years		10 years		20 years		
System Fleet Size			2,000				
Guideway Cost Per Mile			$1,135,000 elev. (single) $ 589,375 grade (single) $ 657,000 mow (dual) $ 138,000 vee (dual)	$730,000 at grade $3,370,000 elevated	$765,600 at grade $1,980,000 elevated $5,227,000 below grade		
Expected Life	50 years		30 years		20 years		
System Lane Kilometers			225				
Power Distribution Cost			N.A.	$225,000 (19)	$448,000-$501,600 (17)		
Expected Life			N.A.				
Station Cost			$1,185,942 CBD $1,417,389 corridor	$45/S.F. CBD $60/S.F. corridor (19)	$940,000 CBD $1,920,000 suburban (17)		
Expected Life			30 years				
Number of Stations			50				
Maintenance and Storage Facilities			$1,495,300 main $ 664,300 operating	$25/S.F. (19)	$2,100,000 plus $900 per veh over 1,000 (17)		
Expected Life	50 years		30 years				
Number of Facilities			1 main, 6 operating				
Communication and Controls			$7,776,305	$2,500,000 (19)	$38,989,000 (17)		
Expected Life			20 year				

TABLE A–4 (SHEET 10 OF 10) OBSERVED SYSTEM CHARACTERISTICS – HIGH SPEED SGRT

System Name	GEC/Minitram	UMTA-AGRT	GM-DMTS	Rohr-DMTS	Rohr-DMTS		
System Operating Cost			$52,484,080				
Operating Hours/Day			24				
Vehicle Kilometers/Day			551,080				
Vehicle Hours/Day							
Energy Cost			$ 9,082,200				
Maintenance Cost			$14,476,900				
Vehicles			$12,083,000		$19,288 per veh[17]		
Stations			$ 1,060,200		$13,240 per sta[17]		
Facilities			$ 1,332,800		$2,800 per mile[17]		
Personnel			2,636				
Maintenance			596				
Vehicle			437				
Stations			106				
Facilities			53				
Operations			2,040		$5,657,000[17]		
Central Control			230				
Stations			370				
General			1,440 (drivers)				
General and Administrative			3.124% of oper.		$1,020,000[17]		

TABLE A–5 (SHEET 1 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
Developer	LTV	Kobe Steel Ltd., and Nissho/Wai Co., Ltd.	Rohr	Rohr	Rohr	Universal Mobility, Inc.	Community Transportation Services
Deployment Status	Operational at Dallas/Ft. Worth	Demo at an exposition	Several installations	Test track	Houston Airport, Pearl Ridge, Bronx Zoo	15 installations	Operational at Disney World (a)
Vehicle Characteristics No. of Seats Per Vehicle	16	10	J 40 K 36 or 40	20 (a)	8	14	4 (a)
Design Load Per Vehicle	40		J 40 K 36 or 40	72 to 45	18 (a)	20	4 (a)
Crush Load Per Vehicle	40	30			24		6 (a)
Vehicle Length	6.8 m (a)	4.72 m w/o coupler 4.77 m with	J 36.9 m K 29.3 - 21.9 m	9.24 m	A car 4.36 m B car 3.14 m	4.11 m	2.46 m
Vehicle Width	2.2 m (a)	2.03 m	1.7 m	2.44 m	2.0 m (a)	1.83 m	1.45 m
Vehicle Height	3.3 m (a)	2.67 m	J 2.2 m K 1.8 m	3.25 m	2.74 m	2.26 m	1.14 m (open car)
Interior Area Per Seated Passenger	$0.42\ m^2$ (a)			$0.368\ m^2$	$0.37\ m^2$		$0.42\ m^2$ (a)
Interior Area Per Standing Passenger	$0.27\ m^2$ (a)			$0.230\ m^2$	$0.23\ m^2$		No standees (a)
Empty Vehicle Weight	6440 kg (a)	4,100 kg	J 12,517 kg K 9,025-6,984 kg	8,389 kg		1,088 kg	426 kg
Load/Unload Rate Per Door	2.5 pass/sec (a)						
Door Width	1.37 m (a)					0.48 m (a)	0.58 m (a)
Number of Doors Per Vehicle	1		J 1 K 1 or 2	2 (a)	Pearlridge–door on each side, not used simultaneously (a)	4/veh, 2 on each side (a)	1
Major Reference (except as noted)	Ref. 2	Ref. 2	Ref. 1	Ref. 1	Ref. 2	Ref. 2	Ref. 2

TABLE A-5 (SHEET 2 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
Vehicle Characteristics (cont'd) Guideway Interface	4 foam-filled rubber tires	4 two-chamber rubber tires	4 pneumatic tires per articulated bogie	2 rubber-tired bogies/veh.	4 permaform tires/ articulated bogie	Rubber tires on steel I beam	Steel wheels with urethane coating (11)
Lateral Control Interface	Double Ackerman actuated by guidewheels	One-side steering	4 pneumatic guide-wheels	Rubber tired guide-wheels on bogie	4 pneumatic guidewheels	Solid rubber tires	Front-rear guide-wheels
Switching Mechanism	Vehicle is passive	On vehicle via steering mech.	Vehicle is passive	Vehicle is passive	Vehicle is passive (a)	Vehicle is passive (a)	Pneumatic power automatic switch under development (11)
Switch Actuation Time	3 s			8 s	9 s (1)	10 - 15 s	5 s
Minimum Turning Radius	45.7 m at 27.4 km/h (a)			30.5 m	20 m at 13 km/hr		Min. track radius at Disneyworld is 6.31m (a)
Coupler	Manual (a)		Manual (a)	Manual	N/A	Manual	
Minimum Traveling Unit	1	1	Articulated trains	1	Pearlridge 4 (a) Bronx 9 Houston 3	2	5 (11)
Maximum Train Consist	2 (expansion to 3 possible)	3	Articulated trains	4	Pearlridge 4 (a) Bronx 9 Houston 3	8	5
"A" and "B" Vehicles	Yes (10)		Yes		Yes	Yes	N.A.
Platooning Capability	None	None	None	None	None	None	None
Propulsion Type	DC motor, drive shaft, differential	DC motor	DC motor	DC motor	DC traction motor solid state relay.	Electric motor	Lim, active track, air gap 3.81 mm
Power Rating Per Unit	44.7 kw	50 kw	Up to 18.7 kw	37.3 kw	Pearlridge 15 HP Bronx 5 HP Houston 7.5 HP	Up to 6.7 kw	400 N thrust @ 240 V, 20 A, 60 cycle
Number of Propulsion Units	1 on chassis (10)	1	1 per bogie	1 per bogie	1 per bogie	1 each end or 1 each bogie (a)	Passive platen

