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PHASE I MORGANTOWN PEOPLE MOVER IMPACT EVALUATION

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FINAL REPORT

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16. Abstract

This report presents a summary of the system and service characteristics and impacts of the Phase I Morgantown People Mover System. The major areas of discussion of this report include an overview of Phase I Morgantown People Mover system and the impact evaluation effort associated with it, a description of system performance and service characteristics, system ridership, system finances, system impacts, and an identification of experiences that are transferable to other applications of automated guideway transit.

System performance in terms of reliability improved as the system matured. Service characteristics of the People Mover system were generally better than the prior University bus system. Corridor auto travel did not decrease; however, on a more localized level, auto vehicle trips did decrease. No adverse environmental impacts resulted from the system. Some locational decisions of the facilities were influenced by the People Mover system. Experiences that have potential application to other AGT systems included the start-up, safety, and station design experience of the Morgantown system. Additionally, the modelling of travel behavior of choice users provided potentially useful information concerning the mode choice behavior of riders of other AGT systems.

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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
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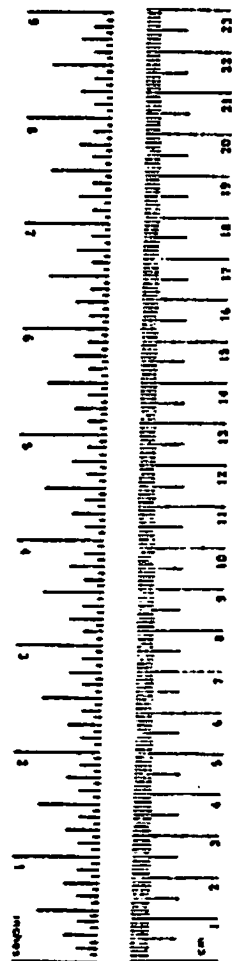

Approximate Conversions from Metric Measures

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m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
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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		
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l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
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m^3	cubic meters	1.3	cubic yards	yd^3
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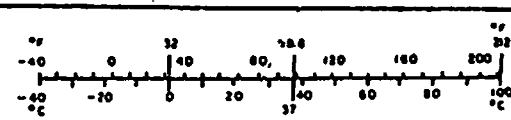

PREFACE

This report was prepared under PPA UM-839, Morgantown People Mover (MPM) Impact Evaluation, and PPA UM-941, Downtown People Mover, sponsored by the Office of Automated Guideway Transit (AGT) Applications, UTD-60, Steven Barsony, Director. It summarizes the impact of the three station Phase I Morgantown People Mover on travel, traffic, and associated activities in the area adjacent to the Phase I MPM guideway and stations. The report integrates previous analyses of the Morgantown area and Phase I MPM system with original data and analyses.

The Morgantown system belongs to a generic class of systems known as automated guideway transit (AGT). Although the Morgantown system has been labeled as a personal rapid transit (PRT) system throughout its history, PRT is a misnomer for the system. A more appropriate system name is Morgantown People Mover (MPM) and will be labeled as such in this report. Data sources that use PRT as the system name in their titles, however, will not be re-labeled in references in this report.

The objective of this report is to analyze the impact of the Phase I MPM system. Because there have been many studies of various aspects of the Phase I MPM system performed at different times and for different purposes (see Bibliography), UTD-60 decided it was necessary to develop a report which comprehensively encapsulated the service characteristics and impacts of the Phase I Morgantown People Mover system. Preliminary to writing this report, available data and research were reviewed and the most useful information was extracted or re-analyzed. This analytic review has been supplemented by analyses of additional Phase I MPM system and community data made available from UMTA and West Virginia University reports, respectively.

This report has four primary sections and two secondary sections. The primary sections include: an overview of the Phase I MPM system and the impact evaluation effort associated with it; a description of the evolution of Phase I MPM system ridership since passenger service was initiated in October 1975; an identification of impacts associated with the operation of the Phase I MPM system, including traffic impacts; and a summary of the findings of the previous sections and an identification of experiences that are transferable to other applications. The secondary sections consist of a description of Phase I MPM system performance, including operating characteristics and a description of Phase I MPM system finances, including capital and operating and maintenance costs.

