RT NO. UMTA-MA-06-0026-79-2

PRT IMPACT STUDY
OPERATIONAL PHASE
Volume I: Travel Analysis

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WEST VIRGINIA UNIVERSITY
Morgantown WV 26506

JULY 1979

FINAL REPORT

DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION
Office of Technology Development and Deployment
Washington DC 20590

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTA-MA-06-0026-79-2		

4. Title and Subtitle	5. Report Date
PRT IMPACT STUDY - OPERATIONAL PHASE Volume I: Travel Analysis	July 1979
	6. Performing Organization Code
7. Author(s) Samy E.G. Elias, Richard T. Ward, Arup K. Mallik, Edward S. Neumann, James M. Rovelstad, John A. Pearie	8. Performing Organization Report No. DOT-TSC-UMTA-79-2
9. Performing Organization Name and Address West Virginia University* Morgantown WV 26506	10. Work Unit No. (TRAIS) UM941/R9720
	11. Contract or Grant No. DOT-TSC-1316
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration Office of Technology Development and Deployment Washington DC 20590	13. Type of Report and Period Covered Final Report Feb. 1977 - June 1978
	14. Sponsoring Agency Code

15. Supplementary Notes

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

16. Abstract This is a study of the impact of the Phase I Morgantown PRT, the first fully automated, origin to destination, nonstop, demand activated, transportation system operational in a city environment. The study was designed to record the effect of the system operation on traffic and associated activities in the areas adjacent to the PRT. To achieve this objective a similar study was also conducted in 1975-76, prior to passenger service.

The system served a large segment of the community reaching some 38% of the Morgantown residents. During the course of the study, it was concluded that the system was a major force in influencing travel habits within its service area. It was further concluded that while auto traffic along the two main arterial thoroughfares experienced a large increase over the two year study period, residents of the service area used autos for their trips less often than they did prior to the PRT. Moreover, compared to the bus system, which it replaced, the PRT was carrying more than the bus's previous share of the total trips. The increase in transit travel is assumed to be, at least, partly due to favorable attitudes towards the PRT. The advantages to using the PRT within its service area included reduced travel time compared to the automobile and the bus. This study is reported in three reports: Volume I - Operational Phase Travel Analysis; Volume II - Operational Phase Data Collection Procedure and Coding Manual; and The Phase I PRT Impact on Morgantown Travel Traffic and Associated Activities.

This report, Volume I, focuses its attention on the analysis of transportation related conditions which existed in the PRT service area in the Spring of 1977.

17. Key Words	18. Distribution Statement
PRT, West Virginia University, Modal Utilization, Modal Attitudes, AGT	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	100	

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

PREFACE

In October, 1975, Phase I of the Morgantown Personal Rapid Transit (PRT) System, a revolutionary new mode of public transportation, built as a research development and demonstration project by the Urban Mass Transportation Administration, commenced passenger service in Morgantown, West Virginia. Because the PRT is the first system of its kind ever operated in a city, it provides a unique opportunity to study the interaction between a new mode and its service area.

Although the present system installation in Morgantown represents only the first phase of a much larger system, it was believed that some measurable impacts could still be derived from its first few years of operation, prior to the initiation of the larger Phase II installation. Phase I consists of a three (3) station system connected by 2.2 miles of guideway and served by 45 vehicles. These vehicles operate at maximum speeds of 30 mph and minimum headway of 15 seconds. Phase II will expand this system to 5 stations, 3.4 miles of guideway, and 73 vehicles.

The PRT Impact Study was designed to record the effects of PRT system operation on traffic and associated activity in the area adjacent to the PRT Phase I. The intent of the study was to provide information which should be useful to other areas contemplating public transit, particularly those planning for Automated Guideway Transit (AGT) type installations. The Operational Phase was called Post-PRT Phase in earlier work and has been renamed due to development of Phase II PRT System and altering of the earlier Pre-Post design of the Impact Study. The Phase I study consists of two data collection stages; the Pre-PRT Stage, prior to passenger service on the Phase I installation, and the Operational Stage. following the commencement of revenue service on the Phase I installation.

The Pre-PRT Stage was completed in 1975 and is reported in three volumes:

- Volume I - Pre-PRT Phase Travel Analysis,
- Volume II - Pre-PRT Phase Data Collection Procedure and Coding Manual
- Volume III - Pre-PRT Phase Frequency Tabulations from Four Transportation-Related Surveys.

This work was sponsored by the Transportation Systems Center (TSC), United States Department of Transportation, Cambridge, MA, under Contract Number DOT-TSC-985.

The Operational Stage, which was also sponsored by TSC, under Contract Number DOT-TSC-1316, was completed in 1977 and is reported in two volumes directly comparable to the Volumes I and II of Pre-PRT stage status reports. An additional summary report was also published, following the operational stage, which assesses the impact that the PRT had on travel in certain areas of Morgantown between 1975 and 1977. The three reports are:

- Volume I - Operational Phase Travel Analysis,
- Volume II - Operational Phase Data Collection Procedure and Coding Manual,
- The Phase I PRT Impact on Morgantown Travel Traffic and Associated Activities.

This report was made possible through the tremendous individual efforts of four Graduate Assistants at West Virginia University who assisted the principal investigators in practically every phase of the Impact Study. The principal Graduate Assistants, in alphabetical order, were:

Patricia Goeke
Ahmed Syed
Phaisal Vejpongsa
Kam-Luan Young.

Additional credit must also be given to three other student assistants who participated in certain aspects of the project:

James R. Penman
Amy L. Rovelstad
Jane A. Hiteshew.

Mrs. Janet Alderman was responsible for the typing and much of the administrative work on this project.

Several agencies and other individuals cooperated in making the PRT Impact Study possible. They include Dr. Mary Stearns and Mr. K.H. Shaeffer of TSC, The City of Morgantown, and the Institutional Research Office of West Virginia University.

Special acknowledgment is also made of the significant contribution made by Mr. Govind K. Deshpande who left the project after the data collection phase of the study was completed.

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

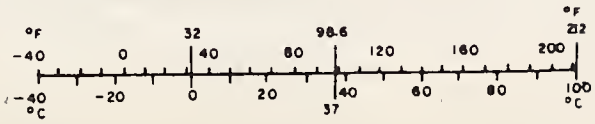


TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

1. INTRODUCTION

A new and revolutionary public transportation system, the Morgantown Personal Rapid Transit System (M-PRT), began regular passenger service operation in Morgantown, West Virginia, in October, 1975. To study the impact of the PRT on Morgantown, a substantial amount of data was collected in an attempt to capture the state of transportation related conditions before and after passenger service. This report contains an analysis of the latter set of data; namely, that collected in the spring of 1977. The data described in this report, together with those reported in the Pre-PRT Phase, will allow assessment of the PRT system impacts on the city of Morgantown. The completed assessment will provide other cities considering implementation of AGT systems, sufficiently detailed information to determine whether they can effectively and efficiently utilize a Morgantown type PRT system to satisfy their transportation needs.

For a period of time following its inauguration, the M-PRT experienced all of the characteristics and growing pains of a new technology. While the system to date has experienced a perfect safety record,* its early operation was anything but perfect - with sporadic interludes of failures due to component "infant mortalities" and the emergence of system, subsystem level "bugs", particularly during the first winter of operation.** Moreover, the overall effect of a fluctuating performance record did little to encourage regular use by those who were at least willing to give the system a chance. For many travelers in the Morgantown area, the introduction of the M-PRT represented a novelty, an attraction, and as a result, trips were generated just for the fun of riding the futuristic looking PRT system.

All of the above conditions were expected: a fairly erratic level of service to start with; people who in the beginning would refrain from regularly using the system; and those who would go out of their way to take a ride. Therefore, travel habits in Morgantown were expected to

*Durant, P., and Ward, R., "The Inspection of an AGT System Safety Record: The Status of the Morgantown Personal Rapid Transit System," College of Engineering, West Virginia University, Morgantown, 1978.

**Barker, T.C., et. al., "1976-77 Winter Operation: Morgantown Personal Rapid Transit System," College of Engineering, West Virginia University, Morgantown, 1978.

be highly unstable for at least a one year period following the inauguration of PRT service, and that any attempt to study the impact of the M-PRT during this period would be misleading.

With these thoughts in mind, the comprehensive operational phase study was planned for the spring of 1977, approximately 1½ years after the commencement of regular service, and approximately 2 years after the completion of the similar study which was conducted prior to the inauguration of service. By the spring of 1977, system performance had pretty much stabilized and it was felt that travel patterns had likewise reached a similar level of stability.

1.1 Objectives

Since this system is the first of its kind ever built and operated in a city, and is expected to be the forerunner of significant changes in public transportation, a thorough study was made of the consequences of installing PRT in Morgantown to find characteristics and impacts which would be of interest to anyone considering the implementation of such a system. The study had two stages. The Pre-PRT stage, prior to the passenger service operation of the system, was completed in 1975. The Operational PRT stage, after the system had been placed into regular passenger service, is the subject under study.

1.2 Organization of the Report

The remainder of this chpater is devoted to an overview of transportation in the city of Morgantown and to a brief description of the M-PRT System. Section 2 provides a brief description of the data which was collected and outlines the boundaries and characteristics of the study area. Section 3 discusses model utilization in the M-PRT corridor and presents the magnitude of travel and trip distribution characteristics of the major modes of travel; namely, the private automobile, the M-PRT system, and the Morgantown Bus System. Section 4 describes travel patterns including trip rates, trip purposes, and each mode's share of total travel. Section 5 analyzes attitudes toward transportation alternatives as measured by the reasons given for mode choice and by preference ratings on modal characteristics, such as safety, convenience, and cost. Lastly, Section 6 presents an analysis of travel behavior through the use of aggregate causal models of trip distribution for both the M-PRT and the automobile.

The models seek to explain the magnitude of travel for each mode and for each trip purpose as a function of certain measures of transportation supply and demand.

1.3 An Overview of Transportation in Morgantown

Morgantown, West Virginia, is a university city with a total population of approximately 30,000 inhabitants. This figure is misleading, however, as the political boundaries of the city are rather small, whereas the entire urban area, including several adjacent communities, approaches a figure closer to 60,000 inhabitants. West Virginia University (WVU) is the largest single employer in the area with some 6,000 faculty and staff on the payroll. The student body at WVU, growing steadily, totaled 17,020 at the end of the spring registration in 1977, and by fall of 1977, had reached the 18,500 mark.

All of the WVU buildings were once located in a compact area immediately adjacent to the north side of Morgantown's central business district (CBD). However, as WVU expanded, new buildings, which included classrooms, research space, dormitory facilities, athletic facilities, a medical center, and a law school, were located in an area some 1½ miles north of the original campus. The original group of buildings near the CBD became known as the Main (or Downtown) Campus and the new buildings, some of which are already nearly 20 years old, are located in what is known as the Evansdale Campus.

In the spring of 1975, at the time that the Pre-PRT Phase data was collected, WVU was operating a fleet of about 16 Blue Bird style school buses, one of the largest campus transportation systems in the United States. Most of the buses were used to transport students, faculty, and staff between the Main and Evansdale Campuses, but a few of the buses were also used for shuttle service within the spacious Evansdale Campus. The total distance from one end of the Evansdale Campus to the other is also nearly 1½ miles. Use of the buses was restricted, however, and Morgantown residents who were not connected with the University were unable to use the system.

Morgantown has only two major north-south thoroughfares: University Avenue and Beechurst Avenue-Monongahela Boulevard, the latter merely changing names at one point along the corridor. These two corridors are the only viable connections between the two campuses, and are the only direct road links between the opposite sides of town (north and south).

In addition to heavy volumes of private automobile and truck traffic, these two thoroughfares carry city and county bus traffic, and have been the routes taken by the University inter-campus buses as well. However, since inauguration of M-PRT passenger service in the fall of 1975, the inter-campus bus service has been discountinued and the M-PRT now provides direct service to and from one location of the Evansdale Campus and the Main Campus, in addition to providing direct service to the CBD to and from both of the campus M-PRT stations. A portion of the University bus system still remains in operation, specifically those buses which operate along the Evansdale intra-campus route. In addition to providing shuttle service from the Medical Center, on the Medical Center Campus, to the Coliseum (Sports Arena), at the far end of the Evansdale Campus, the bus route was realigned to act as a feeder to the Engineering PRT Station.

The M-PRT is the major public transit mode in Morgantown, and unlike the University bus, it has been open to townspeople since it commenced passenger service. Although they operate through the PRT corridor, both of the existing bus services are not competing with the PRT. The city buses reach well outside the PRT's primary market area for their passengers, and the county buses are running from neighboring Star City. Pick-up and delivery within the PMA is almost nonexistent. This is expected to change in Phase II where there should be measurable competition between the two modes. Both systems operate small Mercedes-Benz mini-buses on a maximum scheduled service frequency of ½ hour, compared to the 15 second headway of the M-PRT.

1.4 The Morgantown PRT (M-PRT)

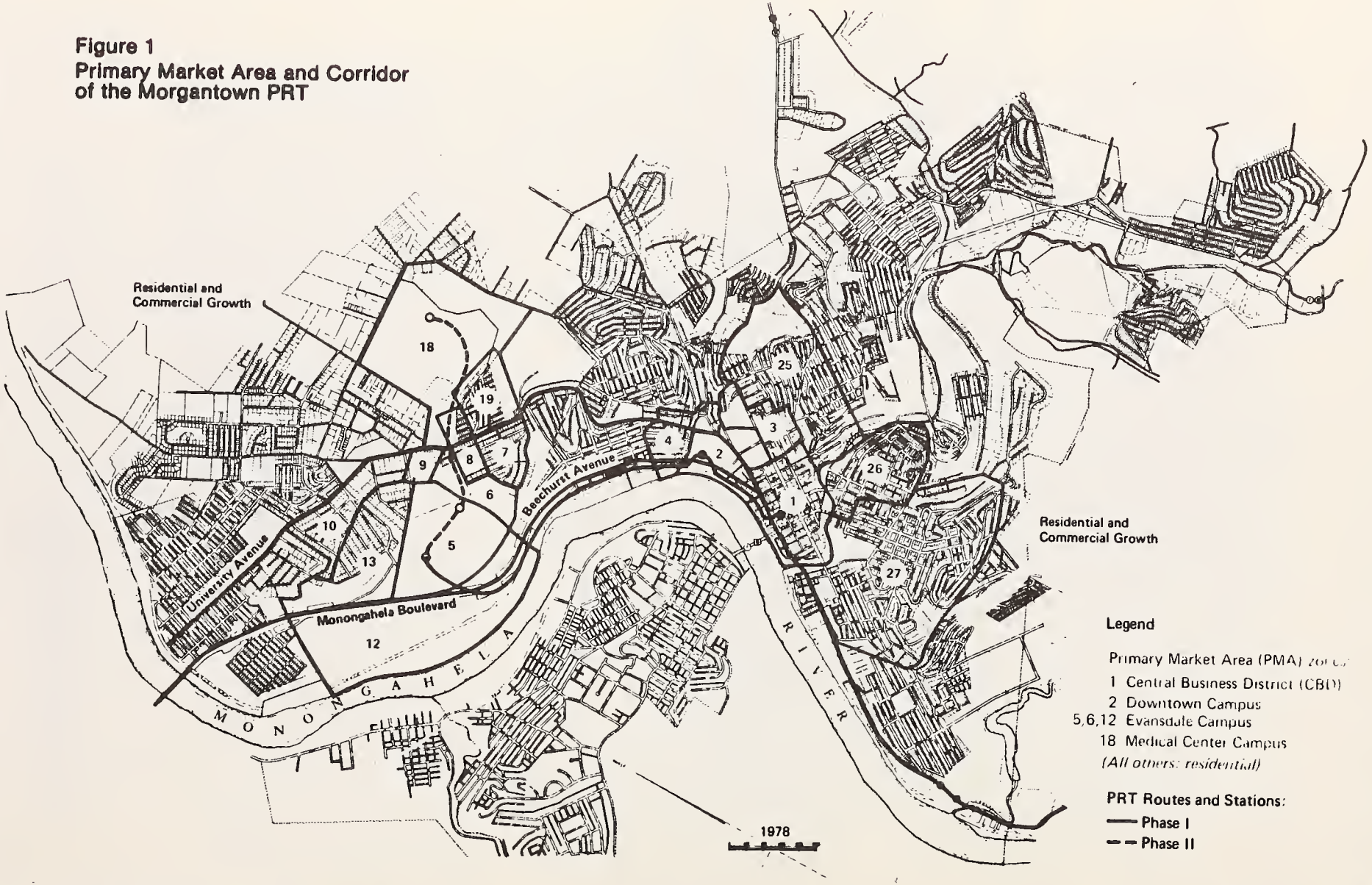
The M-PRT is a computer controlled, fully automated, self-service transportation system which utilizes electrically powered, rubber tired vehicles operating on a dedicated guideway. Vehicle service, which may be instituted by pre-determined schedules, during peak hours, or by passenger actuation (demand mode) during off-peak hours, is non-stop between all stations, with the Main Campus station in the middle of the system being an off-line station. The system is said to belong to a generic class of systems known as automated guideway transit (AGTs), but, it has been known as the M-PRT since its inception in 1969 and will remain so named in this study.