TABLE A-5 (SHEET 3 OF 10) OBSERVED SYSTEM CHARACTERISTICS -- LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
Vehicle Characteristics (cont'd) Acceleration	$1.14 m/s^2$ (a)	$0.6 - 1.2 m/s^2$	$1.34 m/s^2$	$1.34 m/s^2$	$1.0 m/s^2$	$0.91 m/s^2$	$0.6 m/s^2$
Cruise Speed	27.4 km/h	50 km/h	J 24.2 km/h K 48.3 km/h	48.2 km/h	13 km/h	29 km/h	11.0 km/h (a)
Maximum Speed	30.6 km/h	50 km/h		48.2 km/h	13 km/h	29 km/h	21.9 km/h
Service Brake Type	Friction	Friction, dual hyd.	Dynamic plus drum	Dynamic plus hyd. drum	Dynamic plus drum regenerative normal	Dynamic regenerative	Reverse lim polarity
Service Deceleration	$1.14 m/s^2$ (a)	$0.6 - 1.2 m/s^2$	$1.34 m/s^2$	$1.34 m/s^2$	$1.0 m/s^2$	$0.91 m/s^2$	$0.6 m/s^2$
Emergency Brake Type	Service brake, spring actuated		Electromechanical shaft	Motor shaft brake	Spring applied shaft brake	Spring applied friction	Reverse (a) LIM polarity
Emergency Deceleration	$1.96 m/s^2$ (a)	$1.46 - 2.93 m/s^2$	$1.46 m/s^2$	$1.48 m/s^2$	$2.9 m/s^2$	$1.96 m/s^2$	$2.94 m/s^2$
Emergency Brake Reaction Time	0.8 s		1.0 s			0.25 s	Instantaneous (a)
Maximum Grade Capability	8%		6%	6%	4.37%	8%	15%, based on pass. comfort
Reverse Capability (Bi-Directionality)	Yes (a)				Bi-directional (a)	Bi-directional	Yes (a)
Precision Stopping Tolerance	± 457 mm (a)	150 mm	± 152 mm	± 152 mm	± 152 mm	± 50 mm (a)	N.A. (a)
Exterior Noise	NCA 70 @ 1.5 m		NCA 60	NCA 60 @ 30.5 m	NCA 70 @ 15 m	Less than 60 dbA @ 7.62m	No propulsion noise
Energy Consumption (Acceleration, Decel., Cruise)	1.48 kwh/veh-km 1st year av.					6 kwh/125-passenger train @ cruise	0.061 kwh/pers. mile @ 85% load, 90% P.F.
Emissions	No direct		No direct	No direct	No direct	No direct	No direct

TABLE A-5 (SHEET 4 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
Typical Network Configuration	Multiple loop, overlapping [a]				Pearlridge - Shuttle [a] Bronx Zoo - Loop	Single loop, single lane [a]	Loop
Maximum Grade	8.8% [a]				Pearlridge 4.59% [a] Bronx Zoo 11%	8 - 10%	None [a]
Guideway Type	Closed concrete structure	Support	Support			Steel rails, twin I-beam [a]	Closed concrete structure
Guideway Dimensions Outside Width	2.79 m [a]		0.686 m [2]	0.38 m	0.203 m (guidebeam only)	0.762 m	1.07 - 1.16 m
Height	1.52 m [a]		4.6 m	0.28 m	0.121 m (guidebeam only)	0.558 m	0.91 - 1.22 m
Running Surface Width	2.49 m [10]		0.18 m			0.762 m	0.9 m over running rails [a]
Elevated Span Length	30.48 m Max [a]		27.4 m Max	27.4 m Max	40.0 m Max	22.86 m Turn radius 15.3 m	21.3 - 27.4 m
Construction Material	Reinforced concrete		Steel	Concrete surface, steel or alum. guidebeams	Concrete and steel	Steel I-beams [a]	Concrete or steel
Weather Protection (Snow/Ice)	Glycol before freezing, manual removal [10]				Pearlridge: None required	Rubber boot around power rails grit on running surface [a]	None [11]
Power Distribution AC or DC	AC	AC	AC	AC	AC	AC	NA
Voltage	480 V, 3 phase	50 V	1 phase	600 V, 1 phase	480 V, 1 phase	565 V, 3 phase	
Number of Substations Per Lane Kilometer	0.71 substations/lane km [10]						
Lateral Control Equipment	On vehicle			Guidebeam		Rubber tire hold on beam [a]	Guidewheels steer bogie through kingpins and tierods
Switching Equipment	Mechanical switch blade on guideway entraps veh. guidewheels	On vehicle	Guiderails move	Guidebeam moves	Guideway moves [a]	Hydraulically thrown switch [a]	

TABLE A-5 (SHEET 5 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
Station Configuration	Both on-line and and off-line (10)	Either	On-line	On-line	On-line	Either on-line @ Kings I. (a)	Either on-line uses revolving platform
Number of Parallel Platforms	1					1 and 2 (a)	Load/unload (a) platforms in tandem
Number of Berthing Lanes	1 (a)					1 and 2 (a)	N.A. (a)
Length of Platform	30.12 m (a)			At least 36.6 m	Pearlridge 24.4 m	45.72 m	load = 11m (a) unload = 11m
Berth Configuration	Serial	Serial				Serial (no queuing) (a)	N.A. (a)
Number of Berths Per Platform	1 (2 car train) (a)					1 (a)	N.A. (a)
Capacity of Vehicle Queues	1 (a)					1 entrance and exit, 0 storage (a)	
Empty Vehicle Storage Capacity	N.A. (a)						None in station (a)
Average Vehicle Dwell Time	18 s			30 s	Regulated	20 s	load 18 sec (a) unload 18 sec
Vehicle Throughput (Vehicles Per Hour)	60 veh/hr (a)					342 veh/h Max	900/hr (a)
Turnaround Capability	No (a)					Yes, using perpendicular spur (a)	None (a)
Off-Line Acceleration/Deceleration Lane Length	41.15 m (a)					N.A., on-line (a)	N.A. (a)
Operational Control Strategy	Quasi-sync.					Async., vehicle follower	
Dispatch Policy	Internal schedule (a)					Deterministic, centralized	

TABLE A-5 (SHEET 6 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
Headway Protection Fixed Block	Fixed block (10)		Fixed block (2)	Fixed block	Fixed block (a)	Fixed block	Dead zone behind each vehicle/train
Block Lengths	13.6 - 73.1 m 27.4 m avg.						
No. of Blocks Between Vehicles	4 btwn, 1 veh. every 5 blocks						
Moving Block	No (a)						
Communication Sample Rate	N.A. (a)						
Merge Strategy	First in, first out (b)						
Minimum Headway	18 s	9 s	60 s	60 s (2)	Pearlridge 4 min	45 s operational 36 s theoretical	4 s/car (a) 20 s/train
Merge Throughput						60 s min. headway through switch	
Service Policy	Fixed schedule, (a) fixed stop	Scheduled and on-demand	Scheduled	Scheduled	Scheduled	Scheduled, all station stop (a)	Scheduled, demand resp. in dev.
Service Goals	20 min. between terminal (a) 30 min. to parking						
Routing Strategy	Fixed (a)		Fixed	Fixed	Fixed	Fixed	
Empty Vehicle Management	Circulation (a)					Stored in maint. area off-line (a)	Store near anticipated demand on siding