Many people and organizations contributed to this report. The data collection and analysis efforts of West Virginia University in 1975 and 1977, prior to and following Phase I MPM system revenue service operation, were a primary source of the data used in this report. Additionally, the N.D. Lea summary report of cost experiences of automated guideway transit systems and the TSC report on the operating, availability, and maintenance history of the Phase I MPM system provided much information utilized for the analyses in this report. People who contributed to the production of this report include Steven Barsony, John Marino, and Philip Morgan, UTD-60, who provided Phase I MPM system operating data as well as concepts for this report; Ronit Procaccia, and Barry Fink, Kentron, Ltd., who provided programming support; Steven Stark, Northeastern University, and Edward Cooper, TSC, who performed data analyses; and Irene O'Byrne and Vera Ward, TSC, and Fred McGovern, Raytheon Service Company, who were responsible for manuscript preparation.

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1. INTRODUCTION

1.1 Overview

The Urban Mass Transportation Administration's Office of Technology Development and Deployment, UTD-60, sponsored a multi-year evaluation of the Phase I Morgantown People Mover (MPM) system. This evaluation of the Phase I MPM system was conducted to document the impacts of this first system of its type to be built and operated in an urban area. This system is expected to be the forerunner of significant changes in public transportation concepts. Other sites, considering installation of automated systems, will benefit from the experience in Morgantown. Therefore, a thorough evaluation was made of the Phase I MPM to define system characteristics, impacts, and other information of interest to anyone considering the implementation of such a system and to the transportation community in general.

1.2 Objective

This evaluation began in 1974; at that time, UTD-60 stated that the evaluation had the following objectives:

a. To measure the service and accessibility of the Phase I MPM system;

b. To determine the nature of system patronage;

c. To describe the operational costs and revenues of the system;

d. To examine the attitudes of the people in the community toward the system;

e. To measure the impact of the Phase I MPM upon: travel and traffic, economy and land use patterns, society and the environment; and

f. To create a methodology for extrapolation of results.

Since 1974, the Transportation Systems Center (TSC), guided by these objectives, has carried out a continuing evaluation under UTD-60 sponsorship and direction. It should be noted that when the evaluation objectives were stated in 1974, it was expected that a six station MPM system would be built. Therefore, initial evaluation planning focused on coverage of the geographic and service scope to be provided by the proposed six station system. Despite subsequent revision of the MPM into a five station system, constructed in two phases, these six objectives have continued to direct evaluation activities.

1.2.1 Impact Evaluation Scope

Shortly after MPM construction began, changes were made to the MPM system configuration and construction sequence. In 1975, a decision was made to build a five station system instead of the planned six stations.

The Phase I MPM system had three stations with connecting guideway and was financed by an UMTA demonstration grant. Following a year of operational testing, it opened for revenue passenger service in October 1975.

The forthcoming Phase II MPM system will expand the service area by adding two stations to the existing three stations through the UMTA Capital Grant Program. The Phase II MPM is scheduled to be available for revenue passenger service by fall 1979.

This evaluation of the Phase I MPM is based on data and reports on the three station system. It has been guided by the six objectives originally identified by UMTA as far as possible. Because the Phase I system is oriented principally to university travel, it has not been able to thoroughly address the transferability objective. Evaluation results are only transferable to other activity centers dominated by one institution; results have limited applicability to urban areas in general due to the domination of activity patterns by a single institution.

1.2.2 Phase I Morgantown Impact Evaluation Report

This report concludes the evaluation of the Phase I MPM system sponsored by UMTA, UTD-60 and conducted by TSC. It synthesizes and summarizes the major impacts of the system; it reviews the results of evaluation activities occurring since 1974 and interprets them in light of salient data reported by independent studies of the Phase I MPM system; and it provides a comprehensive description of the Phase I system's impacts.

The multi-year evaluation required several waves of research to monitor the progress of MPM system development and implementation since 1974. The evaluation effort was structured into four separate activities which were called the Pre-MPM Phase, prior to system passenger service; Interim Phase, during the initial year of system operation; Operational Phase, following introduction of regular revenue service; and Final Phase, during which this report was produced summarizing impacts and lessons learned.

During the Pre-MPM Phase, TSC contracted with West Virginia University to measure traffic flow, service characteristics of transportation modes, and travel alternatives in the area to be served by the Phase I MPM system. This phase generated a baseline data set from the spring of 1975 against which changes, due to introduction of Phase I service, can be identified.

During the Interim Phase, the interval between the Pre-MPM and Operational Phases (spring 1975 and spring 1977, respectively), TSC collected and analyzed Phase I MPM system operating data in order to monitor the evolution of MPM system performance and ridership growth. TSC recorded Phase I system operating data from October 1975 through June 1978, inclusive, yielding a data file about MPM operation during the first three successive operating and academic years.

During the Operational Phase, a second data collection effort was carried out in the spring of 1977 under contract to West Virginia University, twenty-four months after the first effort. This second data collection replicated earlier data in order to extract changes due to availability of Phase I MPM revenue service.