The vehicles are climate controlled with dimensions of 15.5 feet in length, 9 feet in height, and 6 feet in width, and are capable of carrying 8 seated passengers and up to as many as 12 standees during peak periods. The vehicles operate at a minimum headway of 15 seconds and at speeds up to 30 mph on 10% grades. All-weather operation is provided by means of a guideway heating system to maintain the running surfaces free of ice and snow.

The present system, consisting of three stations and 5.4 miles of equivalent single lane guideway, with a total fleet of 45 vehicles, is only the first phase (Phase I) of a much larger system (Phase II). The three Phase I stations are at Walnut Street in the CBD, Beechurst Avenue on the Main Campus, and across from the Engineering Sciences Building on the Evansdale Campus*. The second phase of the system is currently under construction and will be ready to carry passengers in 1979-80. The expansion of the system, under Phase II, will provide two additional stations on the Evansdale Campus, plus an increase in the size of the Engineering Station, itself an off-line station. Figure 1 depicts the routing and the station location for both phases of the M-PRT System, and Figure 2 shows the location of the City of Morgantown with respect to its urbanized area.

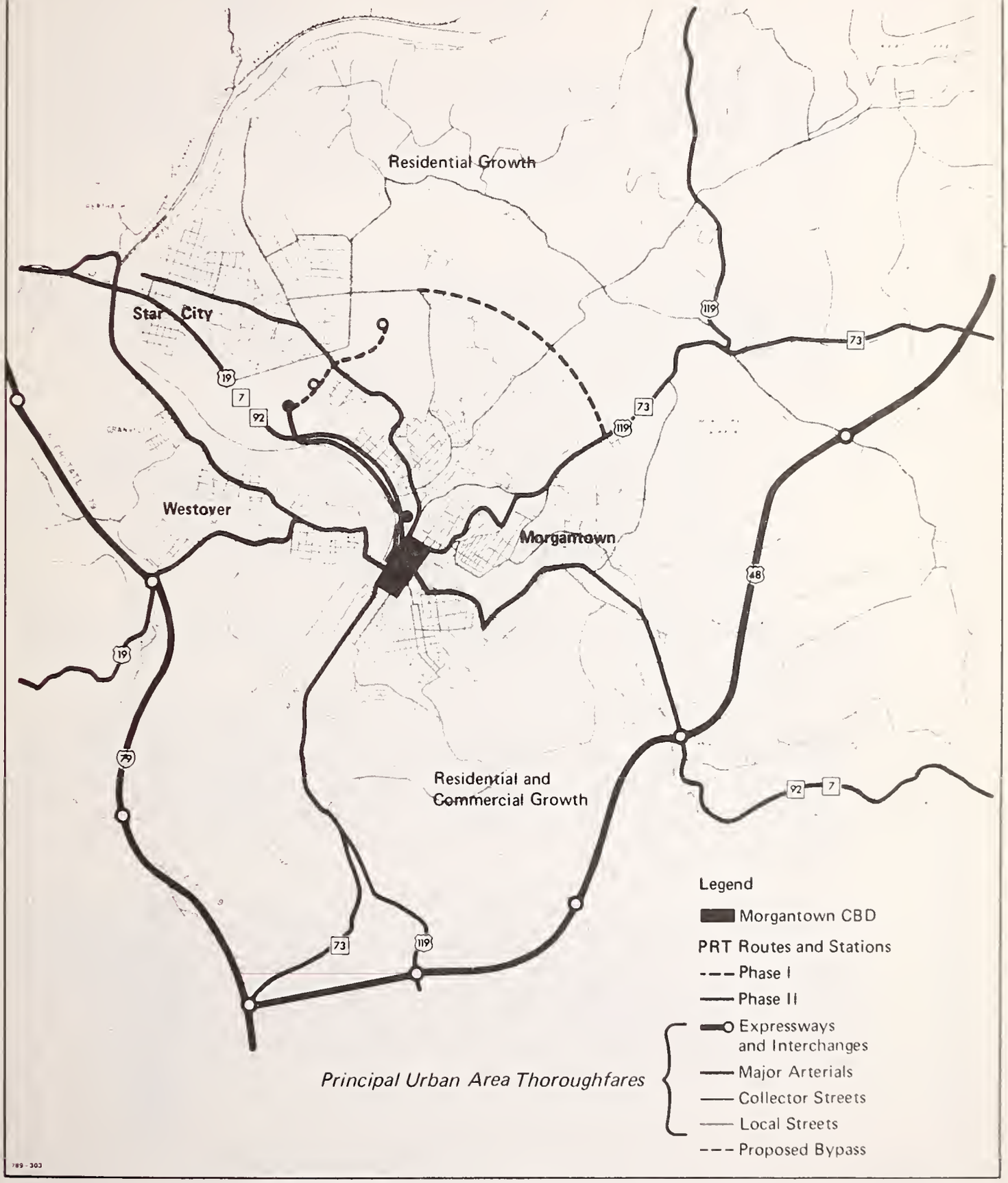
*The Engineering Station, although operational, is only one-third completed.

Figure 1
Primary Market Area and Corridor of the Morgantown PRT



Map used by permission of City of Morgantown

Figure 2
Morgantown Urban Area



2. BACKGROUND

All of the data reported in this study was collected during the spring school semester of 1977, principally during the months of March and April. The following sections describe the study area and briefly outlines the data which was collected to describe modal utilization, travel behavior, travel patterns, and demographic characteristics.

2.1 The Study Area

The study area of the M-PRT is defined in terms of the PRT Corridor or the PRT primary market area (PMA). Following the commencement of passenger service, modal utilization impacts of the M-PRT were expected to occur along the PRT corridor. For the purposes of this report, the corridor has been defined to include the following:

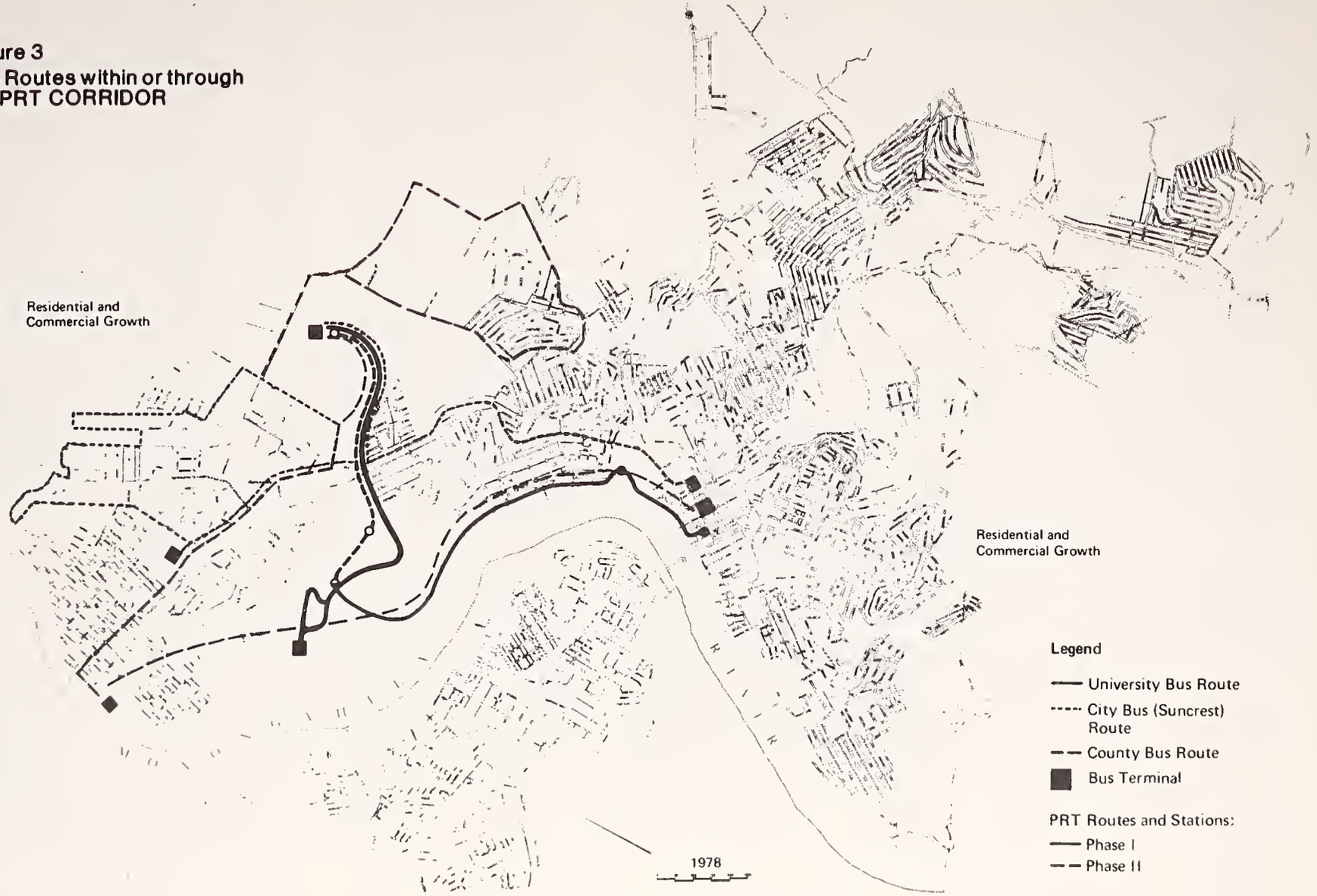
1) The principal auto and bus route segments along Beechurst and University Avenues, both of which approximately parallel the PRT guideway alignment. These two avenues were highlighted on Figure 1, while the bus routes are depicted in Figure 3.
2) Public Parking facilities within approximately a one-quarter mile radius of a PRT station.

The magnitude of total auto traffic (ADT) along the PRT corridor is an example of the modal utilization which the study sought to measure.

The Primary Market Area (PMA) consists of 16 typical planning zones, representing a cross section of land use. The identification of zones is necessary because of the need for travel modeling and is based upon the homogenity of land use occurring within the zone. The boundaries between zones were often natural boundaries, such as major corridors, ridges, streams, etc.

The PMA zones are actually a subset of a larger number of zones (46) into which the entire Morgantown area had been divided. The zonal boundaries of all zones, including the PMA zones, were based on land use, topographic considerations and uniform socio-economic characteristics. The PMA zones, also illustrated on Figure 1, by definition, represent zones within approximately a ten-minute walking distance of a PRT station.

Figure 3
Bus Routes within or through the PRT CORRIDOR



Map used by permission of City of Morgantown

Table 2-1 describes each of the zones within the PMA, and identifies the three zones which are the locations of the M-PRT stations. The numbering of the zones is not sequential, as can be seen. Therefore, to make subsequent computer processing of the data simpler, and to be consistent with the Pre-PRT study, each of the PMA zones was given a second numerical designation which was sequential. This, too, is included in Table 2-1.

2.2 Data Collection

Measures of modes operating within the PRT corridor were based on counts of the volume of daily travel as well as estimates of average daily travel between zones within the PMA. Data was collected on travel times and speeds, operating costs and on automobile accidents within the PMA.

Travel along the PRT corridor and between PMA zones following the commencement of revenue operation of the PRT system primarily involved the use of the automobile and the PRT. (Although city, county, and university buses continued to be available, they did not really compete with the PRT service.) Several data collection techniques were utilized to record trip purposes, the choice of mode, attitudes toward alternative modes, and the socio-economic characteristics of the trip makers.

Estimates of disaggregate zonal populations were established for each of the four major categories of PMA residents. A baseline for these estimates was obtained from the 1970 U.S. census records for Morgantown, which in turn were broken into disaggregate population estimates for the PMA zones. The student population residing in each zone was estimated from WVU enrollment records for the spring semester of 1977.* The PMA residential location of University employees was projected from a sample drawn from the University Telephone Directory.

Table 2-2 is included to give an overview of the population composition of each zone in the PMA.

Full details as to the techniques employed to obtain all the above data are presented in Volume III of both the Pre- and Operational Stage PRT studies: Operational Phase Data Collection Procedures and Coding Manual.

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* Only WVU Freshmen are required to live in University Dormitories.

TABLE 2-1

DESCRIPTION OF PMA ZONES

Map Zone	PRT Station Nearest to Zone	Zone Description	Special Features	Zone Designation for Analysis
1	Walnut St. Station	Central Business District (CBD)		1
2	Beechurst Station	MAIN CAMPUS OF WVU	No Housing	2
3	"	Residential	Dormitory Concentration	3
4	"	Residential		4
5	Engineering Station	EVANSDALE CAMPUS	No Housing	5
6	"	EVANSDALE CAMPUS	No Housing	6
7	"	Residential		7
8	"	Residential	Dormitory Concentration	8
9	"	Residential/ (Light Shopping)		9
10	"			9
11	"	City Park		11
12	"	EVANSDALE CAMPUS (Coliseum)		11
13	"	Residential		12
18	"	MEDICAL CENTER Campus	Limited Housing	13
19	"	Residential		7
25	Walnut St. Station	Residential		14
26	"	Residential		15
27	"	Residential		16

TABLE 2-2

1977 POPULATION ESTIMATES FOR THE FOUR MAJOR CATEGORIES OF PRIMARY MARKET AREA (PMA) RESIDENTS

ZONE	DORM STUDENT	NONDORM STUDENT	FAC/STAFF	RESIDENTS	TOTAL
1	0	513	27	860	1400
3	1630	478	27	160	2295
4	734	489	53	430	1706
7	0	58	69	80	207
8	1860	0	5	0	1865
9	0	0	0	130	130
10	0	93	53	120	266
11	0	12	0	0	12
13	0	70	21	55	146
18	0	42	48	220	310
19	0	634	27	20	681
25	0	932	133	2547	3612
26	0	396	74	1253	1723
27	0	746	329	2005	3080
TOTAL	4224	4463	866	7880	17433
			(17433) PMA Population		

3. MODAL UTILIZATION IN THE PRT CORRIDOR

The purpose of this section is to describe the magnitude of traffic adjacent to the PRT corridor with specific reference to the contribution of each of the modes of transportation to travel within the PRT corridor and the PMA. Additional modal data which characterizes the overall supply of transportation are also discussed. The data was collected by mode. For each mode, characteristics of supplies, congestion, cost and level of service is presented.

3.1 The Automobile

University Avenue and Monongahela Boulevard/Beechurst Avenue are both key thoroughfares as far as the overall mobility of the Morgantown area is concerned. In fact, not only are these two corridors the primary thoroughfares within the PRT corridor, they are also the only practical arterial roadways between the fastest growing residential section of town on the north side, beyond the Evansdale Campus, and the south side of town, including the CBD. For the most part, the importance of these arterials is due to the unique geography of Morgantown, and they have long held the attention of residents and planners as being the source of severe congestion.

The results of directional traffic counts taken within the PMA along both of these corridors are displayed in Appendix A, with the average weekday traffic on both approaches summarized in Table 3-1. The total of the combined average daily weekday auto traffic within the PRT corridor is 44,933 vehicular trips. The auto intercept survey which was conducted at the same time, involving the same thoroughfares, indicated that the average occupancy for all vehicles passing within the corridor was 1.6 passengers per vehicle and that 11% of the total traffic in the corridor was in fact through traffic, consisting of trips having neither origin nor destination in the PMA.

It is difficult to explain the unbalanced northernly flow experienced along Beechurst Avenue, other than to say that there are other approaches convening on the main campus and the CBD which conceivably could make up for the imbalance. The principle examples are Stewart Street and traffic from the Westover Exit of I-79. Interstate I-79, at least that portion which acts as a Morgantown by-pass, was opened in October, 1974, prior to the time that the baseline data was collected.