TABLE A-5 (SHEET 7 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
Station Management							
Separate vs Common Board/Deboard	Common B/D (10)				Common B/D	Common, deboard one side, board other side (a)	Separate (a)
Ripple vs Platoon Movement	N.A. (a)						Ripple (a)
Fleet Management Total Fleet	51 passenger (a) 17 utility						
Peak Operating Fleet	39 vehicles (a) (in 25 trains)					5-9 car trains	
Base Operating Fleet	37 vehicles (a) (in 25 trains)					3-7 car trains	
Failure Management Push/Pull Capability	No, violates headway control sys. (10)					Specified, not operational (a)	30% of non-adj. motors can be inop. without affecting veh. performance; pass. evacuation by walkways and stairways
Emergency Equip. & Crew Location	Sidings throughout sys.				Pearlridge - maint. at lowest point, roll to maint.	At maintenance area (a)	
Redundant Prop. or G'way Power	Yes, trains, veh. No		Yes				
Redundant Local Control	Non-Redundant (a)					Redundant, except for veh. computer (a)	
Redundant Vehicle Electronics	Non-Redundant (a)					12 V bat. for emerg. light (a)	

TABLE A-5 (SHEET 8 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
Mean Time Between Failures	On-board movement and control (a) MTBF 585 hrs ob 500 hrs req Other 312 hrs ob 1000 hrs req Off-vehicle movement and control MTBF 64 out ob 50 req Other 32 hr ob 50 hr req 14,100 km per power brush 27,400 km per signal brush					80 hr/1250 hr downtime (a)	
System			4,000 hr				99.8% operational (a) readiness
Vehicle			4,000 hr	5,000 hr		2,000 hr	
Guideway						No failure	
Station			4,000 hr			4,000 hr	
Central Control						1 year	
Mean Time to Restore Service	On-board Movement and control (10) 0.5 hr req. Other 2.0 hrs req. Off-vehicle Movement and control 0.5 hr req. Other 2.0 hrs req.						
System			0.5 hr	0.5 hr			
Vehicle							
Guideway							
Station							
Central Control	N.A. (a)						
System Availability Number	98.0% (a)				Houston: 4-5% downtime (a)		After 4 months debugging now operates 8-17 hr/day w/appr. 0.2% downtime
Availability Definition	A = Uptime / Scheduled time (a)						
System Response to Failures	N.A. (a)						

TABLE A-5 (SHEET 9 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
System Capital Cost							
Vehicle Cost	$\$10.89 \times 10^6$ total passenger vehicles				Pearlridge: $\$1.15 \times 10^6$ for 366 m track & 1 4-car train (a)	$250,000/train train-10 cars 120 pass/train (a)	$7,200/vehicle for Disney World (d)
Expected Life	20 year				15 years	10 years	20 years (a)
System Fleet Size	Fleet 31 A's 20 B's (10)					7 trains total	150 (a)
Guideway Cost	$\$4.3 \times 10^6$ at grade $\$3.8 \times 10^6$ elevated (10)				Bronx Zoo $\$2.5 \times 10^6$ for electrification and guideway 3,658m (a)	$895,000/km (a)	$\$3.3 \times 10^6$/km (a) $\$1.1 \times 10^5$ for elect. controls
Expected Life							
System Lane Kilometers	16.8 km at grade 4.2 km elevated					3.2 km	
Power Distribution Cost	$\$4.3 \times 10^6$ (10)						
Expected Life						30 years	
Station Cost	$8,880/station (10)					$120,000/station (a)	
Expected Life						30 years	
Number of Stations	55 stations					1 at King's Island (a)	1 (a)
Maintenance and Storage Facilities	$\$2.67 \times 10^6$ (10)					$360,000 (a)	
Expected Life						30 years	
Number of Facilities	1					1 at King's Island	
Communication and Controls	$\$7.35 \times 10^6$ control $468,000 comm. (10)					Appr. 10% of system costs (a)	
Expected Life							

TABLE A–5 (SHEET 10 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LOW SPEED IGRT

System Name	Airtrans	KRT-100	Rohr "J" & "K" Series	Rohr "M" Series	Rohr "P" Series	Unimobil Type II Tourister	WEDway
System Operating Cost	1.55 kwh/veh. km avg. for 5.8x10[6] veh. km (10)					6 kwh/125-pass. train	
Operating Hours/Day							12 (a)
Vehicle Kilometers/Day							100 (a)
Vehicle Hours/Day							
Energy Cost	$10,318/month av. 1/75 - 6/75 (10)						$0.22/km-maint. $0.0081/pass-km utilities
Maintenance Cost	$114,080/month avg. 1976					$12,000/train/yr.	
Vehicles							
Stations							
Facilities							
Personnel						15 people at $2.15/hr 125 days operating (a)	
Maintenance							
Vehicle							
Stations							
Facilities							
Operations							
Central Control							
Stations							
General	$189,500/month, labor, materials, G&A					Installation &700,000 (a)	
General and Administrative							

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
Developer	Bendix Corp.	Kawasaki Heavy Industries, Ltd.	Freid. Krupp GMBH	Mitsubishi Heavy Industries, Ltd.	Tokyo Shibaura Electric Co., Ltd.
Deployment Status	Transpo '72, test track	Test track	Test track planned	Test track	Proto test, 2 proposals
Vehicle Characteristics No. of Seats Per Vehicle	12-40	16-24	24	16	A--4 B--8
Design Load Per Vehicle	40-72	30-50	48	32	A--13 B--25
Crush Load Per Vehicle		45-75 (a)	72	50	A--16 B--30
Vehicle Length	6.7-9.1 m	6.3-8.5m (a)	11 m	5.7m (a)	A--7.15 m B--4.58 m
Vehicle Width	2.1 m	2.4 m	2.2 m	2.2 m	A--2.0 m B--2.0 m
Vehicle Height	3.05 m	3.15 m	2.5 m	2.9 m	A--2.4 m B--2.4 m
Interior Area Per Seated Passenger	$0.46m^2$	$0.28\ m^2$	$0.58\ m^2$	$0.32m^2$ (a)	A--$0.325\ m^2$ B--$0.325\ m^2$
Interior Area Per Standing Passenger	$0.28\ m^2$	$0.14\ m^2$	$0.25\ m^2$	$0.33m^2$ (a)	A--$0.249\ m^2$ B--$0.241\ m^2$
Empty Vehicle Weight	6,800-9,090 kg	6,000-9,500 (a)	11,000 kg	5,000 (a)	A--6,200 kg B--3,500 kg
Load/Unload Rate Per Door					
Door Width					
Number of Doors Per Vehicle				1 each side	
Major Reference (except as noted)	Reference 2	Reference 2	Reference 1	Reference 1	Reference 1