During the Final Phase, TSC produced this report; its purpose is to summarize MPM system impacts and experiences useful to UMTA's Downtown People Mover Program. This integrated comparison of findings from independent research studies is intended to provide an accurate, comprehensive analysis of the Phase I MPM system's impacts.

This report is organized in order to address each of the six original evaluation objectives. Objectives a and c have been the subject of numerous studies and reports and are, thus, addressed in two secondary sections of this report, Appendix A and B. Appendix A, Phase I MPM System and Service, describes the MPM system, its performance, service characteristics, and users' perceptions of the system; this section satisfies objective a enumerated in section 1.1. Appendix B, Phase I MPM Finances, describes the capital cost, operating and maintenance costs, and revenue approximations of the system, answering objective c. The four primary sections of this report address the remaining objectives. Section 2, Phase I MPM Ridership, describes the ridership growth, patronage characteristics, and trip patterns answering objectives b and d. Section 3, Phase I MPM Impacts, reports on area-wide traffic growth trends, reallocated activity patterns, and environmental impacts thus addressing objective e. Section 4, Summary and Conclusions, summarizes the key points of the previous sections and partially addresses objective f by describing experiences that are transferable to other locations.

This report highlights the Phase I system's operational evolution and major impacts. It is not intended to provide a complete, comprehensive description of the Phase I MPM system; for a thorough account, it is necessary to consult the references in the Bibliography.

1.3 Scope

The temporal, geographic and modal scope of this study are addressed below. Also the report's data sources and procedures are briefly described.

1.3.1 Temporal Scope

This report focuses on the time period immediately prior to Phase I MPM system operation through the end of the second academic year of revenue service operation. This corresponds to the time interval from spring 1975 through spring 1978. Most baseline data is from the spring 1975 which was the last semester prior to the opening of MPM passenger service.

Feasibility planning for the system was performed in 1969 and 1970. At some points, this early planning data are used in the analyses in order to establish trends in university and area-wide activity patterns.

1.3.2 Geographic Scope

This evaluation of the Phase I MPM system examines proximate impacts and therefore focuses on data about the geographic area immediately adjacent to the system. The evaluation therefore does not examine the influence of the Phase I MPM system on the entire Morgantown urban area.

The Phase I system principally serves West Virginia University campus destinations and the Morgantown Central Business District. As a result, the data reported in this evaluation represent characteristics of the area enveloping the three stations and guideway. TSC titled this area the "MPM Corridor" and defined it operationally to include the following:

a. All abutting properties within a close walking distance (approximately 1/4 mile) of the MPM stations and the MPM right-of-way.

b. The principal auto and bus route segments along Beechurst and University Avenues, both of which approximately parallel the MPM guideway alignment.

c. Public parking facilities within approximately a one-quarter mile radius of a MPM station and the MPM right-of-way.

In some parts of this report, additional data on the Morgantown urban area are included as available. However, the evaluation designed in 1974 was explicitly limited to the Phase I MPM corridor.

1.3.3 Modal Scope

In evaluating the impacts of the Phase I MPM system, it is necessary to examine what happened to the vehicular modal alternatives to the MPM. This report considers the following modal alternatives: the West Virginia University Inter-Campus Bus System (U-bus), the private auto, and to a limited extent, the municipal and county bus system routes which at several points parallel the MPM alignment. Bicycles and hitchhiking were not evaluated in this study; the former was a little used alternative due to the terrain and the latter was difficult to measure.

1.3.4 Data Sources

This report reviews and synthesizes the data from several reports on the Phase I MPM system. The major sources examined include the series of Phase I reports by West Virginia University, the N. D. Lea Associates summary report of cost experiences of automated guideway transit systems, and the TSC report on the operating, dependability, and maintenance history of the Phase I MPM System. Other sources include MPM system contractor data, local newspaper articles, municipal and university reports, and preliminary planning studies. These sources are utilized to varying degrees depending on their relevance to the topic discussed.

In addition, analyses conducted as part of this evaluation utilize data collected in the spring of 1977 by West Virginia University under TSC direction. These include data from a MPM on-board and follow-up survey, a city bus on-board survey, and a telephone interview survey. The aggregate results of this data collection effort are included as part of the series of Phase I reports by West Virginia University. Data from these surveys were further analyzed to provide a disaggregate perspective of the Phase I MPM system.