TABLE 3-1

AVERAGE DAILY WEEKDAY TRAFFIC IN PRT CORRIDOR

Hour	University Avenue N - Bound	University Avenue S - Bound	University Avenue Total	Beechurst Avenue N - Bound	Beechurst Avenue S - Bound	Beechurst Avenue Total
12-1	189	169	358	146	98	244
1-2	105	137	242	86	63	149
2-3	52	57	109	43	28	71
3-4	23	29	52	37	27	64
4-5	27	12	39	64	49	113
5-6	85	24	109	299	176	475
6-7	250	100	350	745	498	1243
7-8	394	276	670	1085	717	1802
8-9	404	375	779	1146	619	1765
9-10	378	335	713	1110	572	1682
10-11	362	362	724	1101	628	1729
11-12	389	382	771	1156	709	1865
12-1	391	391	781	1220	721	1941
1-2	410	383	793	1211	717	1928
2-3	414	388	802	1265	758	2023
3-4	422	410	832	1377	766	2143
4-5	413	404	817	1381	775	2156
5-6	417	394	811	1294	674	1968
6-7	453	410	863	1169	685	1854
7-8	436	415	851	1050	610	1660
8-9	414	357	771	823	496	1319
9-10	407	334	741	739	386	1125
10-11	331	287	618	491	300	791
11-12	321	305	626	378	223	601
TOTAL	7487	6735	14222	19416	11295	30711

One intersection in the PRT corridor was singled out for a detailed analysis of traffic operation. The chosen intersection (University Avenue, Stewart Street, Campus Drive), depicted in Figure 4, was selected because of its long standing tradition as one of the chief bottlenecks to travel before the inauguration of PRT service. One approach to the intersection (Approach A), along University Avenue, was the route taken by the University inter-campus buses, which then turned right onto Campus Drive, the latter street serving as the Main campus terminus.

The afternoon traffic on the northern approach to the above intersection (southbound on University Avenue) was recorded to peak somewhere around 400-415 vehicles. Using the signal split depicted in Figure 4, along with additional data showing a load factor of 70 (fully loaded cycles = 23), it can be determined that the level of service for the southbound approach in 1977 was greatly congested (level of service E).*

3.1.1 Distribution of Auto Travel Within the PMA

The entire Morgantown urban area is growing at a fast pace and much of the auto traffic within the M-PRT corridor is independent of the M-PRT. Therefore, the auto utilization figures can only be used in conjunction with data to document the overall change in traffic which is presumably due to growth conditions. A certain subset of the corridor traffic is, however, more dependent on the M-PRT. That subset has been labeled as auto travel within the PMA by residents of the PMA, and is limited to trips with both ends (origin and destination) falling within the study area. The magnitude of such travel in the spring of 1977 was estimated to be 8,627 average weekday person trips. A full breakdown of these trips, by origin and destination, is presented in Table 3-2.

3.1.2 Automobile Operating Costs

The supply of transportation is partially measured by the cost of use of a given mode. For the automobile, the principle, more easily measured, factors affecting this cost are the annual mileage driven and the size of the car. Automobile operating costs for standard and compact size cars in the Morgantown area for the year 1977 are summarized in Table 3.3.

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*Highway Capacity Manual, Highway Research Board Special Report 87, 1976, pp. 126-146.

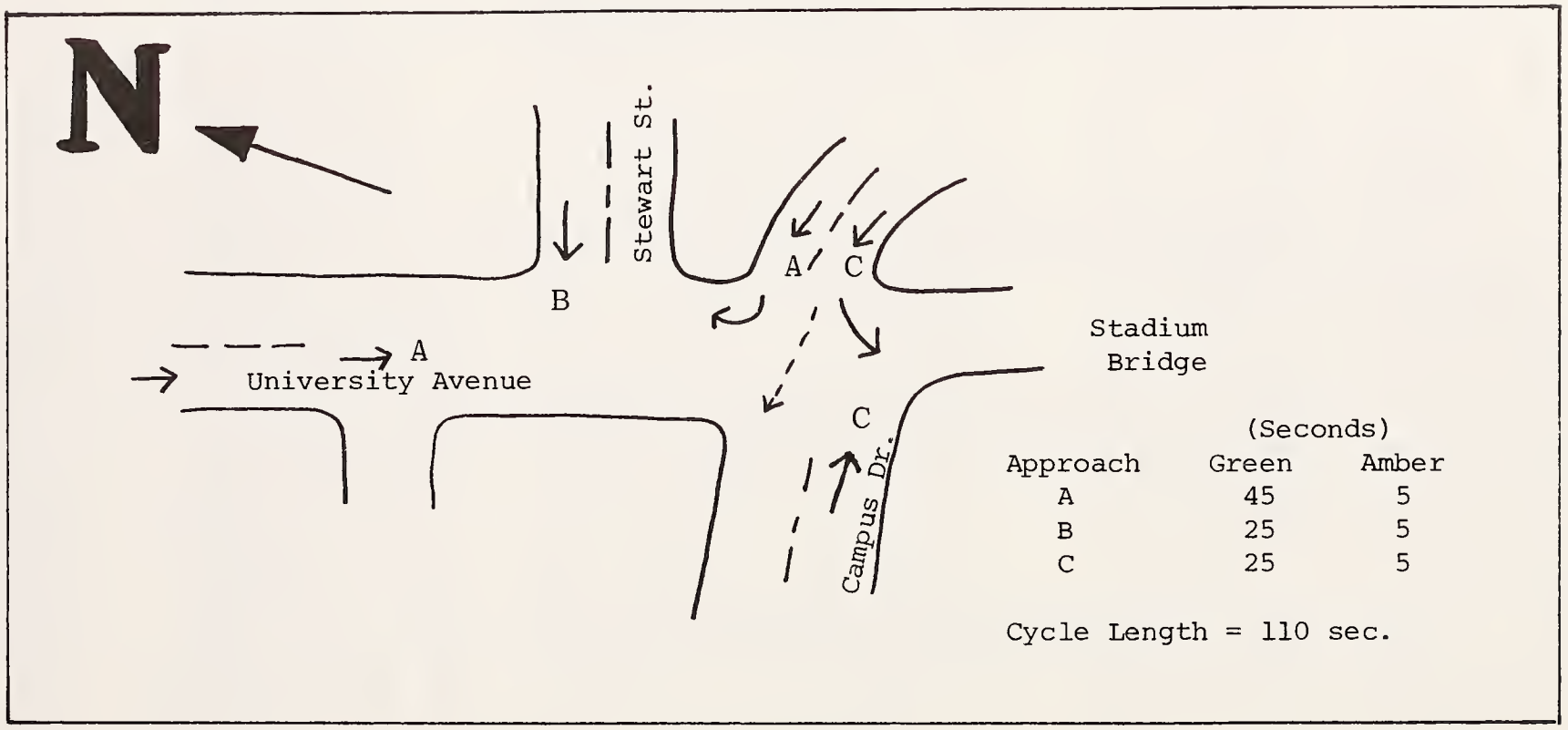


FIGURE 4

STREET INTERSECTIONS
USED IN DETAILED TRAFFIC ANALYSIS

TABLE 3-2

PHASE I - PMA WEEKDAY AUTO TRIP MATRIX

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL
1	0	43	40	81	36	36	36	115	125	48	38	10	81	390	22	164	1265
2	39	0	0	26	33	54	141	307	14	25	50	8	51	91	22	76	937
3	38	0	0	6	58	59	56	63	47	13	97	0	20	0	0	44	501
4	88	94	20	0	81	124	0	20	34	13	72	0	47	20	14	0	627
5	54	27	58	108	0	10	11	0	0	24	11	11	6	100	6	54	480
6	37	26	47	124	0	0	11	0	0	0	0	0	40	31	12	41	369
7	56	160	62	14	32	21	0	0	0	0	36	0	11	0	0	33	425
8	120	313	89	26	0	0	26	0	7	0	0	0	9	20	0	42	652
9	3	20	33	14	0	0	0	7	0	0	0	8	0	0	0	0	85
10	40	19	13	13	24	24	0	0	6	0	0	0	24	0	0	0	163
11	43	6	44	12	0	0	11	0	0	0	0	0	19	14	172	55	376
12	8	11	0	0	11	0	0	0	0	0	0	0	0	0	0	0	30
13	132	24	73	75	10	30	36	7	8	0	19	0	0	124	113	85	736
14	30	205	0	61	110	22	26	26	0	0	0	0	137	0	0	33	650
15	72	50	6	27	6	12	10	0	0	0	65	0	159	0	0	0	407
16	237	153	21	0	129	41	33	7	0	0	28	0	119	134	22	0	924
TOTAL	997	1151	506	587	530	433	397	552	241	123	416	37	723	924	383	627	8627

TABLE 3-3

ESTIMATED 1977 OPERATING COSTS OF AUTOMOBILES IN MORGANTOWN

Standard Size Automobile	Cost/Year	Cost/Mile*	% of Total Cost
Capital Recovery Cost	$821.59	¢ 8.22	39.62
Repairs and Maintenance	$450.24	¢ 4.50	21.71
Gasoline	$456.35	¢ 4.56	22.01
Insurance, Parking, Registration, etc.	$345.50	¢ 3.45	16.66
TOTAL	$2,073.68	¢20.73	100.00

Compact Size Automobile			
Capital Recovery Cost	$656.49	¢ 6.56	36.15
Repairs and Maintenance	$434.24	¢ 4.34	23.19
Gasoline	$381.91	¢ 3.82	21.03
Insurance, Parking, Registration, etc.	$343.50	¢3.43	18.91
TOTAL	$1,816.14	¢18.16	100.00

* Based on 10,000 annual miles driven

Additional factors perceived as a cost to the operation of an automobile are parking costs, and travel time. A summary of PMA interzonal travel times is given in Table 3-4. The average auto speed for selected trips along University and Beechurst Avenues is presented in Table 3-5. The higher speeds experienced in the northbound direction are in fact consistent with the less restrictive geometry of both thoroughfares as one approaches the Evansdale Campus, and the fact that there are no bottleneck points in and around Evansdale which can come even close to matching the congestion present near the CBD or within the Main Campus. For example, Beechurst Avenue, when it becomes Monongahela Boulevard, changes from 2 to 4 lanes as traffic travels North to Evansdale.

Parking

With regard to parking in the Morgantown area, there are two types of lots available. In the CBD, area city lots predominate while parking within the campus area is provided by the University. Volume III of this study describes each of the lots in the study area.

The parking costs of city lots are $0.10 for 20 minutes. The University structure on the Main Campus charges $0.35, flat, for each entry. The users of the other University lots can park by permit only and pay $3.00 per month. On the main campus, "permit only" lots are limited to faculty members. However, on the Evansdale Campus, certain of the "permit only" lots are available for student use although the number of students who get permits is quite low. Students at present using CAC and Engineering Buildings use the Coliseum lots. At the time of this study there was also a 400-vehicle capacity lot located at the Towers. This lot was free and was used mainly by Towers residents. (This lot was displaced with the advent of Phase II PRT construction.)

3.1.3 Traffic Accidents

While the magnitude and costs of accidents is not really perceived as a supply variable, these factors are nonetheless related to the magnitude of auto utilization and indirectly to congestion. The following narrative, therefore, is included as a summary of the traffic accident history within the PMA from June, 1975 (following the completion of the Pre-PRT Impact Study) to June, 1977.

TABLE 3-4

ESTIMATED WEEKDAY PMA AUTO TRAVEL TIMES IN THE SPRING OF 1977
(including the time to travel, park, and walk to destination)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	19.7	22.4	13.9	16.8	14.1	12.6	14.3	13.2	14.0	13.2	14.5	18.4	4.7	3.0	3.4
2	19.7	0	20.4	11.7	14.2	11.9	12.1	13.2	12.2	11.8	11.9	13.2	15.7	5.8	7.7	8.3
3	19.3	18.6	0	3.0	15.4	12.9	6.7	13.3	12.0	11.0	13.1	15.1	12.8	6.0	8.5	9.2
4	20.4	18.5	15.4	0	13.3	10.9	7.6	11.3	9.9	7.8	11.2	12.3	14.1	6.6	8.5	9.2
5	28.6	26.0	29.0	18.3	0	5.0	7.1	7.5	3.0	3.8	7.0	3.4	10.6	14.6	18.0	17.8
6	26.9	23.9	27.4	16.8	5.5	0	5.8	1.5	6.5	4.5	7.5	7.5	9.6	13.4	16.8	16.3
7	24.6	22.3	25.2	14.6	9.1	6.8	0	6.0	4.6	5.4	7.3	9.0	9.7	10.8	13.4	14.0
8	26.2	24.0	26.9	16.2	7.5	1.5	4.0	0	1.5	5.1	7.0	6.0	9.1	12.6	15.1	15.8
9	26.8	24.7	27.4	16.8	7.0	6.0	3.0	1.1	0	1.5	3.4	2.3	9.7	13.2	12.1	16.4
10	27.8	25.5	22.1	7.8	3.8	2.6	3.4	1.9	1.5	0	7.3	3.0	10.8	10.8	16.6	13.9
11	27.0	25.6	28.5	18.0	5.7	6.7	8.5	9.0	3.4	4.2	0	1.9	12.8	14.1	15.4	16.1
12	28.1	27.0	29.7	19.1	8.8	9.1	7.5	8.0	5.4	3.0	1.9	0	12.0	14.4	16.5	17.3
13	30.3	27.5	30.3	19.6	10.6	8.5	6.0	8.8	7.4	5.0	10.1	11.7	0	16.0	18.5	19.3
14	11.5	11.1	12.4	14.0	16.3	13.8	10.5	14.3	12.9	13.8	14.7	15.6	17.6	0	5.3	5.7
15	3.4	13.1	14.9	16.0	20.2	16.8	13.5	17.1	15.2	16.2	15.4	16.5	20.6	4.2	0	2.3
16	5.3	14.9	16.7	17.8	21.2	18.7	15.5	19.2	17.8	18.8	16.1	17.3	22.5	5.7	2.3	0

TABLE 3-5

WEEKDAY AUTO-TRAVEL SPEEDS IN PRT CORRIDOR
TRAVEL TIME (MINUTES)

ROUTE	UNIVERSITY AVENUE		BEECHURST AVENUE	
HOUR	Main Campus-Towers NORTHBOUND	Main Towers-Campus SOUTHBOUND	Walnut-Coliseum NORTHBOUND	Coliseum-Walnut SOUTHBOUND
8:00 AM	5.33	6.33	6.10	6.40
9:00 AM	5.20	--	5.50	6.00
10:00 AM	6.90	10.00	--	6.20
11:00 AM	9.70*	--	5.30	6.30
12:00 PM	6.50	15.1*	10.00*	8.00
1:00 PM	--	--	6.60	8.00
2:00 PM	8.60	9.02	6.00	7.00
3:00 PM	9.00	9.30	5.10	15.50
4:00 PM	5.80	9.80	7.50	16.00
5:00 PM	7.10	--	--	18.05*
AVERAGE TIME (MINUTES)	7.13	9.93	6.51	9.75
DISTANCE (MILES)	1.5	1.5	2.1	2.1
AVERAGE SPEED (MPH)	12.62	9.06	19.35	12.92
MINIMUM SPEED (MPH)	9.28	5.96	12.60	6.98

*Travel Time for Slowest Trip

The records for various accidents in the City were separated to reflect accidents occuring only within the M-PRT corridor. The information collected on these accidents included the zonal location, intersection identifier, nature of injury, accident type, and total damage in terms of dollars. The complete set of results are presented in Volume III. However, Table 3-6 presents a summary of the most important statistics.

The most noticeable figure in the table is the very large increase in accidents in 1976 or the first part of 1977. However, Morgantown, like many sections of the county, was particularly hard hit with an extreme winter, which no doubt was the most significant contribution to the high accident rate.

3.2 M-PRT Travel

The M-PRT is available for service to any who choose to ride, including townspeople who are in no way connected with West Virginia University. This fact is one of the biggest advantages in the service offered by the M-PRT over that which was offered by the University buses at the time of the Pre-PRT Study. Moreover, it is estimated that six percent (6%) of the PRT users are non-University related.

From the records provided by the previously cited destination selection unit on the M-PRT fare gates, (April 4 - April 6, 1977), it was estimated that the average weekday travel volume on the M-PRT was 10,294 passenger trips. This figure represents the total travel in the M-PRT corridor, contributed by the M-PRT by all user groups.

The distribution of the PRT corridor travel, during the peak hours of the day, is provided in Table 3-7. Certain peaks are seen to occur, but the predominant one occurs over the noon hour, when the University students redistribute themselves for lunch. It is also clear from Table 3-7 that the link between the Beechurst (Main Campus) and Engineering (Evansdale) stations is consistently the heaviest traveled.