TABLE A-6 (SHEET 1 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAIN	UNIMOBIL TRANSPORTER	URBA 30	VONA
Niigata Engineering Co., Ltd. & Sumitomo Shojikaisha	Transit Innovations	Bertin & CIC	Universal Mobility Inc. Harbegger, Ltd.	Compagnie d'Energetique Lineaire m.b.	Mitsui & Co., Ltd. & Nippon Sharyo Seizo Kaisha, Ltd.
Test track	Drawing board	Test track	Prototype testing	Prototype testing	Prototype demonstration at amusement park
25 (a)	22	36	10-20	30	11
50	37	52	34	30	25
75	42		40	30	35
7.6m (a)	A—8.23 m B—7.37 m	16,255 m	6,096 m	9 m	5.3 m
2.28 m	A—2.4 m B—2.4 m	1.93 m	2.286 m	2 m	2.06 m
3.15m (a)	A—2.44 m B—2.44 m	2.59 m	2.743 m	2 m	3.06 m
0.3m² (a)	A—0.49 m² B—0.46 m²		0.23 m²	0.5 m²	0.28 m²
0.29 m²	A—0.29 m² B—0.36 m²		0.22 m²		0.25 m²
10,500 kg (a)	A—4,467 kg B—4,400 kg	5,895 kg	4,080 kg	3,636 kg	4,500 kg
1.3 m (a)					
1 each side	1 side door - emergency end doors	4			1 each side
Reference 2	Reference 2	Reference 1	Reference 2	Reference 1	Reference 1

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
Vehicle Characteristics (cont'd) Guideway Interface	Hard rubber or foam filled tires	Rubber tires, concrete guideway	Steel wheel, steel rail	Pneumatic tires	Rubber tires
Lateral Control Interface	Horizontal tires	Guide tire	Flanged wheels	Horizontal tires under vehicle on center I beam	Rubber tires
Sw[illegible]g Mechanism	Guide way wheel entrapment	Guideway vertical wall movement	Conventional rail switch	Physically move guideway surface	Horizontal movement of guideway
Switch Actuation Time	1 s	3 s		6 s	8 s
Minimum Turning Radius	22.8 m	20 m	60 m	10 m [a]	20 m
Coupler		Automatic			
Minimum Traveling Unit	1	1	1	1	2
Maximum Train Consist	4	6	5	8	12
"A" and "B" Vehicles					Yes
Platooning Capability					
Propulsion Type	Rotary electric	DC shunt	Electric DC motors	Electric DC motors	DC electric
Power Rating Per Unit	25-125 hp	50 kw at 2,210 rpm	75 kw at 3,300 rpm	87 hp	60 hp
Number of Propulsion Units	1 or 2	1 or 2	2	1	1

TABLE A-6 (SHEET 2 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
4 foam filled tires on concrete guideway	Steel wheel, steel rail with roller grip	Air cushion suspended with pinion drive	Rubber tires	Air suction (rail backup)	Pneumatic tires
Double Ackerman by 4 guidewheels	Wheel grip rail	Center beam	Tires follow walls	Air suction	Center beam
Mechanical switch blade captures guidewheel	Movable actuator and back-to-back switches		Side switch on guideway	On Guideway (mechanical movement)	Moveable guideway
3 s	10 s		6-14 s	5 s	10 s
20 m	27.43 m	25m	12 m	40 m	20 m
Automatic					
2 (a)	1	1	1	1	1
6	4		5	8	12
	Yes		Yes		Yes
DC shunt	Electric motors	Electric motors	Electric motors	Linear induction motor	Rotary DC engine
(2) 80 kw (a)	60 hp per wheel at 4,800 rpm	150 kw, 35 kw lift	7.5-40 hp/motor	26.8 hp (20 kw)	73.8 hp at 55 kw and 2,200 rpm
1 per 2 vehicles (a)	2 on each wheel	1	2-4	6	1

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
Vehicle Characteristics (cont'd) Acceleration	1.73 m/s^2	4.2 km/h/s (a)	1.3 m/s^2	1.11 m/s^2	0.56 m/s^2
Cruise Speed	48 km/h	65 km/h	33 km/h	60 km/h	30 km/h
Maximum Speed	64 km/h	70 km/h (a)	70 km/h	60 km/h	60 km/h
Service Brake Type	Friction (dynamic optional)	Regenerative with hydraulic backup	Motor brakes	Air brake	Dynamic regenerative disk
Service Deceleration	0.98-1.73 m/s^2	3.0-4.2 km/h/s (a)	1.2 m/s^2	1.11 m/s^2	0.84 m/s^2
Emergency Brake Type	Disk - pneumatic		Spring loaded plus E-mag track brakes		Pneumatic disk
Emergency Deceleration	2.9-3.92 m/s^2	5.4 km/h/s (a)	2.5 m/s^2	1.67 m/s^2	1.25 m/s^2
Emergency Brake Reaction Time	0.6 s	0.5 s		0.9 s	3 s
Maximum Grade Capability	10%	10%	10%	10%	10%
Reverse Capability (Bi-Directionality)					
Precision Stopping Tolerance	± 0.15 m	± 0.15 m	± 1.0 m		3 m
Exterior Noise	NCA 60 at 7.5 m	67 dbA at 6 m	80 dbA at 5 m	64 dbA at 30 m	75 dbA at 10 m
Energy Consumption (Acceleration, Decel., Cruise)	1.9-3.1 kwh/veh-km	Acc/dec: 1.25 kw/veh-km Cruise: 0.88 kw/veh-km	Cruise: 1.1 kwh/veh-km		Acc/dec: 9.2 kwh/veh-km Cruise: 0.47 kwh/veh-km
Emissions	None directly	None directly	None directly	None directly	None directly

TABLE A-6 (SHEET 3 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
0.97 m/s^2		1.15 m/s^2	0.91 m/s^2	1.25 m/s^2	.69 m/s^2
50 km/h	89 km/h	80 km/h	56 km/h	50 km/h	60 km/h
60 km/h	89 km/h	105 km/h	56 km/h	70 km/h	72 km/h
Regenerative - electric Air-actuated disk (a)	Regenerative - disk	Electro dynamic with grip pads	Regenerative (SCR)	Dynamic - by Linear motor	Hydraulic
0.97 m/s^2			0.91 m/s^2	1.25 m/s^2	0.69 m/s^2
Air actuated disk (a)	Disk tread		Friction disk or drum	Friction (drop to skid pad), shoe brakes	Spring brakes
1.39 m/s^2		1.96 m/s^2	1.95 m/s^2	2.5 m/s^2	1.25 m/s^2
1 s			0.5 s	0.5 s	0.3 s
10%	12%	8-15%	8%	10%	7%
Yes (a)					
±0.5 m (a)	±0.05 m		±0.076 m	±0.127 m	±0.3 m
60 dbA at 7.5 m		70 dbA at 7.5 m		70 dbA at 7 m	65 dbA at 8 m
1.95 kwh/veh-km (a)	Acc/dec: 0.42 kwh/veh-km Cruise: 0.47 kwh/veh-km			Acc/dec: 5 kwh/veh-km Cruise: 3.25 kwh/veh-km	Acc/dec: 0.99 kwh/veh-km Cruise: 0.76 kwh/veh-km
None directly	None directly		None directly	None directly	None directly

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
Typical Network Configuration	Line haul - loops	Shuttle or loop	Linear, grid	Line haul, loops	Linear, loops
Maximum Grade		10%	10%		10%
Guideway Type	Closed concrete	Open concrete	Steel rail	Open concrete	Steel box beam
Guideway Dimensions	Single / Double	Single / Double	Single / Double		Single / Double
Outside Width	2.53 m / 6.03 m	3.12 m / 6.12 m	2.5 m / 5.7 m	2 m	2.7 m / 4 m
Height	1.524 m / 1.524 m	0.95 m / 0.95 m	2.7 m / 2.7 m	0.6 m	1.8 m / 1.8 m
Running Surface Width	2.033 m / 2.033 m	0.4 m each tire / 0.4 m each tire	2 m / 2 m/lane	0.3 m strips at 17 m separation	0.9 m / 0.9 m
Elevated Span Length	18.3-36.6 m	40 m / 40 m	30 m	15 m	30 m
Construction Material	Steel or reinforced concrete	Steel or concrete	Steel	Steel or reinforced concrete	Welded steel
Weather Protection (Snow/Ice)			None (25-30% degradation)		None
Power Distribution AC or DC		Power rail			
Voltage	480 Vac, 3 phase	440 Vac, 3 phase 300-600 A/veh	750 Vdc	550 Vac, 3 phase	600 Vdc
Number of Substations Per Lane Kilometer					
Lateral Control Equipment	Wall or rail	Guide wall (0.95 m high)	Rail	Center I-beam	Box beam
Switching Equipment	I-beam or sidewall blade entrapment	Rapid vertical action of guidewall	Rail movement	Electrohydraulic: physical movement of surface	Guideway physically moves sideways

TABLE A-6 (SHEET 4 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
Shuttle, loop	Linear, 2-way	Line haul	Shuttle or loop	Loops, line haul, limited area	Linear or loops
10%	12%	15%		10%	7%
Closed concrete	Steel rail	Steel slab and box	Steel plate	Suspended monorail	Open steel surface
Single: 3.5 m; Double: 7.0 m [m]	1.77 m	6.3 m (double)	1.067 m	1.73 m	Single: 1.6 m; Double: 4.3 m
1.4 m; 1.4 m	1.50 m		0.609 m	1.603 m	0.59 m; 0.59 m
2.75 m; 2.75 m [m] lane	1.362 m	2.19 m			0.3 m; 0.3 m/lane
30 m [m]	22.9-27.4 m	30.48 m	22.86 m	100 m	15 m
Prestressed concrete or steel	Prefab steel bolted to concrete slab	Steel	Steel	Steel or concrete	Steel
			Heat		Enclosed guideway
AC or DC [m]		Side rail			
600-Vac [m]	600 Vdc		440-575 Vac, 3 phase, 250 A max.	500 Vac, 3 phase	600 Vdc at 220 A max.
1-1.5 [m]					
Double Ackerman by 4 guidewheels	Rail and rollers		Side walls	Center beam and sidewalls	Center beam
Mechanical blade on guideway traps wheel	Inclined plane: actuator and dual switches all move		Rotary or sliding switch	Mechanical movement of guideway section	Rotating guideway horizontal

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
Station Configuration	On and Off-line	Off and On-line	On-line	On-line	On-line
Number of Parallel Platforms					
Number of Berthing Lanes					
Length of Platform			30-50 m berth		70 m
Berth Configuration					
Number of Berths Per Platform					
Capacity of Vehicle Queues					
Empty Vehicle Storage Capacity					
Average Vehicle Dwell Time	15-20 s	25 s	20 s	20 s	20 s
Vehicle Throughput (Vehicles Per Hour)					
Turnaround Capability					
Off-Line Acceleration/Deceleration Lane Length					
Operational Control Strategy	Quasi-synchronous	Quasi-synchronous			
Dispatch Policy					

TABLE A-6 (SHEET 5 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
On-line or Off-line [a]	On and Off-line	On-line	On and Off-line	On and Off-line	On-line
50 m [a]			24m		
20 s	20 s		15-30 s	30 s	20-30 s
			Asynchronous		Asynchronous

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
Headway Protection Fixed Block	Fixed Block	Fixed Block		Fixed Block	Fixed Block
Block Lengths					
No. of Blocks Betwe... Vehicles					
Moving Block					
Communication Sample Rate					
Merge Strategy					
Minimum Headway	15 s	75 s	90 s	90 s (a)	90 s
Merge Throughput					
Service Policy	Scheduled, demand stop, demand responsive	Scheduled, demand stop, demand responsive	Scheduled	Scheduled, demand stop, demand responsive	Scheduled, demand stop, demand responsive
Service Goals					
Routing Strategy	Fixed, variable	Fixed	Variable	Fixed	Fixed
Empty Vehicle Management					

TABLE A-6 (SHEET 6 of 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
				Fixed Block	
150 m (a)					
2 (a)					
			Moving block		
90 s (a)	25 s	18.72 s	45 s	60 s	60 s
Scheduled, demand stop, demand responsive		Scheduled, demand stop, demand responsive	Scheduled, demand responsive	Scheduled	Scheduled, demand stop, demand responsive
Fixed, variable		Fixed	Fixed	Fixed	Fixed

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
Station Management					
Separate vs Common Board/ Deboard					
Ripple vs Platoon Movement					
Fleet Management Total Fleet					
Peak Operating Fleet					
Base Operating Fleet					
Failure Management Push/Pull Capability	Yes	Yes			Yes
Emergency Equip. & Crew Location					
Redundant Prop. or G'way Power					
Redundant Local Control	Yes				Yes
Redundant Vehicle Electronics	Yes - emergency power				Yes

TABLE A-6 (SHEET 7 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
			Separate B/D		
13 trains [(a)]					
11 trains [(a)]					
7 trains [(a)]					
Yes	Yes		Yes	Tow vehicle only	
				Can operate with the failed power unit	

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
Mean Time Between Failures					
System					30 hr
Vehicle					
Guideway					
Station					5,600 hr
Central Control					
Mean Time to Restore Service					
System					
Vehicle					
Guideway					
Station					
Central Control					
System Availability Number	90%				
Availability Definition					
System Responses to Failures	Push failed vehicle	Push by following vehicle	Remove failed vehicle with diversion track; if failure occurs, system comes to complete stop		

TABLE A-6 (SHEET 8 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
			300 hr		2,000 hr
			600 hr		3,000 hr
			2,000 hr		10,000 hr
Pushed by following vehicle	Push vehicle to next stop		Tow failed vehicle	Tow vehicle to siding	

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
System Capital Cost					
Vehicle Cost	$125,000				
Expected Life		10 yr.			10 yr.
System Fleet Size					
Guideway Cost	$1.25-5 m/km (includes all components except vehicles)				$2.2 m/km double guideway
Expected Life					
System Lane Kilometers					6.7 km
Power Distribution Cost					$2.9 M
Expected Life					10 yr.
Station Cost					$550,000 each
Expected Life					10 yr.
Number of Stations					9
Maintenance and Storage Facilities					$3 M
Expected Life					10 yr.
Number of Facilities					
Communication and Controls					$57 M
Expected Life					10 yr.