3.2.1 The Distribution of M-PRT Travel Within the PMA

Not all of the 10,294 M-PRT average weekday trips are made completely within the bounds of the PMA. Using data on zones of origin and destination, when both were within the PMA, the resulting origin/destination data presented

TABLE 3-6

SUMMARY OF PMA ACCIDENT RECORDS

Year	Total No. of Accidents	Damage	Damage/Accident
1972	566	$208,686	$400.91
1973	518	$239,590	$462.53
1974	395	$186,835	$473.00
1975	674	$399.397	$592.57
1976	808	$404.028	$500.03
1977 (Jan-June)	358	$223,372	$623.94

TABLE 3-7

AVERAGE DAILY M-PRT TRAFFIC BY HOUR OF DAY*
AND STATION PAIR (April 4-April 6, 1977)

Hour	Walnut to Beechurst	Walnut to Engineering	Beechurst to Walnut	Beechurst to Engineering	Engineering to Walnut	Engineering to Beechurst	TOTALS
7-8 AM	12	49	1	164	3	360	589
8-9 AM	33	56	5	314	6	321	735
9-10 AM	31	58	16	372	15	474	966
10-11 AM	29	53	25	459	24	560	1150
11-12 AM	10	46	28	478	36	455	1053
12-1 PM	17	68	39	564	46	527	1261
1-2 PM	12	86	34	562	49	559	1302
2-3 PM	12	66	37	441	50	320	926
3-4 PM	7	69	44	452	60	279	911
4-5 PM	6	38	24	270	61	225	624
5-6 PM	5	18	15	120	31	105	294
6-7 PM	4	31	9	80	11	79	214
7-8 PM	6	16	7	98	9	50	186
8-8:30 PM	0	2	3	34	4	40	83
TOTALS	184	656	287	4408	405	4354	10294

*M-PRT Weekday Operating Hours Where 7:00 AM - 8:30 PM., and during the study period was only operated in the scheduled mode.

TABLE 3-8

PRT WEEKDAY PMA TRIP MATRIX BY RESIDENTS OF THE PMA

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	0	10	0	20	132	36	0	84	0	0	0	24	48	0	0	0	354
2	70	0	0	0	852	180	12	1344	0	0	0	72	276	0	28	28	2862
3	7	0	0	0	180	12	12	48	0	0	48	24	48	0	0	0	379
4	7	0	0	0	204	132	0	48	12	0	0	0	48	0	0	7	458
5	90	1078	238	168	0	0	0	0	0	0	0	0	0	27	59	54	1714
6	18	126	0	42	0	0	0	0	0	0	0	0	0	18	0	9	213
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	63	1708	14	28	0	0	0	0	0	0	0	0	0	0	0	0	1813
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	14	84	42	0	0	0	0	0	0	0	0	0	0	0	0	0	140
13	18	224	42	28	0	0	0	0	0	0	0	0	0	0	9	18	339
14	0	10	0	0	108	12	0	0	0	0	0	0	12	0	0	0	142
15	0	5	5	0	96	24	0	12	0	0	0	0	12	0	0	0	154
16	0	20	0	0	72	24	0	0	0	0	0	0	0	0	0	0	116
TOTAL	287	3279	341	286	1644	420	24	1536	12	0	48	120	444	45	96	116	8698

in Table 3-8 was developed so that estimates of PMA travel were only for residents of the PMA, and therefore, Tables 3-8 and 3-2 (PMA Auto Trips) could be compared on the same basis with each other, and with similar tables developed during the Pre-PRT study. Overall, a total of 8,598 PRT trips were made completely within the PMA by residents of the PMA. Table 3-9 displays the total PRT and Auto Trips.

3.2.2 Level of Service

Certain measures of the level of service offered by a transit system are looked upon as standards, such as the number of people within "reach" of the system stops (stations), and the percent of these potential riders which were diverted to the service ("penetration"). The following measures have been estimated for the M-PRT, based on the data collected during the 1977 study period:

1)	PMA population	17,433
2)	Reach (1)	17,433
3)	Morgantown Population	45,892
4)	Coverage (2 ÷ 3)	38%
5)	Ridership	10,294
6)	Penetration (5 ÷ 2)	59%
7)	Mobility	138,150

(# trips x distance x speed),(See Tables B-1 and 3-10).

The most meaningful measures of the M-PRT level of service, at least to the potential users, must be the total travel time between PMA zones which would result if the M-PRT wereused, the expected waiting time at origin stations, and the expected performance of the system in terms of the combined likelihoods of the system being available when needed and its being capable of completing trips without delay. The figures used to estimate total inclusive travel time are provided in Table 3-10. A breakdown of waiting times experienced during the study period are reported in Table 3-11. Overall, nearly eighty-six percent (86%) of the riders perceived their waiting time to be less than or equal to five minutes. The average wait, assuming 15 minutes wait for those who reported 11 minutes or longer, is 3.1 minutes, as shown in Table 3-12.

With regard to system performance, the M-PRT designed a measure which it is believed reflects the majority of the concerns of a user. This measure is termed conveyance dependability, which averaged 96.48%. Perfect conveyance dependability would be 100%.

TABLE 3-9

TOTAL TRIP MATRIX

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	0	53	40	101	168	72	36	199	125	48	38	34	125	390	22	164	1619
2	109	0	0	26	885	234	153	1651	14	25	50	80	327	91	50	104	3799
3	45	0	0	6	238	71	68	111	47	13	145	24	68	0	0	44	880
4	95	94	20	0	285	256	0	68	46	13	72	0	95	20	14	7	1085
5	114	1105	226	276	0	10	11	0	0	24	11	11	6	127	65	108	2194
6	55	152	47	166	0	0	11	0	0	0	0	0	40	49	12	50	582
7	56	160	62	14	32	21	0	0	0	0	36	0	11	0	0	33	425
8	183	2021	103	54	0	0	26	0	7	0	0	0	9	20	0	42	2465
9	3	20	33	14	0	0	0	7	0	0	0	8	0	0	0	0	85
10	40	33	13	13	24	24	0	0	6	0	0	0	24	0	0	0	177
11	43	6	44	12	0	0	11	0	0	0	0	0	19	14	172	55	376
12	22	95	42	0	11	0	0	0	0	0	0	0	0	0	0	0	170
13	150	248	115	103	10	30	36	7	8	0	19	0	0	124	122	103	1075
14	30	215	0	61	218	34	26	26	0	0	0	0	149	0	0	33	792
15	72	55	11	27	102	36	10	12	0	0	65	0	171	0	0	0	561
16	237	173	21	0	201	65	33	7	0	0	28	0	119	134	22	0	1040
TOTAL	1284	4430	847	873	2174	853	421	2088	253	123	464	157	1167	969	479	743	17325

TABLE 3-10

PRT TRAVEL TIME (MINUTES)

(Including walking, waiting, and in transit time)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	4.6	-	16.5	10.4	17.3	18.4	17.0	18.2	14.3	16.9	18.1	16.0	-	-	-
2	4.6	0	-	-	11.2	18.5	19.6	17.8	19.4	15.5	17.5	18.7	17.2	-	29.0	31.0
3	10.1	-	0	-	14.8	22.1	23.2	21.4	23.0	19.1	21.1	22.3	20.8	-	-	-
4	16.5	-	-	0	14.8	22.1	23.2	21.4	23.0	19.1	21.1	22.3	20.8	-	27.0	-
5	11.7	9.8	17.8	17.8	0	-	-	-	-	-	-	-	-	33.7	25.0	27.8
6	18.0	17.0	22.1	22.1	-	0	-	-	-	-	-	-	-	31.0	32.0	34.0
7	19.1	19.7	27.7	27.7	-	-	0	-	-	-	-	-	-	33.7	33.1	35.1
8	17.3	18.0	26.0	26.0	-	-	-	0	-	-	-	-	-	32.0	31.3	33.3
9	18.3	19.6	27.6	27.6	-	-	-	-	0	-	-	-	-	33.6	32.3	34.3
10	15.0	16.0	24.0	24.0	-	-	-	-	-	0	-	-	-	30.0	29.0	31.0
11	17.0	17.7	25.7	25.7	-	-	-	-	-	-	0	-	-	31.7	36.0	33.0
12	18.2	18.9	22.3	22.3	-	-	-	-	-	-	-	0	-	33.0	32.2	34.2
13	16.7	17.4	25.4	25.4	-	-	-	-	-	-	-	-	0	31.4	30.7	32.7
14	-	-	-	-	23.6	27.9	29.0	27.2	28.8	24.9	27.0	28.1	26.6	0	-	-
15	-	22.0	36.5	30.0	28.2	32.5	33.6	31.8	33.4	29.5	31.5	32.7	31.2	-	0	-
16	-	32.0	-	40.0	36.7	41.0	42.1	40.3	41.9	38.0	40.0	41.2	39.7	-	-	0

TABLE 3-11

PRT WALKING AND WAITING TIMES (Minutes)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	2.1	0	14	3.7	10.6	11.7	10.3	11.5	7.6	10.2	11.4	9.3	0	0	0
2	1.6	0	0	0	6.1	13.4	14.5	12.7	14.3	10.4	12.4	13.6	12.1	0	26.0	28.0
3	7.1	0	0	0	9.7	17.0	18.1	16.3	17.9	14.0	16.0	17.2	15.7	0	0	0
4	13.5	0	0	0	9.7	17.0	18.1	16.3	17.9	14.0	16.0	17.2	15.7	0	24.0	0
5	4.6	4.7	12.7	12.7	0	0	0	0	0	0	0	0	0	26.6	17.9	20.7
6	10.9	11.9	17.0	17.0	0	0	0	0	0	0	0	0	0	25.9	26.9	28.9
7	12.0	14.6	22.6	22.6	0	0	0	0	0	0	0	0	0	28.6	26.0	28.0
8	10.2	12.9	20.9	20.9	0	0	0	0	0	0	0	0	0	26.9	24.2	26.2
9	11.2	14.5	22.5	22.5	0	0	0	0	0	0	0	0	0	28.5	25.2	27.2
10	7.9	10.9	18.9	18.9	0	0	0	0	0	0	0	0	0	24.9	21.9	23.9
11	9.9	12.6	20.6	20.6	0	0	0	0	0	0	0	0	0	26.6	28.9	25.9
12	11.1	13.8	17.2	17.2	0	0	0	0	0	0	0	0	0	27.9	25.1	27.1
13	9.6	12.3	20.3	20.3	0	0	0	0	0	0	0	0	0	26.3	23.6	25.6
14	0	0	0	0	16.9	21.2	22.3	20.5	22.1	18.2	20.4	21.4	19.9	0	0	0
15	0	19.5	34.0	27.5	21.5	25.8	26.9	25.1	26.7	22.8	24.8	26.0	24.5	0	0	0
16	0	29.5	0	37.5	30.0	34.3	35.4	33.6	35.2	31.3	33.3	34.5	33.0	0	0	0

TABLE 3-12

PERCEIVED WAITING TIMES FOR PRT SERVICE

Minutes of Wait	Frequency	Percent
0-2	959	57.9
3-5	461	27.8
6-10	173	10.4
Greater than 10	64	3.9
TOTAL	1657	100

M-PRT calculates the conveyance dependability (D) as follows:

$$D = SA \times FA \times TR \qquad (1)$$

where SA = System Availability

$$= \frac{\text{Up-Time}}{\text{Up=Time + Downtime}}$$

FA = Fleet Availability

$$= \frac{\text{\# of Vehicles Available}}{\text{\# of Vehicles Required}}$$

TR = Trip Reliability

$$= \frac{\text{\# of Successful Trips}}{\text{\# Successful Trips + \# Unsuccessful Trips.}}$$

System availability refers to the probability that a system is available for use on passenger demand. A fleet availability rate less than 1 implies excessive passenger wait time due to an insufficient fleet size (perhaps due to a maintenance backlog), where the desired fleet size is determined from an analysis of historical ridership levels. Trip reliability refers to the probability of a successful passenger trip (uninterrupted), given the system was available.

The system performance has pretty much stabilized around the level stated above, and has been recording many individual days at the 100% level. Certain anomalies in the original design, which will be remedied in Phase II, have nonetheless kept strains on consistantly achieving perfect performance. Overall, the Phase I system has matured, and can be said to have reached a steady state. Figure 5 tracks the performance record of the system from its first day of passenger service. Previously footnoted reports deal more specifically with the subject of PRT performance. As can be seen, the system operated rather erratically in the early months. It is our judgement that exposure to this condition probably had a distinct effect on ridership, even in the spring of 1977. Some indication of this is provided in Section 5 where the attitudes of users and nonusers is explored, particularly looking at the issue of reliability.

FIGURE 5

CUMULATIVE MONTHLY M-PRT CONVEYANCE DEPENDABILITY

There is no question, however, that the system is achieving steadily increasing acceptance. To illustrate this point, Figure 6 is included, which, overall, demonstrates an increasing ridership trend. The steep drops in ridership have been shown to be due to periods when the system either was simply not in service, or when certain failures made it necessary for service to be temporarily curtailed. It is clear from the figure that ridership is repeatedly off during the summer months, from mid May (5) to mid August (8), and repeatedly peaks on the opening of the fall semester in late August (8).

3.2.3 PRT Operating Costs

The operating budget for the M-PRT is broken down in Table 3-13, and covers the period (one full year) from June 1, 1976, to May 31, 1977. The total annual operating cost was reported as slightly under 1.3 million dollars. Using this figure, the average cost per passenger trip was estimated to be seventy cents (70¢). However, if one were to consider the passenger carrying capacity of the system (based on 594,000 revenue miles and 20 passenger/vehicle) the average cost per passenger trip would drop to just under eleven cents (11¢). The other point to be made is that buried in the reported budget are costs which are attributable to design changes, and to the support of design activities for Phase II. The only service provided by the University, which is not included in the budget figures, is the availability of University security police in the event of an emergency.

3.3 University Bus (U-Bus) Travel

Once the M-PRT gained some stability in its performance, U-Bus service within the PRT corridor was realigned. While service to and from the Main Campus was discontinued, U-Bus shuttle service remained between the Evansdale Campus and the Medical Center Campus (also in the Evansdale area). This service was not considered to be in the PRT corridor, and it did not compete with the PRT in any way. Moreover, it acted as feeder service to the M-PRT Engineering Station, at least for University students and some faculty and staff members.

The breakdown of the average weekday University shuttle bus ridership is provided in Table 3-14. The estimates for the total ridership is given as 5,381, based on U-Bus passenger counts (see Volume III). The budgeted annual operating cost for the shuttle bus service is given in Table 3-15.

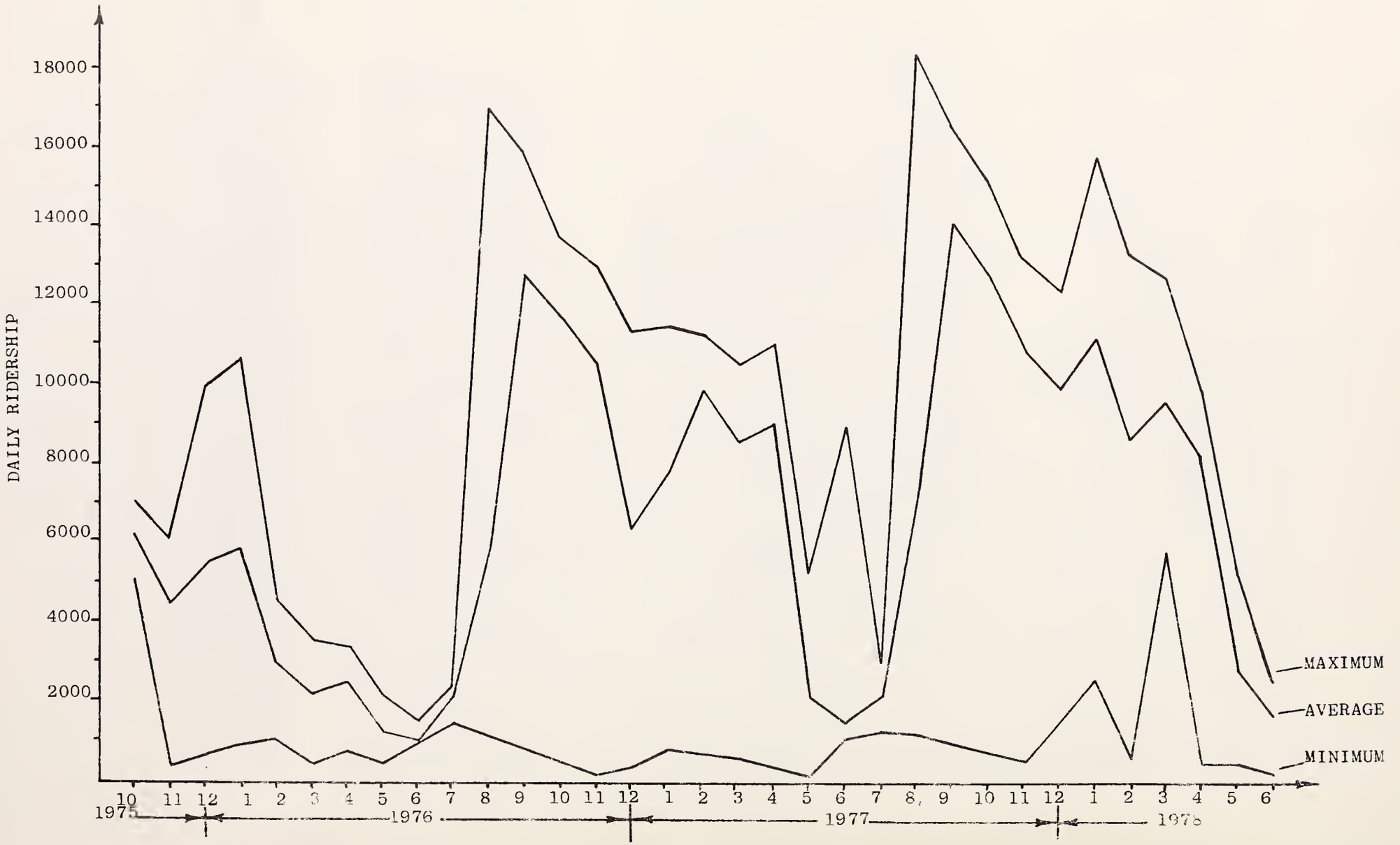


FIGURE 6

TRENDS IN DAILY M-PRT RIDERSHIP

TABLE 3-13

PRT OPERATING BUDGET
(for the 12 months 7/1/76 - 6/31/77)