TABLE A-6 (SHEET 9 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
				All total $2.61 m/km	
$230,000 (a)	$100,000	$200,000 (5)			$80,000
20 yr. (a)	15 yr.		15 yr.		13 yr.
52					
$3 M/km (a)	$1.9 m/km	$1.5 m/km elevated guideway, including electrification (5)			$1.3 m/km
50 yr. (a)					
14 km (a)					15 km
$13 M (including substations) (a)					$2.7 m
20 yr. (a)					20 yr.
$1.9 M (a)					
50 yr. (a)			40 yr.		
8 (a)					
$9.5 M (a)					
50 yr. (a)					
1 (a)					
$15 M					$5.3 m
20 yr. (a)					20 yr.

System Name	DASHAVEYOR I	KCV	KOMPAKTBAHN	MAT	MINI-MONORAIL
System Operating Cost	$0.31-0.62/veh-km				$18,490/day for 216 vehicles
Operating Hours/Day					19 hour/day
Vehicle Kilometers/Day					31,656 km/day
Vehicle Hours/Day					1,680 hour/day
Energy Cost					
Maintenance Cost					
Vehicles					
Stations					
Facilities					
Personnel					
Maintenance					
Vehicle					
Stations					
Facilities					
Operations					
Central Control					
Stations					
General					
General and Administrative					

TABLE A-6 (SHEET 10 OF 10). OBSERVED SYSTEM CHARACTERISTICS - HIGH SPEED IGRT

NTS	PROJECT 21 RTS	TRIDIM AEROTRAN	UNIMOBIL TRANSPORTER	URBA 30	VONA
				$0.78/seat-km	$0.04/veh-km for 120 vehicles
250 veh-km/day[a]					208 veh-km/day
600 veh-hr/day[a]					7 veh hour/day

TABLE A–7 (SHEET 1 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse						
Developer	Westinghouse Electric Corp.						
Deployment Status	Tampa Airport (T), Seattle-Tacoma Airport (S), Busch Gardens (B), & Miami Airport (M)						
Vehicle Characteristics No. of Seats Per Vehicle	T 0 S 12						
Design Load Per Vehicle	T 100 S 102						
Crush Load Per Vehicle	T 125 (a) S 125						
Vehicle Length	T 11.05 m S 11.28 m						
Vehicle Width	T & S 2.84 m B & M 2.97 m						
Vehicle Height	3.35 m						
Interior Area Per Seated Passenger	S 0.42m^2 (a)						
Interior Area Per Standing Passenger	T 0.23 m^2 S 0.25 m^2 (a)						
Empty Vehicle Weight	T 9,772 kg; B & M 12,020 kg; S 11,591 kg						
Load/Unload Rate Per Door	T–3 pass/s B–2.[illegible] p/s S–3 pass/s M–2.5 p/s (a)						
Door Width	T & S 2.44 m B & M 2.13 m						
Number of Doors Per Vehicle	4, 2 each side S–2 (a)						

Major Reference (except as noted) Reference 2

TABLE A–7 (SHEET 2 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse						
Vehicle Characteristics (cont'd) Guideway Interface	Rubber tires						
Lateral Control Interface	Rubber guidewheels on steel I-beam						
Switching Mechanism	Exchange one section of guideway for another						
Switch Actuation Time	5 s + 5 s to verify						
Minimum Turning Radius	25 - 58 m						
Coupler	S - automatic (a)						
Minimum Traveling Unit	1						
Maximum Train Consist	S - 3 B - 2 (a)						
"A" and "B" Vehicles	No						
Platooning Capability	Yes (a)						
Propulsion Type	DC traction motor						
Power Rating Per Unit	75 kw (a)						
Number of Propulsion Units	2/vehicle T & B 1/vehicle S & M (a)						

TABLE A–7 (SHEET 3 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse						
Vehicle Characteristics (cont'd) Acceleration	$0.89\ m/s^2$						
Cruise Speed	48 km/h						
Maximum Speed	96.3 km/h						
Service Brake Type	Drum						
Service Deceleration	$0.67\ m/s^2$						
Emergency Brake Type	Spring-loaded						
Emergency Deceleration	$1.8 m/s^2$ (a)						
Emergency Brake Reaction Time	0.75 s						
Maximum Grade Capability	6% sustained 10% max.						
Reverse Capability (Bi-Directionality)	Yes						
Precision Stopping Tolerance	±152 mm						
Exterior Noise	NCA 60 at 30.5 m NCA to beneath guide-way						
Energy Consumption (Acceleration, Decel., Cruise)	4.97 - 5.28 kw/km/car						
Emissions	No direct						

TABLE A–7 (SHEET 4 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse						
Typical Network Configuration	Shuttle and loop						
Maximum Grade	T 1%, B 10% S & M 2%						
Guideway Type	Open concrete structure						
Guideway Dimensions Outside Width	2.59 m						
Height	0.89 m						
Running Surface Width	2.59 m						
Elevated Span Length	Max. 36.6 m						
Construction Material	Concrete running surface						
Weather Protection (Snow/Ice)	None or run empty vehicle until guideway is clear						
Power Distribution AC or DC	AC						
Voltage	480 V, 3 phase (S&B)[a] 480 V, 3 phase (T&M)						
Number of Substations Per Lane Kilometer							
Lateral Control Equipment	Guidebeam						
Switching Equipment	Transfer tables (S & B)						

TABLE A–7 (SHEET 5 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse							
Station Configuration	On-line							
Number of Parallel Platforms	None							
Number of Berthing Lanes	1 [a]							
Length of Platform								
Berth Configuration	Serial							
Number of Berths Per Platform	1, for up to a 3-car train [a]							
Capacity of Vehicle Queues	None							
Empty Vehicle Storage Capacity	Entire fleet [a]							
Average Vehicle Dwell Time	T 30 s, M & B 20 s, S 45–60 s							
Vehicle Throughput (Vehicles Per Hour)								
Turnaround Capability								
Off-Line Acceleration/Deceleration Lane Length								
Operational Control Strategy								
Dispatch Policy								

TABLE A-7 (SHEET 6 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse						
Headway Protection Fixed Block	Fixed block						
Block Lengths							
No. of Blocks Between Vehicles							
Moving Block							
Communication Sample Rate							
Merge Strategy							
Minimum Headway	T 70 s, B 5 min., S 150 s, M 85 s						
Merge Throughput							
Service Policy	Schedule or demand-responsive						
Service Goals							
Routing Strategy	Fixed (a)						
Empty Vehicle Management	Store where emptied, possible to circulate (a)						