OPERATING EXPENSES		
Labor	= $	542,754.00
Unclassified (Benefits, insurance, etc.)	= $	86,840.64
Energy		
Electricity	= $	100,552.00
Natural Gas	= $	100,619.00
Materials, Supplies, equipment, maintainance, contracts, etc.	= $	466,412.00
TOTAL OPERATING COST	= $	1,297,177.64
Operating Days = 329		
Average System Cost Per Day	=	$3,942.79
Total Vehicle Miles* = 629,157		
Average Cost Per Mile	=	$ 2.06
Total Passengers = 1,856,861		
Average Cost Per Passenger Trip	=	$ .70
Average # of Vehicles Operated/Weekday	=	19

* Vehicle miles and revenue miles are termed as equivalent units

TABLE 3-14

AVERAGE WEEKDAY U-BUS RIDERSHIP COUNTS
(NUMBER OF PASSENGERS LOADING AT VARIOUS STOPS)

STOP NAME	MED. CENT		TOWER			AG. SCIENCE			ENG.		CAC	COLISEUM		MT.LAIR	
TIME/ROUTE	M-CL	CL-M	T-E	M-CL	CL-M	T-E*	E-T*	E-T	M-CL	CL-M	M-CL*	M-CL	CL-M	Mt-M**	Total
8:00 - 9:00	18	6	207	24	21	3	2	78	4	13	1	4	7		388
9:00 - 10:00	25	8	284	44	16	33	5	192	10	20	2	9	12		660
10:00 - 11:00	31	7	199	29	16	50	5	201	14	21	3	4	24		604
11:00 - 12:00	41	4	166	31	17	53	7	198	9	18	3	1	22		570
12:00 - 13:00	33	3	238	64	37	31	8	293	19	43	29	2	24		824
13:00 - 14:00	18	11	198	27	26	43	5	165	14	32	5	4	25		573
14:00 - 15:00	33	8	96	22	21	26	4	234	22	58	5	2	24		555
15:00 - 16:00	44	18	54	26	20	46	5	204	17	42	6	6	19		507
16:00 - 17:00	43	13	21	13	12	19	9	163	12	45	6	7	17		380
Evening**	6			158		4			67		2	15		68	320
Totals	286	84	1463	280	344	304	54	1728	188	292	62	39	189	68	5381

Route: M-CL = Medical Center to Coliseum, CL-M - Coliseum to Medical Center

T-E = Tower to Engineering, E-T = Engineering to Tower

* Includes counts for M-CL-M Route

** Counts refer to evening route

TABLE 3-15

COST ANALYSIS--WVU CAMPUS-BUS SYSTEM
July, 1976 - June, 1977

Operating Expenses		
7 buses @ $25,000		= $175,000
Estimated Life		= 10 years
Estimated Salvage Value at the end of 10 years @ $2,00		= $14,000
Assuming 7% cost on Capital Investment, annualized Capital Cost		
= 151,000(A/P, 7%, 10) + .07(14,000)		= $23,903
Operating Expenses (Annual)		
Total Labor:	$ 86,306.00	
Fuel Parts, Etc:	$ 82,706.00	
Unclassified (Benefits, insurance, etc.):	$ 13,161.66	
Total	$182,173.66	= $182,173.66
Number of Operating days/year		= 302
Average System cost/day		= $603.22
Total Estimated Platform hours/day		= 65.37
(19,742 hours/year) Average cost per platform hour		= $9.23
Number of Miles driven/year		= 140,781
Average System cost/mile		= $1.29

4. TRAVEL BEHAVIOR ANALYSIS

This section of the report profiles travel in the PRT corridor. Particulars of the sampling procedure are detailed in Volume III of this report.

The four subpopulations of interest in the study were WVU employees, dormitory students, non-dormitory, and townspeople. Because it was expected that these groups would likely exhibit different travel characteristics and make different utilization of the PRT, an attempt was made to compare the travel of these subpopulations.

Using the above approach, travel characteristics which include number of trips per day, trips by mode, auto ownership, auto availability, possession of a driver's license, trip purpose and time of day when trips were made were determined for subpopulations. Table 4-1 summarizes the data discussed in Sections 4.1 - 4.4.

4.1 Daily Vehicle Trips

Results indicate that WVU employees made 2.13 vehicle trips per day, more than any of the other subpopulation groups, followed by 1.92 trips per day for the townspeople, 1.42 trips per day for nondormitory students, and finally, 1.38 trips per day for dormitory students. Trips in this instance only represent those vehicle trips made within the PMA. The lower number of trips per day by students may be due to the fact that they chose their place of residence to correspond to the campus where they take most of their classes.

4.2 Trip Mode

The analysis of trips by mode provides further information on the importance of auto versus other modes of transportation among each population group. Among WVU employees, over 83 percent of all daily trips were made as an auto driver, and over 93 percent as an occupant of an auto (driver or passenger). Thus, most auto trips were made as single occupant trips with the trip maker also being the driver. Only one percent of the WVU employee trips were made on the PRT.

Among dormitory students, only 20 percent of daily trips were made as auto drivers, but another 19 percent were made as an auto occupant, indicating the importance of shared rides to the dormitory students. PRT trips

TABLE 4-1

SELECTED TRAVEL CHARACTERISTICS OF PMA RESIDENTS
FOR TRIPS WITHIN THE PMA

	Students		WVU Faculty/Staff	Townspeople
	Dorm	Nondorm		
Sample Size	558	234	63	169
Average Daily Vehicular Trips per Person by all Modes	1.38	1.42	2.13	1.92
Percent of Trips by Mode-				
Auto Driver	20.64	57.05	83.3	58.5
Auto Pass.	19.58	18.61	9.3	19.1
PRT	49.33	15.61	1.04	16.0
U-Bus	2.7	---	---	.3
City Bus	---	---	4.16	1.2
Other	7.62	8.73	2.17	4.9
Percent of Trips for which Auto was Available	39.5	66.66	97.61	86.79
Percent of Respondents who have a Car Available	39.5	69.0	97.61	75.74
Percent of Respondents who own a Car	30.6	66.0	61.1	24.26
Percent of Total Trips by Hour of Day-				
7-9 am	22.6	28.86	25.17	22.2
11-1 pm	21.97	16.52	17.0	21.45
4-6 pm	16.92	16.95	27.21	18.39
Other times	38.51	45.67	30.62	37.06

represented 49 percent of the total trips made by the dormitory students, a larger share of total trips than auto trips (40 percent).

Among townspeople, auto and PRT use occur at the same level as nondormitory students, suggesting some behavioral similarity.

4.3 Automobile Availability

Automobile ownership and availability indicated some of the reasons why use of autos may have varied among the groups. Only 39 percent of the dormitory students owned a car or had one available, whereas 69 percent of the non-dormitory students owned a car or had one available. The townspeople again were similar to the nondormitory students in that a similar percentage, 75 percent, owned a car or had one available. The WVU employees exhibited the highest auto ownership and availability, 97 percent. Thus, comparing the groups, increasing auto ownership and availability appeared to be related to increasing use of auto, and decreasing use of the PRT.

4.4 Temporal Distribution of Travel Patterns

Comparison of the distribution of trips made during the AM noontime, and PM peak hours indicated that the WVU employees concentrate 52 percent of their trip making in the AM and PM peak hours (7-9 AM and 4-6 PM). Dormitory students made 40 percent of their trips at these times, and nondormitory students 38 percent. Townspeople tend to be similar to students, concentrating 40 percent of their trip in the peak AM and PM hours.

Between 11 AM - 1 PM , dormitory students and townspeople made about 22 percent of their trips, whereas WVU employees and nondormitory students made only about 17 percent of their trips during the noontime hours.

Nondormitory students made 45.6 percent of their trips during off-peak times, dorm students, 38.5%, and townspeople, 37.1%. WVU employees made the smallest percentage of off-peak trips, 30.6%. Thus, WVU employees tend to have higher concentrations of trips around the conventional peak hour time associated with the journey to and from work.

4.5 Trip Purpose

The data in Table 4-2 summarizes the purpose of each trip made by both auto and PRT by each of the subpopulations. The PRT was clearly the predominant mode for school related trips for University students. A larger percent of the WVU employee PRT trips were made for work related purposes, 26%, than the corresponding auto trips, 17%, again emphasizing the importance of the PRT to the life of the University. Morgantown residents not related to the University (townspeople) as expected, did not use the PRT for work related trips. However, a larger percentage of the resident's PRT trips, 52%, were for the more casual purposes of shopping, social, or recreation.

4.6 Daily PRT Trips

From a random sample of PRT riders (Table 4-2). it was estimated that 87% of the daily PRT trips are made by students, with the remaining percent being split nearly equally between WVU faculty and staff and townspeople. The PRT ridership by townspeople is much larger than expected. Given that the M-PRT system is only partially completed, and does not offer a convenient auto intercept at the Engineering station, it was not expected that the system would be utilized at all by townspeople.

It is striking to note the narrow range of average daily PRT travel exhibited in Table 4-3. The range is 1.86 to 2.33, suggesting that most people use the PRT to make one round trip. As expected, the higher number of daily trips, 2.33 and 2.25, are taken by Sophomores and Junior students, respectively. Freshmen and Seniors travel campuses less frequently as the curriculum in these first and fourth years are less varied. Overall, people surveyed on the PRT reported a slightly higher average number of PRT trips per day (2.21) than the average total vehicle trips reported by the random sample of PMA residents (1.52).

From the on-board survey of PRT riders, it was also found that the temporal distribution of PRT trips was different from the distribution of total trips, by all modes, which was discussed in Section 4.4. By comparing the figures in Table 4-4 with those in Table 4-1. several differences can be seen. The most striking is that PRT travel is concentrated more during the off-peak times, which, at least for University students, emphasizes the use of the PRT for travel before and after classes, which occur throughout the day. Townspeople using the PRT likewise made more of their trips during normal off-peak times (47%). Townspeople also made far more trips over the noon hours than did faculty/staff and students (35% vs 5-8%).

TABLE 4-2

DISTRIBUTION OF TRIP PURPOSE STRATIFIED BY MODE OF TRAVEL AND USER GROUP

Trip Purpose	Student		WVU Employees		Townspeople		Total	
	Auto	PRT	Auto	PRT	Auto	PRT	Auto	PRT
Returning Home	44%	24%	42%	37%	33%	14%	40%	24%
School Related	29%	64%	8%	6%	3%	19%	20%	57%
Work Related	2%	---	17%	26%	18%	---	8%	2%
Shopping	9%	3%	5%	---	---	7%	7%	3%
Social/ Recreational	---	5%	---	9%	11%	45%	3%	8%
Eat Meal	3%	---	---	---	---	---	2%	---
Other	13%	4%	28%	22%	35%	15%	20%	6%
Total	100%	100%	100%	100%	100%	100%	100%	100%
	(370)	(720)	(36)	(50)	(169)	(58)	(575)	(828)

TABLE 4-3

FREQUENCY OF NUMBER OF PRT TRIPS PER DAY FOR RESPONDENTS
TO AN ON-BOARD SURVEY OF PRT RIDERS

Users Status	1	2	3	4	5	6	7	8	9 or more	Total	Average Trips/Day
Part-Time Student	4	4	2	0	0	0	0	0	0	10	2
Freshman	5	17	0	2	0	1	0	0	0	25	2.12
Sophomore	13	55	5	16	1	1	0	0	0	90	2.33
Junior	25	56	7	12	1	1	0	1	1	104	2.25
Senior	25	65	2	10	0	5	0	0	0	107	2.25
Graduate Student	5	23	2	1	0	1	0	1	0	33	2.27
Fac/Staff	3	8	2	1	0	0	0	0	0	14	2.07
Other	1	6	0	0	0	0	0	0	0	7	1.86
Totals	81	234	19	42	2	9	0	2	1	390	2.21

Overall, it appeared as though the townspeople respondents rode the PRT for somewhat different purposes than those people affiliated with WVU, whereas WVU employees and students were riding it for similar purposes, in terms of time of day.

TABLE 4-4

TEMPORAL DISTRIBUTION OF PRT TRAVEL PATTERNS

Percent of Total PRT Trips by Hour of Day	Students	WVU Faculty/Staff	Townspeople
7-9 AM	16.8	12.0	1.7
11-1 PM	5.0	8.0	34.5
4-6 PM	15.0	14.0	17.2
Other Times	63.1	66.0	46.6

5. MODAL ATTITUDES

Measures of attitudes towards travel modes within the PMA were collected. The objectives were to measure why trip makers chose modes and to measure attitudes towards modal alternatives. Data are described and analyzed under the following main headings: (1) Reasons for Mode Choice and (2) Rank Ordering of Modes.

5.1 Reasons for Mode Choice

All travelers were asked for their principle reason for mode choice. Table 5-1 summarizes the responses given by mode.

A comparison of automobile with PRT trip makers displays a difference in the reasons for mode choice. The automobile, as expected, was chosen for convenience by 49% of the respondents, only 12% stated that they had no choice in using the auto. The opposite response was recorded by PRT riders, with the majority of PRT trips (59%) made because they had no choice in the selection of a mode. The majority of PRT riders are students without a car, or who at least perceived their car to be unavailable or impractical for the campus to campus (class) trips.

It should be noted that 34% of the non-WVU (townspeople) users choose the PRT for its convenience. Another 47% reported some "other" reason for selecting the PRT. Both of these findings were somewhat surprising as it was not initially felt that Phase I of the PRT would be particularly convenient or otherwise attractive to townspeople, especially since there was no station side parking or community accessible feeder service to the Engineering Station. Moreover, the area surrounding the Engineering Station is not a major activity center and normally has no special attraction for non-WVU people. The unspecified ("other") but presumably desirable characteristic of the PRT may well be a partial cause for the substantial number of PRT trips which was not really expected until completion of Phase II, which would, among other things, offer station side parking at both ends of the corridor.

5.2 Rank Ordering of Modes

Respondents were asked to rank order the PRT, bus, and automobile in the order in which they satisfy seven attributes:

TABLE 5-1

REASONS FOR MODE CHOICE BY MODE AND USER GROUP

Reason for Mode Choice	Student		WVU Employees		Townspeople		Total	
	Auto	PRT	Auto	PRT	Auto	PRT	Auto	PRT
Convenience	51%	21%	58%	37%	39%	34%	49%	22%
Low Cost	2%	2%	5%	5%	1%	7%	2%	2%
Speed	10%	3%	7%	4%	3%	2%	8%	3%
Safety	34%	1.1%	---	25%	---	---	25%	2%
No other Transportation	1%	64%	28%	---	53%	10%	12%	59%
Other	3%	10%	2%	29%	4%	47%	4%	12%
Total	100%	100%	100%	100%	100%	100%	100%	100%
	(1023)	(1561)	(85)	(83)	(274)	(58)	(1354)	(1702)

- Safety
- Reliability
- Comfort
- Convenience
- Travel Time
- Cost to Use
- Pleasant Atmosphere.

These rankings provide a qualitative measure of the respondents' attitudes toward the PRT relative to other modes, and help to identify factors which influence modal choice.

Ranking scores, cross-classified by selected respondent attributes, or modes, are shown in the tables included in Appendix C. A first place, or highest ranking received a score of 3, a second place 2, and third (lowest) place 1. Thus, the modal alternative receiving the highest ranking score on any attribute is the mode which was viewed as best among the three modes on that attribute.

The summed attitudinal scores give the automobile first place, the PRT second, and the bus third.* Inspection of the individual attribute measures shows that for four of the seven characteristics (viz., comfort, convenience, travel time, and pleasant atmosphere), the pattern is the same as the overall summed rankings. However, on safety, the PRT was first, the bus second, and the auto third; while on reliability, the PRT was valued last, and the auto was valued as most satisfactory.

It is interesting to note that the third characteristic on which ratings differed was cost to use. Respondents to the on-board follow-up survey valued the bus as the most satisfactory (lowest cost). Telephone survey respondents rated the PRT first. It is the authors' opinion that this may be partially explained by the differences in sample frame. The on-board follow-up survey was composed of nearly all nondormitory residing students, while the home telephone survey had a high percentage of dormitory residing students, especially those in the Towers dormitory. The dorm students in particular are believed to perceive the PRT to be as inexpensive, ride-for-ride, as the bus. Indeed, those who live in the dormitories and who would presumably use their PRT passes, because of their proximity to PRT stations, frequently, with resulting low marginal cost per ride compared with the bus, should perceive PRT as lowest in cost.

*The exceptions occurred when the sample size was too small for statistical validity, e.g., the "housewife" category in the follow-up survey.

Summarizing the ratings of the three modes, the PRT is seen as better than the bus, but is is not perceived to be better than auto for comfort, convenience, economy of travel time, and pleasantness of atmosphere. The PRT received high ratings for safety, but low for reliability, and vied with the bus for best economy for the user.

It must be pointed out, however, that the PRT operates at a disadvantage to the auto. Specifically, Phase I PRT, as it stands, is an incomplete system. The remainder of the system is under construction as this report is being prepared. Therefore, the service which the PRT can offer, both to the University Campus and the non-University community, is significantly less than what will be available upon the completion of Phase II.

5.2.1 Rank of Modal Attitudes by Demographic and Socio-Economic Factors

Analyses relate rank order to demographic and socio-economic characteristics, and to trip modal choice/experience alternatives. Spearman rank correlation techniques are used to test the strength of inter-relationships.

The influence of demographic and socio-economic characteristics, on the rank order of modal characteristics, provide insight into attitudes toward PRT vis-a-vis the auto and bus. In some cases, there are differences among the classifications, in some cases not. However, the emphasis has been placed on these factors where there is evidence of a difference.

Age

Analyses were performed to determine whether attitudes toward the PRT, automobile, and bus were related to age of the respondent.

Age displayed no significant relationship with PRT riders' attitudes except on the issues of trip travel time and cost to use. In these cases, the PRT riders 25 years and older perceived the PRT as the economical mode, followed in succession by the automobile and the bus. On the other hand, both groups of younger riders (15-19 and 20-24) felt that the automobile was less costly in terms of time and dollars than the PRT, which they felt was in turn less costly than the bus.

Differences in ranking were also related to age when scores on the seven attitudinal variables were summed. Specifically, it was found that riders 25 years and older joined with the youngest rider group in their perceptions of the PRT as the superior travel mode, followed by the automobile, with travel by bus unanimously seen as inferior to the other two alternatives. The middle age group, containing individuals of 20-24 years, also rated the bus as most poor, but found the automobile to be preferable to the PRT.

The home interview survey, since it divided the 25 and older category into smaller categories, provided the opportunity to study the relationship between age and attitudes of this older group in more detail. However, except for safety and convenience, age had no relationship with attitudes. The only additional exception on the overall scores was that the most senior group (65 years and older) preferred the bus to the PRT, which was contrary to the ranking of all the other age groups. This same senior group differed with the others by ranking the bus as the safest mode, as opposed to the PRT, which was favord by the remaining age groups.

In assessing the relative convenience of the three travel modes, age was also related to the attitudes. In this case there was no distinguishable difference with the 25 and older groups, but all respondents over 25 differed with the younger groups by ranking the PRT last.

5.2.2 Income

With one exception, attitudes towards the PRT, automobile, and bus were not related to the income group within which a student respondent fell. The exception was the different groups' attitudes regarding the cost to use each of the modes. In this case, there were considerable differences in perception.

Data was also available for nonstudents. The level of the nonstudents respondents income also appeared to have no relationship with the ranking of the modes with regard to "safety", "comfort", and "pleasantness of atmosphere".

On the remaining attitudinal variables, the perceptions of relative qualities of the PRT, automobile and bus varied.

Sex

Overall, sex seemed to have no effect on the ranking of the three modes. Some within-group differences, due to sex, were present, notably between the student and nonstudent respondents.

For the student respondents, there was no significant agreement between the two sex groups in their perceptions regarding safety (although both gave the highest rating to the PRT), comfort (although both gave the highest rating to the automobile), or convenience.

5.2.3 Effect of PRT Experience

It was hypothesized that the amount of experience an individual has with using the PRT might be related to attitudes.

The general public was categorized into one of four groups depending upon the number of times they had ever ridden the PRT: never, 1-10, 11-100, or more than 100 times. The groups were compared on the rankings which each gave to the seven attitudes used to evaluate the PRT.

Spearman analysis showed that the less frequent PRT users agreed that the PRT deserved high ratings on the criteria of safety and required cost to use, intermediate ratings on comfort, required travel time, and pleasant atmosphere, and low ratings on reliability and convenience. The frequent users ranked the PRT higher on convenience, giving it an intermediate ranking.

5.2.4 Conclusion

Reviewing the analyses of respondents' rankings of the PRT, the bus, and the auto on attitudinal questions suggests some generalizations about peoples' use and perceptions of these modes. Perhaps the most obvious is that PRT is seen as definitely preferred to the bus.

Overall, the one attribute on which PRT received a low rating was reliability. In the authors' judgement, however, it appears that this may be due largely to early exposure to the system, prior to the system performance achieving a steady high state of performance. Thus, one would anticipate fewer problems, and less concern, by users of successor AGT type systems, which will presumably not have these problems to the same degree.

It should be noted that the PRT was the first choice on the attribute of safety, and the auto was last. But, however important this feature may be, it probably has little promotional value. Safety is a necessary but probably not a sufficient factor in fostering a shift in demand from the auto to mass transit.

More frequent PRT users perceive it as convenient, which suggests -- not suprisingly -- that convenience is a significant factor in modal choice. But convenient access to present PRT stations is limited to certain groups of users. As the new stations are added, one would certainly expect proportionately more favorable attitudes on convenience, and substantial marginal increases in PRT use.

This study provides insights on relative ranking of PRT and buses versus the auto for specific attributes. It suggests that the auto, for the Phase I PRT, is a clear leader among this set of alternatives. The one factor that does appear to have some power to bring about a shift in behavior may be convenience, since frequent users perceive the convenience of the PRT over the auto and the bus. Additionally, a high percentage of nonstudents who had a choice in the selection of a mode, reported "convenience" as the reason for choosing the PRT. A substantial portion of the same group of nonstudents reported some "other" reason for choosing the PRT; which leaves the implication that the attributes of the PRT were probably underspecified, and that there may have been some predominant reason, other than convenience, which influenced mode choice.

6. OPERATIONAL PRT MODELS

6.1 Overview and Scope of the Models

The models attempt to explain the conditions of transportation use within the M-PRT's Primary Market Area (PMA) following the introduction of regular PRT service. Overall, they are aggregate causal models of the magnitude of travel between PMA zones.

The objective of model development was to identify the factors (independent variables) which seemingly are the most significant causes for the variations in trip making which were observed taking place between PMA zones, for both transit (M-PRT) and automobile travel. The modeling effort is comparable to that which was completed for the Pre-PRT Study.

It is possible that a careful examination of both sets of models may yield certain insights into the reasons behind any shifts in travel behavior between these two points in time. For example, at the onset of the impact study, it was speculated that if the models (independent variables) to evolve from the Pre-PRT data offered little explanatory power when exposed to the operational phase data, then one reason for this might well be due to a shift in travelers' attitudes towards the alternate transportation modes. A separate report compares the Pre-PRT and the Operational Phase I PRT models and interpretates changes in explanatory power of the independent variables.

The models were formulated so as to explain variations in interzonal traffic flow for a given mode (T_{ijk}) as a function of the supply (S) characteristics of transportation alternatives and the zonal characteristics influencing transportation demand (D). The resulting formulations were multiplicative exponential modes which were calibrated and analyzed using the log-linear regression facilities of SAS-76. The following paragraphs document the development of both the dependent (T_{ijk}) and independent (S,D) variables.

6.1.1 Interzonal Travel Mode (T_{ijk})

The interzonal travel models, while being models of trip distribution, have also implicitly modeled trip generation. Simple linear trip generation models were not investigated during the operational stage because of the poor results achieved with such models during the Pre-PRT study. Therefore, during the operational stage, modeling efforts were focused solely on models of interzonal trip distribution.

The data and the actual source of the estimates given for the magnitude of travel, by zone of origin and zone of destination, was presented in Sections 2 (An Overview of Data Collection), 3.1.1 (ref., Table 3-2), and 3.2.1 (Ref., Table 3-8). Volume III of the Operational PRT Impact Study documents the specific data collection instruments.

For the transportation alternatives which were investigated during the Operational Study (M-PRT and auto), five different models were employed. Each of the models were intended to reflect the total travel attributable to different trip purposes. Fortunately, the zones of the PMA were suitable for such an analysis, as each of the zone could be described as being either predominately residential (home-based), campus, or commercial (CBD). Based on this categorization, the following trip purposes were established.

1) Campus-to-Campus
2) CBD Oriented (Zone 1 either as an origin or destination)
3) Home-to-Campus
4) Campus-to-Home
5) Interzonal (involving neither the CBD nor campus zone).

The location and description of the PMA zones were presented previously in Figure 1 and Table 2-1.

A breakdown of travel, by trip purpose (Table 6-1) is possible by aggregating trips (T_{ijk}) from their respective origin/destination matrices. Table 6-1 only includes those zone pairs where the alternate modes were actually competing and where the same trip was actually possible by the University bus during the time that the Pre-PRT Study was conducted. Trips between such zone pairs will be referred to as "competing" trips in later discussion. An analysis of Table 6-1 clearly indicates that trip purposes that are campus oriented involve more use of the M-PRT, while the remaining trips favor the automobile. Both these facts are to be expected, even though one of M-PRT stations is located in the CBD.

One can only speculate that the CBD oriented trips still favor the automobile for convenience for shopping. However, it must be emphasized that the other PRT stations are not convenient auto intercept stations and they offer no short term station side parking. This particular characteristic of the M-PRT is expected to change, however, once Phase II is completed and operational. City bus feeder service may also be implemented once the Phase II System has matured.

TABLE 6-1

SUMMARY OF THE TOTAL NUMBER OF TRIPS CATEGORIZED BY TRANSPORTATION MODE AND TRIP PURPOSE

Trip Purpose	M-PRT Trips	Auto Trips	Total	Split (M-PRT/Total)
Campus-to-Campus	2533	265	2798	.91
CBD Oriented	559	1028	1587	.35
Home-to-Campus	2773	1777	4550	.61
Campus-to-Home	2087	1770	3857	.54
Interzonal*	287	601	888	.32
TOTAL**	8239	5441	13680	.60

NOTES: * Interzonal trips are categorized as those trips which involve neither the CBD nor any of the campus zones at either end of the trip.

** Figures in a similar tabulation on page 69 of Volume I of the Pre-PRT series of reports should not be compared with the above figures. The former tabulation includes all interzonal pairs, including the noncompeting trips. The above tabulation includes only interzonal pairs where the alternate modes are competing. The operational stage impact assessment report has taken this into account by deducting the noncompeting trips from the original Pre-PRT tabulations.

For interzonal trips, the auto is the dominant mode because of the requirement for driver transfer, should the M-PRT be chosen, and the clear advantage of door-to-door travel.

6.1.2 Independent Variables in the Models

The independent, causal variables were classed as either characteristics of the supply (S) of the alternative transportation modes or characteristics of demand or of the zones being served. In the latter case, the zonal characteristics were chosen on the basis of their being likely correlatives of potential travel demand (D). The zonal characteristics which were chosen, included population measures, employment characteristics, and measures of the magnitudes of classroom activity in the various campus zones. Table 6-2 provides a complete description of each of the independent variables which were used in the modeling effort. The procedures used to estimate the population and employment of the zones are described in Volume III. The estimates of the total floor area for all campus buildings were supplied by officials of the University while the estimates of magnitude of classroom activity were obtained from an analysis of student records for the spring of 1977, also provided by data obtained by University officials. There is a subtle difference, however, between the number of classes scheduled and the number of class changes. The former is self explanatory but the latter corresponds to the number of class changes for a particular campus which results in the next class being scheduled on a different campus. Both variables were considered in the models.

The transportation supply variable employed was trip cost. However, in this case, the total costs of the trip were included in the numerical estimates. For the automobile, this meant summing individual estimates of the cost of driving time (valued at $3.00 per hour); the average cost of operating an automobile; the value of the time it took to park the car at the destination (again at $3.00 per hour); and the average parking cost, where appropriate.

The cost of a PRT trip was considered to be the cost of total travel time (valued at $3.00 per hour), including the average time required to travel to the origin station; the average wait time at the station; the PRT trip time; and the average time required to reach the ultimate destination. The actual user cost (PRT fare) was not considered in the formulation because of the low marginal cost, the fact that a flat semester fee is paid by the majority of users, and the fact that the fare collection gates were

TABLE 6-2

DEFINITION OF INDEPENDENT VARIABLES
EMPLOYED IN THE MODELS

Variable Name	Definition of Variables Characterizing PMA Zones
P_1	Total residential population of origin zone
P_2	Total residential population of destination zone
S_1	Residential population of students in origin zone
S_2	Residential population of students in destination zone
FA_1	Total floor area of campus buildings in origin zone
FA_2	Total floor area of campus buildings in destination zone
CL_1	Number of student classes scheduled at campus of origin
CL_2	Number of student classes scheduled at campus of destination
C_1	Number of class changes occuring in campus of origin
C_2	Number of class changes occuring in campus of destination
E_1	Number of people employed at origin zone
E_2	Number of people employed at destination zone

TABLE 6-2 (Cont'd)

DEFINITION OF INDEPENDENT VARIABLES
EMPLOYED IN THE MODELS

Variable Name	Definition of Variables Used to Characterize Transportation Supply
AC	Total cost of an auto trip between specific zone pairs
PC	Total cost of a PRT trip between specific zone pairs
RPC	The ratio of the cost of a trip by PRT (PC) to the cost of the same trip auto (AC) for specific zone pairs
RAC	The ratio of the cost of a trip by auto (AC) to the cost of the same trip by PRT (PC) for specific zone pairs

actually not in use at all times due to certain malfunctions. This particular anomaly is expected to be rectified, however, in Phase II of the M-PRT. The tables in Appendix B tabulate the interzonal distances, the travel times estimated for each travel mode and their respective total travel costs.

Table 6-3 summarizes the figures used as the estimates for each of the zonal variables. Once again it is pointed out, as it was in Section 2.1 and Table 2-1, that the PMA zones were renumbered, from 1-16, in order to facilitate automatic processing and analysis of the data. This particular change is also shown in Table 6-3.

6.2 Calibration of the Models

Not all zone pairs were used in the models even though they may have satisfied the definition of the particular trip purpose being modeled. The criteria for inclusion as an observation was based on whether or not the respective trips were modally competitive, as discussed earlier. The resulting models, selected from a step-wise regression procedure, are presented in Table 6-4. Because of the models' intended use in studying the impact of the M-PRT, commentary on this part of the study has been deferred to the report which assess the PRT's impact (re., The Phase I Impact on Morgantown).

The fact that the campus to campus trips are dominated by school related purposes is emphasized by the selection of variables describing land use (i.e., campus building floor area and the number of student classes scheduled) as being more strongly related to variations in trips than either of the zonal population variables. The resident population of a zone was more important to explaining variations in the home based trips, as would be expected.

The relative ratio of the cost to make a trip by PRT to the cost of making the same trip by auto displayed a fairly good and consistent relationship to variations in PRT travel between zones. The travel cost was a direct function of trip length and included travel time as one of its components. Clearly, the utilization of the PRT was influenced in many cases by the relative travel time advantage which the PRT had over the automobile. It is believed that the importance of this advantage is seen best in the models of campus-to-campus and interzonal trips.