TABLE A–7 (SHEET 7 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse						
Station Management							
Separate vs Common Board/ Deboard	Common – S [a] Separate – T, M, &B						
Ripple vs Platoon Movement	N.A.						
Fleet Management Total Fleet	Prescheduled [a] S 12 veh M–4 B 2 veh T–8						
Peak Operating Fleet	S 11 veh [a]						
Base Operating Fleet	S 6–7 veh [a]						
Failure Management Push/Pull Capability	Yes						
Emergency Equip. & Crew Location							
Redundant Prop. or G'way Power							
Redundant Local Control							
Redundant Vehicle Electronics							

TABLE A-7 (SHEET 8 OF 10) OBSERVED SYSTEM CHARACTERISTICS — LGRT

System Name	Westinghouse						
Mean Time Between Failures							
System							
Vehicle							
Guideway							
Station							
Central Control							
Mean Time to Restore Service							
System							
Vehicle							
Guideway							
Station							
Central Control							
System Availability Number	S 99.6 - 99.7%[m]						
Availability Definition							
System Response to Failures	Failure recovery is done manually[m]						

TABLE A–7 (SHEET 9 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse						
System Capital Cost							
Vehicle Cost							
Expected Life							
System Fleet Size							
Guideway Cost							
Expected Life							
System Lane Kilometers							
Power Distribution Cost							
Expected Life	20 years						
Station Cost							
Expected Life							
Number of Stations	T 8, B 3, S 6, M 2 (a)						
Maintenance and Storage Facilities							
Expected Life							
Number of Facilities	S 2						
Communication and Controls							
Expected Life							

TABLE A-7 (SHEET 10 OF 10) OBSERVED SYSTEM CHARACTERISTICS – LGRT

System Name	Westinghouse						
System Operating Cost							
Operating Hours/Day							
Vehicle Kilometers/Day							
Vehicle Hours/Day							
Energy Cost							
Maintenance Cost							
Vehicles							
Stations							
Facilities							
Personnel							
Maintenance							
Vehicle							
Stations							
Facilities							
Operations							
Central Control							
Stations							
General							
General and Administrative							

TABLE A–8 (SHEET 1 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
Developer	Rohr (vehicle) Westinghouse (controls)	Delaware River (a) Port Authority	Rohr	Engins Matra, C.E.M., C.I.M.T. Lorraine			
Deployment Status	Operational	Operational	San Diego Wild Animal Park (manual)	Test track & project for Lille, France 1976–'78	Operational		
Vehicle Characteristics No. of Seats Per Vehicle	72	77 (21) (a)	A car 72 B car 78	44–68	80		
Design Load Per Vehicle	170	125 (5) (a)	A car 72 B car 78	160–124	208		
Crush Load Per Vehicle	216	150 (a)		208	240		
Vehicle Length	A veh 22.8 m B veh 21.3 m	20.57 m(5) (a)	12.5 m	25.48 m	23 m		
Vehicle Width	3.2 m	30.5 m(21)	3.35 m	2.06 m	3.09 m		
Vehicle Height	3.2 m	3.76 m (a)	3.89 m	3.2[illegible] m	2.3 m		
Interior Area Per Seated Passenger			0.368 m^2		0.25 m^2		
Interior Area Per Standing Passenger	0.25 m^2		0.230 m^2		0.20 m^2		
Empty Vehicle Weight	A veh 26,800 kg B veh 25,400 kg	34,776 kg (5) (a)	8,617 kg	27,000 kg	32,900 kg		
Load/Unload Rate Per Door							
Door Width		4'2" (a)					
Number of Doors Per Vehicle	4, 2 on each side, all 4 (a) are not used simultaneously	4, 2 per side (8)	12	2 per side	2 per side		
Major Reference (except as noted)	Reference 1		Reference 1	Reference 1	Reference 1		

TABLE A–8 (SHEET 2 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
Vehicle Characteristics (cont'd) Guideway Interface	Steel wheels/ steel rails	Steel wheels/steel rails (21)	2 rubber tired bogie. per vehicle	Rubber tired	Steel wheel/steel rail		
Lateral Control Interface	Rails	Rails (21)	Lateral rubber tired guidewheels on bogie	Horizontal tires	Rails		
Switching Mechanism	Vehicle is passive (a)	Vehicle is passive (a)	Vehicle is passive	Vehicle is passive	Vehicle is passive		
Switch Actuation Time			8 s	2 s			
Minimum Turning Radius	122 m	125'0" (a)	30,5 m	40 m	48.6 m		
Coupler	Automatic (a)	Automatic (9)					
Minimum Traveling Unit	2 (a)	1 (9)	Married pairs	2	2 (5)		
Maximum Train Consist	10 (a)	6 (9)		4	8 (5)		
"A" and "B" Vehicles	Yes (a)	Yes (9)	Yes		Yes (5)		
Platooning Capability	None	None	None	None	None		
Propulsion Type	DC motor	DC (21)	DC electric motor	Electric motor	Electric		
Power Rating Per Unit	104 kw, 310 V	104 kw, 600 V (21)	(2) 35 HP (a)	180 kw	131 kw		
Number of Propulsion Units	4/veh, 1/axle	4 per car (a)	1/bogie	2	4/veh		

TABLE A–8 (SHEET 3 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
Vehicle Characteristics (cont'd) Acceleration	$1.34\ m/s^2$	3 mph/sec (a)	$0.89\ m/s^2$	$1.3\ m/s^2$	$0.91\ m/s^2$		
Cruise Speed	65 km/h	64.5 km/h (9)	80.5 km/h	59.6 km/h			
Maximum Speed	129 km/h	105 km/h (a)	80.5 km/h	80.5 km/h	120 km/h		
Service Brake Type	Dynamic, regenerative, & hydraulic friction (a)	Dynamic & air brakes (21)	Dynamic & hydraulic drum	Dynamic, regenerative, & pneumatic	Hydraulic		
Service Deceleration	$1.34\ m/s^2$	2.2-3.2 mph/s (a)	$1.34\ m/s^2$	$1.3\ m/s^2$	$0.91\ m/s^2$		
Emergency Brake Type	Same as service	Air (a)	Motor shaft brake	Pneumatic	Pneumatic hydraulic		
Emergency Deceleration	$1.34\ m/s^2$	3.5-3.2 mph/s (a)	$1.46\ m/s^2$	$2.0\ m/s^2$	$0.98\ m/s^2$		
Emergency Brake Reaction Time	0.3 s	1.0 sec (a)		0.2 s	0.5 s		
Maximum Grade Capability	4%	5% (a)	6%	10%	4%		
Reverse Capability (Bi-Directionality)	Yes	Yes (a)					
Precision Stopping Tolerance		6.1 m (a)	± 305 mm	±51 mm			
Exterior Noise	74 dBA at 129 km/h		NCA 60 at 30.5 m	70 dBA at 60 m	84 dBA at 15 m		
Energy Consumption (Acceleration, Decel., Cruise)	9.2 kwh/veh mile (overall) (5)	8.1 kwh/veh mile (a)					
Emissions		No direct (a)	No direct	No direct			