The effect of trip length, as accounted for in the measures of auto cost, was also a significant contributor to variations in all auto trips which involved residential

TABLE 6-3

SOCIO-ECONOMIC DATA FOR PRIMARY MARKET AREA

Analysis Zone No.	PMA Zone No.(s)	Working Population (E)	No of Student** Classes Scheduled (CL)	Floor Area in 10^4 sq. ft. (FA)	No. of Student*** Class Changes (C)	Population (P)	Student Population (S)
1	1	1294	-	-	-	1400	513
2	2*	1337	24936	76.9	1476	-	-
3	3	127	-	-	-	2295	2108
4	4	41	-	-	-	1706	1223
5	5*	573	4756	32.4	1354	-	-
6	6*	228	5173	27.7	805	-	-
7	(7+19)	81	-	-	-	888	692
8	8*	292	-	-	-	1865	1860
9	9	235	-	-	-	130	-
10	10	26	-	-	-	260	93
11	12*	133	935	22.4	236	-	-
12	13	-	-	-	-	146	70
13	18*	1538	2511	46.0	2	-	-
14	25	67	-	-	-	3612	932
15	26	17	-	-	-	1723	396
16	27	-	-	-	-	3080	746

* Campus Zone
** Number of students scheduled to take a class on the campus on a given day
*** Total number of students requiring transportation because next class is scheduled on another campus

TABLE 6-4

SUMMARY OF CALIBRATED TRAVEL MODELS

Trip Purpose	Mode(k)	Model Description				R^2
Campus-to-Campus	Auto	$T_{ijk} = CL_1^{-.817}$	$FL_1^{-2.698}$	$E_1^{1.032}$	$RAC^{-.445}$	.999
		F 65.4	40.03	46.7	27.4	
		t 8.09	-6.35	6.83	-5.24	
		p .001	.003	.002	.006	
	PRT	$T_{ijk} = F_1^{4.627}$	$CL_2^{1.86}$	$RPC^{-7.04}$		.937
		F 13.48	15.88	14.7		
		t 3.67	3.98	-3.83		
		p .014	.011	.012		
CBD Oriented	Auto	$T_{ijk} = E_1^{.342}$	$E_2^{.278}$			.954
		F 29.63	19.59			
		t 5.44	4.43			
		p .000	.000			
	PRT	$T_{ijk} = E_1^{.2686}$	$RPC^{-.8512}$			.649
		F 8.42	1.83			
		t 2.9	-1.35			
		p .009	.191			

TABLE 6-4 (Cont'd)

SUMMARY OF CALIBRATED TRAVEL MODELS

Trip Purpose	Mode(k)	Model Description					R^2
Home-to-Campus	Auto	$T_{ijk} = S_1^{.469}$	$FA_2^{1.287}$	$AC^{-.788}$			.93
		F 5.75	3.26	1.59			
		t 2.4	1.8	-1.26			
		p .025	.084	.220			
	PRT	$T_{ijk} = S_1^{.899}$	$CL_2^{.659}$	$PC^{-1.799}$			.789
		F 6.90	7.43	8.28			
		t 2.03	2.73	-2.88			
		p .015	.012	.008			
Campus-to-Home	Auto	$T_{ijk} = E_1^{.313}$	$S_2^{.668}$	$AC^{-.503}$			.961
		F 4.10	8.57	1.72			
		t 2.03	2.93	-1.31			
		p .056	.008	.203			
	PRT	$T_{ijk} = CL_1^{1.104}$	$P_2^{2.002}$	$PC^{-4.484}$	$RPC^{-1.004}$		.863
		F 29.19	16.22	21.87	2.31		
		t 5.4	4.03	-4.68	-1.52		
		p .000	.001	.000	.144		

TABLE 6-4 (Cont'd)

SUMMARY OF CALIBRATED TRAVEL MODELS

Trip Purpose	Mode(k)	Model Description				R^2
Interzonal	Auto	$T_{ijk} = P_1^{.913}$	$P_2^{.842}$	$AC^{-2.138}$	$RAC^{2.734}$	.647
		F 20.0	19.5	20.4	10.9	
		t 4.47	4.42	-4.51	3.3	
		p .000	.000	.000	.002	
	PRT	$T_{ijk} = P_1^{.559}$	$P_2^{.522}$	$PC^{-1.317}$	$RPC^{-1.449}$	.428
		F 10.6	10.5	10.9	7.6	
		t 3.25	3.24	-3.30	-2.76	
		p .002	.002	.002	.008	

zones, except when the CBD was involved either as an origin or destination. In the latter cases, zonal employment seemed to be the most important correlate with auto travel.

7. SUMMARY

The Phase I PRT System which exists in Morgantown, West Virginia, directly serves a large part of this community, reaching some 38% of the Morgantown residents. This report focuses its attention on the analysis of transportation related conditions which existed in the PRT's service area (Primary Market Area) in the Spring of 1977.

The PRT is viewed as a significant mode of transportation in Morgantown, along with the automobile. It has been the subject of repeated press coverage and numerous special studies, and its 3 stations and 2.2 miles of double guideway dominate the landscape in many areas, especially in the center of town and on the campuses of West Virginia University, which it most directly serves. Moreover, during the course of this study, it was concluded that the PRT is a major force in influencing travel habits within its service area, with a total penetration of 59% (ridership/residents within reach). The residents of this service area averaged a 60% weekday modal split (PRT trips/total trips). Figures ranged from a low of .32 for trips between residential areas, to a high of .91 for trips between campuses of West Virginia University. This last figure emphasizes the fact that the PRT provides the most direct service to the University campuses. Most of the trips between these areas are, in fact, for school related purposes.

Despite the predominance of WVU student travel (both school related and discretionary) on the PRT (87% of all trips), townspeople (nonuniversity related people) accounted for a 6% share of total trips. The majority of the trips by townspeople were discretionary trips made for such purposes as shopping and recreation.

Advantages to using the PRT within its service area include reduced travel time between most areas when compared to the travel time of the automobile. Auto traffic and surface street congestion is common along the corridors which are also served by the PRT. The fact that the PRT is grade separated provides most of its advantage. The scarcity of good parking in certain sections of the service area (e.g., the CBD) also contributes to the PRT's advantage.

The PRT's frequent service (often departing stations at 15 second intervals) and relatively low wait times (86% of the riders waited less than 5 minutes for service) was, in the opinion of the authors, viewed by residents as one of the PRT's major assets. These assets, coupled with the location of stations, particularly the CBD station, no doubt accounted for the fact that the convenience of the PRT was the second most important reason for choosing the PRT for a trip. The main reason was reported to be that many of the travelers felt that they had no choice, either because they simply did not have a car available, or the car was perceived as out of the question because of parking and traffic congestion.

Attitudes towards the PRT and its characteristics vary depending on the user group and the characteristic being investigated. However, overall, the PRT was ranked second to the automobile but superior to the bus. Looking at specific characteristics,the PRT was ranked first when it came to modal safety, but its reliability was perceived as inferior to the bus as well as to the automobile. In the opinion of the authors, attitudes towards the PRT were greatly influenced both by the fact that the PRT system, as it existed in the Spring of 1977, was an incomplete system, and the fact that users were exposed to erratic operation during the first year of revenue service when many of the "bugs" in this new technology were being uncovered.

The potential impacts of the PRT are really what are being investigated throughout these reports. A summary of the impact findings, along with an analysis of some specific areas, are provided in the volume entitled "The Phase I PRT Impact on Morgantown." This report, along with Volume I of the Pre-PRT Study, form the basis for assessing the PRT's impact within its service area.

TABLE A-1

MODAL ATTITUDINAL SCORES STRATIFIED BY RESPONDENT'S AGE AND MODAL ATTRIBUTES

AGE	SAFETY			RELIABILITY			COMFORT			CONVENIENCE			TRAVEL TIME			COST TO USE			PLEASANT ATMOSPHERE			OVERALL RANKING SCORE		
	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS
14 or less	3	1	2	1	1	2	2	1	1	1	1	2	1	3	2	3	1	2	3	1	2	3	1	2
15 - 19	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
20 - 24	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
25 - 34	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	3	2	2	1	3	2	1	3
35 - 44	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	3	2	2	1	3	2	1	3
45 - 54	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	2	3	2	1	3	2	1	3
55 - 64	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	3	2	2	1	3	2	1	3
65 or older	2	3	1	3	1	2	2	1	3	3	1	2	2	1	3	2	3	1	2	1	3	3	1	2
Totals	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	1	3	2	2	1	3	2	1	3

TABLE A-2

MODAL ATTITUDINAL SCORES STRATIFIED BY USERS RELATIONSHIP TO WVU, SEX, AND MODAL ATTRIBUTES

		SAFETY			RELIABILITY			COMFORT			CONVENIENCE			TRAVEL TIME			COST TO USE			PLEASANT ATMOSPHERE			OVERALL RANKING SCORE		
		PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS
Student	M	1	3	2	3	1	2	2	1	3	1	2	2	1	2	3	1	2	1	2	1	3	2	1	3
	F	1	3	2	3	1	2	3	1	2	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
Fac/Staff	M	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	3	2	2	1	3	2	1	3
	F	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	3	2	2	1	3	2	1	3
Non-WVU	M	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	3	2	2	1	3	2	1	3
	F	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	2	3	2	1	3	2	1	3
Subtotal	M	1	3	2	3	1	2	2	1	3	1	2	3	2	1	3	1	3	2	2	1	3	2	1	3
	F	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
Total		1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3

TABLE A-3

MODAL ATTITUDINAL SCORES STRATIFIED BY STUDENT INCOME LEVEL AND MODAL ATTRIBUTES

INCOME	SAFETY			RELIABILITY			COMFORT			CONVENIENCE			TRAVEL TIME			COST TO USE			PLEASANT ATMOSPHERE			OVERALL RANKING SCORE		
	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS
$250 - $499	2	3	1	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
$500 - $749	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	1	3	2	2	1	3	2	1	3
$750 - $999	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
$1000 - $1249	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
$1250 - $1499	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
$1500 - $1749	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	1	3	2	2	1	3	2	1	3
$1750 - $1999	2	1	1	3	1	2	2	1	3	2	1	2	2	1	3	2	1	1	2	1	3	3	1	2
$2000 - $2249	1	2	3	3	1	2	3	1	2	3	1	2	3	1	2	1	2	1	3	1	2	3	1	2
Over $2250	3	1	2	2	1	2	2	1	3	2	1	2	2	1	2	3	1	2	2	1	2	3	1	2
Total	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3

TABLE A-4

MODAL ATTITUDINAL SCORES STRATIFIED BY NONSTUDENT INCOME LEVEL AND MODAL ATTRIBUTES

INCOME	SAFETY			RELIABILITY			COMFORT			CONVENIENCE			TRAVEL TIME			COST TO USE			PLEASANT ATMOSPHERE			OVERALL RANKING SCORE		
	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS
More than $15,000/yr	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	1	3	2	2	1	3	2	1	3
More than $10,000/yr	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	3	2	2	1	3	2	1	3
More than $5,000/yr	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	2	1	3	2	1	3	2	1	3
Below $5,000/yr	1	3	2	2	3	1	2	1	3	3	1	2	3	1	2	1	3	2	2	1	3	3	1	2
Total	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	3	2	2	1	3	2	1	3

TABLE A-5

MODAL ATTITUDINAL SCORES STRATIFIED BY NUMBER OF TIMES RESPONDENTS HAVE RIDDEN THE PRT AND MODAL ATTRIBUTES

TIMES RIDDEN ON PRT	SAFETY			RELIABILITY			COMFORT			CONVENIENCE			TRAVEL TIME			COST TO USE			PLEASANT ATMOSPHERE			OVERALL RANKING SCORE		
	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS
Never	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	1	2	3	2	1	3	2	1	3
1 - 10	1	3	2	3	1	2	2	1	3	3	1	2	2	1	3	2	3	1	2	1	3	2	1	3
11 - 100	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	2	3	1	2	1	3	2	1	3
More than 100	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	1	3	2	2	1	3	2	1	3
Totals	1	3	2	3	1	2	2	1	3	2	1	3	2	1	3	1	3	2	2	1	3	2	1	3

TABLE A-6

MODAL ATTITUDINAL SCORES STRATIFIED BY WHETHER OR NOT THE RESPONDENT HAD A CHOICE IN USING THE PRT AND MODAL ATTRIBUTES

	SAFETY			RELIABILITY			COMFORT			CONVENIENCE			TRAVEL TIME			COST TO USE			PLEASANT ATMOSPHERE			OVERALL RANKING SCORE		
CHOICE	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS	PRT	CAR	BUS
Choice	1	3	2	3	1	2	2	1	3	1	2	3	2	1	3	1	3	2	2	1	3	1	2	3
No Choice	1	3	2	3	1	2	2	1	3	1	2	3	2	1	3	2	3	1	2	1	3	2	1	3
Total	1	3	2	3	1	2	2	1	3	1	2	3	2	1	3	2	3	1	2	1	3	2	1	3

TABLE B-1

STUDY INTERZONAL DISTANCE (MILES)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0.0	0.7	0.8	0.9	2.7	2.3	1.8	2.1	2.3	2.5	2.3	2.6	2.9	1.1	0.7	0.8
2	0.7	0.0	0.4	0.4	2.1	1.8	1.3	1.6	1.8	2.0	2.0	2.3	2.4	0.7	1.2	1.3
3	0.6	0.4	0.0	0.7	2.3	2.0	1.5	1.9	2.0	2.2	2.3	2.7	2.6	0.8	1.1	1.2
4	0.8	0.4	0.6	0.0	1.9	1.6	1.0	1.4	1.6	1.8	2.1	2.2	0.9	1.4	1.5	0.0
5	2.7	2.1	2.3	1.9	0.0	0.5	1.0	0.4	0.8	1.0	0.7	0.9	1.4	2.6	3.1	3.3
6	2.3	1.8	2.0	1.6	0.5	0.0	0.7	0.3	0.4	0.7	1.1	0.9	1.1	2.3	2.8	3.0
7	1.8	1.3	1.5	1.0	1.0	0.7	0.0	0.6	0.7	0.9	1.4	1.1	1.3	1.8	2.3	2.5
8	2.1	1.6	1.8	1.4	0.6	0.3	0.6	0.0	0.3	0.5	1.0	0.7	0.9	2.2	2.7	2.9
9	2.2	1.8	2.0	1.6	0.8	0.4	0.7	0.3	0.0	0.4	0.9	0.6	1.1	2.3	2.8	3.0
10	2.5	2.0	2.2	1.8	1.0	0.7	0.9	0.5	0.4	0.0	1.1	0.8	1.3	2.5	3.0	3.2
11	2.3	2.0	2.2	1.8	0.7	1.0	1.4	1.0	0.9	1.1	0.0	0.5	1.8	2.5	2.8	2.9
12	2.5	2.3	2.5	2.0	0.9	1.3	1.1	0.7	0.6	0.8	0.5	0.0	2.2	2.8	3.0	3.2
13	2.9	2.4	2.6	2.2	1.4	1.0	1.3	0.9	1.1	1.3	1.8	2.2	0.0	2.9	3.5	3.6
14	0.9	0.8	0.6	1.0	2.5	2.2	1.7	2.1	2.2	2.3	2.6	2.4	2.8	0.0	1.4	1.5
15	0.9	1.3	1.2	1.5	3.4	2.9	2.4	2.7	2.7	2.9	2.8	3.0	3.5	1.1	0.0	0.6
16	1.4	1.7	1.7	1.9	3.6	3.3	2.8	3.2	3.3	3.5	2.9	3.2	3.9	1.5	0.6	0.0

TABLE B-2

TOTAL AUTO TRAVEL TIME (Minutes)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	19.7	22.4	13.9	16.8	14.1	12.6	14.3	13.2	14.0	13.2	14.5	18.4	4.7	3.0	3.4
2	19.7	0	20.4	11.7	14.2	11.9	12.1	13.2	12.2	11.8	11.9	13.2	15.7	5.8	7.7	8.3
3	19.3	18.6	0	3.0	15.4	12.9	6.7	13.3	12.0	11.0	13.1	15.1	12.8	6.0	8.5	9.2
4	20.4	18.5	15.4	0	13.3	10.9	7.6	11.3	9.9	7.8	11.2	12.3	14.1	6.6	8.5	9.2
5	28.6	26.0	29.0	18.3	0	5.0	7.1	7.5	3.0	3.8	7.0	3.4	10.6	14.6	18.0	17.8
6	26.9	23.9	27.4	16.8	5.5	0	5.8	1.5	6.5	4.5	7.5	7.5	9.6	13.4	16.8	16.3
7	24.6	22.3	25.2	14.6	9.1	6.8	0	6.0	4.6	5.4	7.3	9.0	9.7	10.8	13.4	14.0
8	26.2	24.0	26.9	16.2	7.5	1.5	4.0	0	1.5	5.1	7.0	6.0	9.1	12.6	15.1	15.8
9	26.8	24.7	27.4	16.8	7.0	6.0	3.0	1.1	0	1.5	3.4	2.3	9.7	13.2	12.1	16.4
10	27.8	25.5	22.1	7.8	3.8	2.6	3.4	1.9	1.5	0	7.3	3.0	10.8	10.8	16.6	13.9
11	27.0	25.6	28.5	18.0	5.7	6.7	8.5	9.0	3.4	4.2	0	1.9	12.8	14.1	15.4	16.1
12	28.1	27.0	29.7	19.1	8.8	9.1	7.5	8.0	5.4	3.0	1.9	0	12.0	14.4	16.5	17.3
13	30.3	27.5	30.3	19.6	10.6	8.5	6.0	8.8	7.4	5.0	10.1	11.7	0	16.0	18.5	19.3
14	11.5	11.1	12.4	14.0	16.3	13.8	10.5	14.3	12.9	13.8	14.7	15.6	17.6	0	5.3	5.7
15	3.4	13.1	14.9	16.0	20.2	16.8	13.5	17.1	15.2	16.2	15.4	16.5	20.6	4.2	0	2.3
16	5.3	14.9	16.7	17.8	21.2	18.7	15.5	19.2	17.8	18.8	16.1	17.3	22.5	5.7	2.3	0