TABLE A-8 (SHEET 4 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
Typical Network Configuration	Radial	Shuttle line [a]		Linear	Radial		
Maximum Grade		5% [a]					
Guideway Type	Steel rail	Steel rail [a]		Closed concrete	Steel rail		
Guideway Dimensions Outside Width			0.38 m	6 m			
Height			0.38 m				
Running Surface Width	1.7 m			2.134 m			
Elevated Span Length			Max. 27.4 m				
Construction Material	Concrete [a]		Concrete surface with steel or aluminum guidebeam	Prestressed concrete			
Weather Protection (Snow/Ice)	None [a]	Switch heaters, 3rd rail cover and heater [a]					
Power Distribution AC or DC	AC [a]	DC [a]	AC	DC			
Voltage		650 V [a]	600 V, 1 phase	750 V			
Number of Substations Per Lane Kilometer	34 for 226 km (single lane), therefore, 0.15 substa/lane-km [a]	10 for 46.7 km [a]					
Lateral Control Equipment	Steel rails	Steel rails [a]	Guidebeam		Steel rails		
Switching Equipment	Rails move	Rails move [a]	Guidebeam moves	Guideway rail moves	Rails move		

TABLE A–8 (SHEET 5 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
Station Configuration	On-line (a)	On-line (21)	On-line	On-line	On-line (a)		
Number of Parallel Platforms	1 (a)	N.A. (a)					
Number of Berthing Lanes	1 (a)	N.A. (a)					
Length of Platform	213 m	123.4 m (a)	≥ 25 m		182 m		
Berth Configuration	Serial (a)	Island platforms (a)					
Number of Berths Per Platform	2, one on each side (a)	2 (a)					
Capacity of Vehicle Queues	20 s	12 s (8)	100 (a)	30 s			
Empty Vehicle Storage Capacity		134 cars (a)					
Average Vehicle Dwell Time	20 s	12 s (8)	30 s	30 s			
Vehicle Throughput (Vehicles Per Hour)	190 (peak) (a) (7)	83 veh/hr (a)					
Turnaround Capability		2–4 min (a)					
Off-Line Acceleration/Deceleration Lane Length	N.A.	N.A.	N.A.	N.A.	N.A.		
Operational Control Strategy	Fixed block speed command (a)	ATO (8)					
Dispatch Policy		Automatic as scheduled (a)					

TABLE A-8 (SHEET 6 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	ROHR "N" Series	VAL	WMATA		
Headway Protection Fixed Block	Fixed block [20]	Fixed block	Fixed block				
Block Lengths	45–385 m [20]						
No. of Blocks Between Vehicles	4 block aspect [20]	5 block aspect					
Moving Block							
Communication Sample Rate							
Merge Strategy	First in, first out [a]	As scheduled [a]					
Minimum Headway	2 min. [2] presently maintaining 1 sta. separation [a]	2 min. [8]	60 s	60 s	120 s		
Merge Throughput		As scheduled [a]					
Service Policy	Scheduled	Scheduled [21]	Scheduled	Scheduled			
Service Goals		Defined by traffic checks [a]					
Routing Strategy	Fixed [a]	Fixed [21]	Fixed	Fixed			
Empty Vehicle Management	Circulation [a]	Crew supervisor and yard operation [a]					

TABLE A–8 (SHEET 7 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
Station Management		Manned (a)					
Separate vs Common Board/Deboard	Common (a)	Common (a)					
Ripple vs Platoon Movement							
Fleet Management Total Fleet	A cars - 176 B cars - 274	Single (72 seats) - 25 Trains (160 seats) - 25 (22)					
Peak Operating Fleet	10 car trains						
Base Operating Fleet	3 - 4 car trains						
Failure Management Push/Pull Capability				Yes			
Emergency Equip. & Crew Location		Lindenwold Yard (a)					
Redundant Prop. or G'way Power							
Redundant Local Control							
Redundant Vehicle Electronics							

TABLE A–8 (SHEET 8 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
Mean Time Between Failures							
System							
Vehicle	9.40 days [a] (5)		5,000 hr				
Guideway	34.35 days/1.609 km [a] (5)						
Station							
Central Control	10.14 days [a] (5)						
Mean Time to Restore Service							
System			0.5hr				
Vehicle							
Guideway							
Station							
Central Control							
System Availability Number	70 - 80% [a]	94% [a]					
Availability Definition	% of trains arriving within a specified time limit (5)	Able to meet peak demand (5)					
System Response to Failures		Store defective [a] equipment off main line					

TABLE A-8 (SHEET 9 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
System Capital Cost		$94 M (a)	< $1 M for 4 trains and guidebeam (a)	$30 M/1.609 km avg.			
Vehicle Cost	$339,000 (3)	$180,000 (a)	$126,000/2 car train (a)		$91,600,000/300 veh		
Expected Life	30 yr (6)	160,900 km (21)					
System Fleet Size	450 (a)	75 (a)					
Guideway Cost	$480,000,000 (4)				$3.3 K/m at grade, $8.2 K/m soft heading $11.5 K/m hard heading, $19.7 K/m cut and cover (23)		
Expected Life	80 yr (6)						
System Lane Kilometers	113 km, double lane	46.7 km (a)					
Power Distribution Cost	$238,100/1.609 km (4)						
Expected Life							
Station Cost	$226,900,000 (total) (14)	$600,000 each (8)					
Expected Life	80 yr (6)						
Number of Stations	8 at grade, 12 above, 14 below	13 (a)			86		
Maintenance and Storage Facilities	$21,630,000 (4)						
Expected Life	80 yr (6)						
Number of Facilities	3 garages, 1 adm. bldg. (a)	1 (a)					
Communication and Controls	$34,500,000 (4)				$42 M		
Expected Life	20 yr (6)						

TABLE A–8 (SHEET 10 OF 10) OBSERVED SYSTEM CHARACTERISTICS – ART

System Name	Bart	PATCO	Rohr "N" Series	VAL	WMATA		
System Operating Cost	$76,000,000/yr (a)	$8,878,000 (a)					
Operating Hours/Day		24 (a)					
Vehicle Kilometers/Day		20968 (a)					
Vehicle Hours/Day		448 (a)					
Energy Cost		$1,517,000 (a)					
Maintenance Cost							
Vehicles	800 (a)						
Stations							
Facilities							
Personnel							
Maintenance							
Vehicle							
Stations							
Facilities							
Operations	1,280 (a)						
Central Control							
Stations							
General							
General and Administrative							

APPENDIX B

REPORT OF INVENTIONS

Work performed by GM Transportation Systems Division under Contract DOT-TSC-1220, in the area covered by this report, resulted in no inventions or improvements of inventions.

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