TABLE B-3

TOTAL AUTO TRAVEL COST (Dollars)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	1.46	1.78	0.86	1.33	1.13	0.96	1.10	1.08	1.16	1.08	1.19	1.45	0.43	0.28	0.32
2	1.35	0	2.26	0.66	1.09	0.93	0.85	0.90	0.84	0.96	0.96	1.08	1.23	0.42	0.61	0.66
3	1.33	1.36	0	0.28	1.19	1.01	0.61	1.01	0.96	0.95	1.08	1.25	1.11	0.45	0.63	0.68
4	1.42	1.35	1.39	0	1.00	0.84	0.56	0.82	0.79	0.71	0.94	1.02	0.87	0.58	0.70	0.46
5	2.17	2.03	2.38	1.27	0	0.34	0.54	0.45	0.30	0.37	0.48	0.33	0.78	1.20	1.46	1.49
6	2.01	1.87	2.24	1.13	0.37	0	0.42	0.14	0.40	0.36	0.58	0.54	0.58	1.09	1.35	1.36
7	1.81	1.70	2.04	0.91	0.64	0.47	0	0.41	0.36	0.43	0.62	0.65	0.73	0.87	1.09	1.15
8	1.94	1.84	2.15	1.06	.049	.013	0.31	0	0.13	0.35	0.53	0.43	0.62	1.03	1.25	1.32
9	2.00	1.91	2.24	1.13	0.50	0.37	0.28	0.12	0	0.14	0.33	0.23	0.69	1.08	1.12	1.37
10	2.09	1.99	2.02	0.72	0.37	0.26	0.33	0.18	0.14	0	0.57	0.30	0.78	1.00	1.38	1.28
11	2.02	1.99	2.34	1.23	0.42	0.52	0.68	0.63	0.33	0.41	0	0.19	0.97	1.16	1.28	1.34
12	2.13	2.12	2.45	1.32	0.60	0.70	0.58	0.53	0.38	0.30	0.19	0	1.00	1.23	1.38	1.45
13	2.29	2.16	2.50	1.38	0.78	0.61	0.54	0.60	0.57	0.49	0.84	.099	0	1.33	1.57	1.62
14	1.02	1.05	1.24	0.88	1.27	1.09	0.84	1.10	1.05	1.11	1.21	1.22	1.39	0	0.52	0.56
15	0.55	1.24	1.47	1.07	1.63	1.37	1.12	1.35	1.25	1.34	1.28	1.38	1.67	0.41	0	0.23
16	0.66	1.40	1.65	1.24	1.71	1.54	1.29	1.54	1.49	1.58	1.34	1.45	1.84	0.56	0.23	0

TABLE B-4

TOTAL PRT TRAVEL TIME (Minutes)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	4.6	-	16.5	10.4	17.3	18.4	17.0	18.2	14.3	16.9	18.1	16.0	-	-	-
2	4.6	0	-	-	11.2	18.5	19.6	17.8	19.4	15.5	17.5	18.7	17.2	-	29.0	31.0
3	10.1	-	0	-	14.8	22.1	23.2	21.4	23.0	19.1	21.1	22.3	20.8	-	-	-
4	16.5	-	-	0	14.8	22.1	23.2	21.4	23.0	19.1	21.1	22.3	20.8	-	27.0	0
5	11.7	9.8	17.8	17.8	0	-	-	-	-	-	-	-	-	33.7	25.0	27.8
6	18.0	17.0	22.1	22.1	-	0	-	-	-	-	-	-	-	31.0	32.0	34.0
7	19.1	19.7	27.7	27.7	-	-	0	-	-	-	-	-	-	33.7	33.1	35.1
8	17.3	18.0	26.0	26.0	-	-	-	0	-	-	-	-	-	32.0	31.3	33.3
9	18.3	19.6	27.6	27.6	-	-	-	-	0	-	-	-	-	33.6	32.3	34.3
10	15.0	16.0	24.0	24.0	-	-	-	-	-	0	-	-	-	30.0	29.0	31.0
11	17.0	17.7	25.7	25.7	-	-	-	-	-	-	0	-	-	31.7	36.0	33.0
12	18.2	18.9	22.3	22.3	-	-	-	-	-	-	-	0	-	33.0	32.2	34.2
13	16.7	17.4	25.4	25.4	-	-	-	-	-	-	-	-	0	31.4	30.7	32.7
14	-	-	-	-	23.6	27.9	29.0	27.2	28.8	24.9	27.0	28.1	26.6	0	-	-
15	-	22.0	36.5	30.0	28.2	32.5	33.6	31.8	33.4	29.5	31.5	32.7	31.2	-	0	-
16	-	32.0	-	40.0	36.7	41.0	42.1	40.3	41.9	38.0	40.0	41.2	39.7	-	-	0

TABLE B-5

TOTAL PRT TRAVEL COST (DOLLARS)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL
1	0	0.23	-	0.83	0.52	0.87	0.92	0.85	0.91	0.72	0.85	0.91	0.80	-	-	-	9.32
2	0.23	0	-	-	0.56	0.93	0.98	0.89	0.97	0.78	0.88	0.94	0.86	-	1.45	1.55	11.02
3	0.51	-	0	-	0.74	1.10	1.16	1.07	1.15	0.96	1.05	1.12	1.04	-	-	-	9.90
4	0.82	-	-	0	0.74	1.10	1.16	1.07	1.15	0.96	1.05	1.12	1.04	-	1.35	-	11.56
5	0.58	0.49	0.89	0.89	0	-	-	-	-	-	-	-	-	1.69	1.25	1.39	7.18
6	0.90	0.85	1.10	1.10	-	0	-	-	-	-	-	-	-	1.55	1.60	1.70	8.80
7	0.95	0.98	1.38	1.38	-	-	0	-	-	-	-	-	-	1.68	1.65	1.75	9.77
8	0.86	0.90	1.30	1.30	-	-	-	0	-	-	-	-	-	1.60	1.56	1.66	9.18
9	0.91	0.98	1.38	1.38	-	-	-	-	0	-	-	-	-	1.68	1.61	1.71	9.65
10	0.75	0.80	1.20	1.20	-	-	-	-	-	0	-	-	-	1.50	1.45	1.55	8.45
11	0.85	0.86	1.28	1.28	-	-	-	-	-	-	0	-	-	1.58	1.55	1.65	9.05
12	0.91	0.94	1.11	1.11	-	-	-	-	-	-	-	0	-	1.65	1.61	1.70	9.03
13	0.83	0.87	1.27	1.27	-	-	-	-	-	-	-	-	0	1.57	1.53	1.63	8.97
14	-	-	-	-	1.18	1.39	1.45	1.36	1.44	1.24	1.35	1.40	1.33	0	-	-	14.64
15	-	1.10	1.80	1.50	1.41	1.62	1.68	1.59	1.67	1.47	1.57	1.63	1.56	-	0	-	18.60
16	-	1.60	-	2.00	1.83	2.05	2.10	2.01	2.09	1.90	2.00	2.06	1.98	-	-	0	21.62
TOTAL	10.10	12.10	12.71	15.24	6.98	9.06	9.45	8.84	9.38	8.03	8.75	9.18	8.61	15.41	16.61	16.29	176.74

APPENDIX C

RECALIBRATED PRE-PRT MODELS

During the Pre-PRT Stage of the Impact Study, travel models were developed which were similar in formulation to the operational PRT models reported in Section 6. Subsequent to the Pre-PRT models being documented in Volume I in the Pre-PRT series of reports, it was determined that a recalibration of the Pre-PRT interzonal travel models was necessary in order to portray a more accurate accounting of travel behavior by mode, within the PMA during the Spring of 1975. Some specific reasons for deciding to recalibrate were:

1) Some computer errors in data base (input) preparations were discovered which caused some erroneous calibrations.

2) Although travel cost for each mode was considered in the original models, the relative ratio of travel costs was not considered as independent variables having possible explanatory power. It was felt that the recalibrated models should not, as a matter of policy, preclude this supply variable.

3) The Pre-PRT auto trip table was recalculated because it was believed that the original table gave an inflated estimate of the average daily auto trips occurring between zones within the PMA.

4) In order for the models and trips of both the Pre-PRT and operational PRT stages to be comparable, it is necessary that analyses only include those zone pairs where the alternate modes were actually competing and where the same trip was actually possible by the University bus during the Pre-PRT stage. For example, trips between the main campus and the CBD (Zones 1 and 2) should not be included in any calibration because the U-Bus never operated between these two zones.

The recalculated auto trip table for the Pre-PRT stage is shown in Table C-1. The total auto trips sum to 10,369; lower than the figure originally presented in Volume I of the Pre-PRT reports.

Table C-2 summarizes the Pre-PRT models which resulted from the recalibration. The models in Table C-2 present the baseline against which Operational PRT models were compared in the impact assessment volume.

TABLE C-1

PRE-PRT PMA AUTO TRIP MATRIX BY RESIDENTS OF THE PMA

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
1	0	14	35	87	57	16	387	167	37	126	8	3	30	248	181	197	1593
2	64	0	184	12	14	20	139	309	5	26	29	27	7	129	21	110	1096
3	35	202	0	4	5	10	10	149	10	0	55	0	7	0	0	20	507
4	109	12	4	0	8	17	4	31	0	0	20	0	12	31	11	48	307
5	81	200	5	12	0	2	5	0	0	7	6	0	14	114	39	156	641
6	13	40	5	37	2	0	9	0	0	0	0	10	6	5	12	139	278
7	164	154	5	4	5	10	0	5	5	0	15	0	25	0	0	26	418
8	186	267	88	27	0	0	5	0	15	0	23	8	15	0	59	99	792
9	42	9	0	4	0	0	5	8	0	36	0	19	19	61	0	30	233
10	52	21	0	0	9	5	0	0	27	0	7	3	22	0	27	0	173
11	11	30	49	12	12	0	10	30	0	2	0	0	5	10	61	17	249
12	0	25	0	20	0	10	0	0	19	0	10	0	0	0	0	0	84
13	83	24	15	12	9	6	20	23	19	21	3	0	0	253	186	136	810
14	349	36	17	31	210	8	0	11	61	0	10	0	313	0	0	61	1107
15	248	78	55	11	15	12	3	59	27	27	60	0	192	0	0	58	845
16	251	140	20	56	269	139	26	28	15	0	61	0	145	61	27	0	1238
Total	1688	1252	482	329	615	255	623	820	240	245	307	70	812	912	624	1097	10371

TABLE C-2

SUMMARY OF CALIBRATED TRAVEL MODELS
FOR THE PRE-PRT STAGE

Trip Purpose	Mode (k)	Model Description				R^2
Campus-to-Campus	Auto	$T_{ijk} = C_1^{3.305}$	$CL_1^{-3.913}$	$E_1^{2.3104}$		.985
		F 25.87	24.65	30.03		
		t 5.09	-4.96	5.48		
		p .007	.008	.005		
	Bus	$T_{ijk} = CL_1^{-1.501}$	$FA_1^{2.103}$	$E_1^{-6.015}$	$CL_2^{1.301}$	.994
		F 16.22	22.43	19.3	26.61	
		t -4.03	4.74	-4.39	5.16	
		p .028	.018	.022	.014	
CBD Oriented	Auto	$T_{ijk} = E_1^{.377}$	$E_2^{.225}$			.887
		F 11.64	4.12			
		t 3.41	2.03			
		p .004	.059			
	Bus	$T_{ijk} = E_2^{.358}$	$RBC^{1.04}$			.598
		F 19.07	1.79			
		t 4.37	1.34			
		p .001	.20			

TABLE C-2 (Continued)

SUMMARY OF CALIBRATED TRAVEL MODELS
FOR THE PRE-PRT STAGE

Trip Purpose	Mode (k)	Model Description				R^2
Home-to-Campus	Auto	$T_{ijk} = P_1^{.841}$	$C_2^{-.646}$	$FA_2^{5.755}$	$E_2^{-3.026}$	.916
		F 7.08	5.27	6.25	4.95	
		t 2.66	-2.3	2.5	-2.22	
		p .015	.033	.021	.038	
	Bus	$T_{ijk} = S_1^{.771}$	$CL_2^{1.503}$	$BC^{-2.968}$	$RBC^{2.935}$	.894
		F 11.74	27.46	31.68	6.64	
		t 3.43	5.24	-5.63	2.58	
		p .003	.000	.000	.018	
Campus-to-Home	Auto	$T_{ijk} = FA_1^{.620}$	$P_2^{.221}$	$RAC^{-2.356}$		.92
		F 3.32	1.7	4.69		
		t 1.82	1.3	-2.7		
		p .083	.207	.042		
	Bus	$T_{ijk} = FA_1^{3.474}$	$P_2^{1.312}$	$BC^{-4.221}$	$RPC^{-2.946}$	.958
		F 97.09	28.67	58.96	14.43	
		t 9.85	5.35	-7.68	-3.80	
		p .000	.000	.000	.001	

TABLE C-2 (Continued)

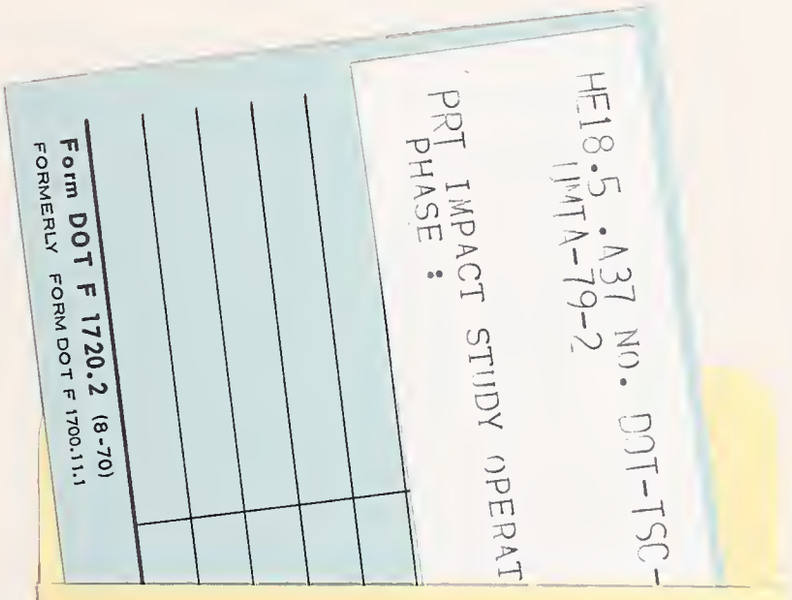
SUMMARY OF CALIBRATED TRAVEL MODELS
FOR THE PRE-PRT STAGE

Trip Purpose	Mode (k)	Model Description			R^2
Interzonel	Auto	$T_{ijk} = P_1^{.362}$	$P_2^{.075}$	$AC^{-.315}$	.494
		F 2.34	.15	.38	
		t 1.53	.39	-.62	
		p .134	.702	.541	
	Bus	$T_{ijk} = P_1^{-.307}$	$P_2^{.209}$	$BC^{.393}$	.412
		F 2.83	1.92	1.01	
		t -1.68	1.39	1.01	
		p .100	.173	.320	

APPENDIX D

REPORT OF NEW TECHNOLOGY

The work performed under this contract, while leading to no new invention, has reported the travel and traffic conditions in the area adjacent to the Phase I Morgantown PRT System following introduction of revenue service during Spring 1977. Transportation supply, modal utilization, and travel behavior were measured and models for travel in the area were developed.



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