1.4 Phase I MPM Development

1.4.1 Background - Phase I MPM System Development

The Phase I MPM system is an Urban Mass Transportation Administration (UMTA) demonstration to provide people mover service between the Morgantown, West Virginia Central Business District and the separated campuses of West Virginia University. It consists of 2.1 route miles of two lane guideway, 3 passenger stations, an integral maintenance facility, and a 45 vehicle fleet.[1] The stations are Walnut, located in the downtown or Central Business District of Morgantown; Beechurst, on the main or downtown campus; and Engineering, on the suburban or Evansdale campus of West Virginia University. This three-station system primarily serves inter-campus trips.

The Phase I MPM system was developed in two phases, 1A and 1B. Under Phase 1A, a three-station, five-vehicle, 2.1 mile system was designed and installed in Morgantown by June, 1973. It underwent extensive system test and evaluation to verify the technical feasibility of a fully operational three-station system. The objective of Phase 1B, which commenced in FY74, was the operational demonstration of the three-station system. This phase included all previously deferred items from Phase 1A, additional new vehicles, operational software, expanded maintenance facilities, and fare collection and destination selection equipment as well as reliability and safety improvements and design changes resulting from the Phase 1A test experience.

Upon successful completion of the Phase 1B acceptance test program in August 1975, passenger service operation of the three-station system commenced under the management of West Virginia University on October 3, 1975. The system was evaluated under operational conditions from October 3 to October 23, prior to the turnover of final ownership to the University. During operational testing, system operating characteristics varied as problems were encountered and overcome.[2]

At the time of this report (Fall 1979), the three station system has been expanded to a five-station system called the Phase II MPM through the UMTA Capital Grant Program. Construction and system testing were carried out during academic

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[1]The Boeing Company, <u>MPRT O&M Phase Operating Availability and Maintenance History</u> - January 3, 1977, No. 81205, Page 5.
[2]This discussion is drawn from Stearns and Schaeffer, <u>Impact Evaluation of Morgantown PRT 1975-1976 Ridership: Interim Analysis</u>, June 1977.

years 1977-1978 and 1978-1979. This required Phase I system shutdown during academic year 1978-1979 to link the Phase II system to the Phase I system. The Phase II system began revenue passenger service in the fall of 1979.

The expansion of the MPM system during Phase II will add two stations, 28 MPM vehicles, and more control and power distribution systems. The additional stations at Medical Center and Towers will expand the MPM service configuration to provide downtown-to-Medical Center service, as well as inter-campus service. It should be noted that the West Virginia University Medical Center, with its 600-bed hospital, is the major regional medical facility and a major employer in the area.

Prior to the opening of the Phase I MPM system, West Virginia University provided inter-campus transportation using a fleet of 15 university owned and chartered buses. When the Phase I MPM began offering passenger service in October 1975, the existing fleet of campus buses was re-deployed to provide feeder service to MPM stations. On any day, approximately 10 to 12 buses were used in this feeder service. Additionally, when the MPM system was not operating, the bus fleet provided substitute service to all locations on both campuses.

The campus buses provided two feeder routes to the MPM to complement MPM operation. One route was a feeder service operating on 5-minute headways to the Engineering Station from Towers (a large undergraduate dormitory on the Evansdale campus) with stops at the Agricultural Sciences Building and Allen Hall. The second route was a shuttle service operating on 15 minute headways between Coliseum and Medical Center, both of which have large parking lots, stopping en route at the Engineering MPM station, Allen Hall, and the Towers Dormitory.

The MPM system's service was interrupted on a number of occasions by mechanical and systems problems. At these times, the campus bus fleet provided inter-campus substitute service. Buses would leave from Campus Drive (downtown campus) at 5-minute headways for Evansdale Campus and Medical Center.[3]

After MPM service was re-started, no bus service was provided between MPM stations during the hours that the MPM was operating. This arrangement meant that the bus did not compete with the MPM for riders during MPM operating hours. The University provided MPM feeder service from October 23, 1975, through January 28, 1976.

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[3]"PRT Guide to Riding the Personal Rapid Transit System", Daily Atheneum, West Virginia University, October 3, 1975.

Wintery weather caused difficulties with the MPM's operation. At these times, West Virginia University implemented route alterations to the bus feeder service. From January 29, 1976, through April 28, 1976, the University operated its buses along their former routes to all campus destinations which had existed for many years prior to MPM passenger service. However, the campus bus routes were modified to include stops adjacent to two of the three MPM stations rather than their former stops. For example, buses stopped at the MPM Engineering Station rather than at the Engineering Building located across the road. The buses did not serve the downtown, off-campus, Walnut Street MPM station.

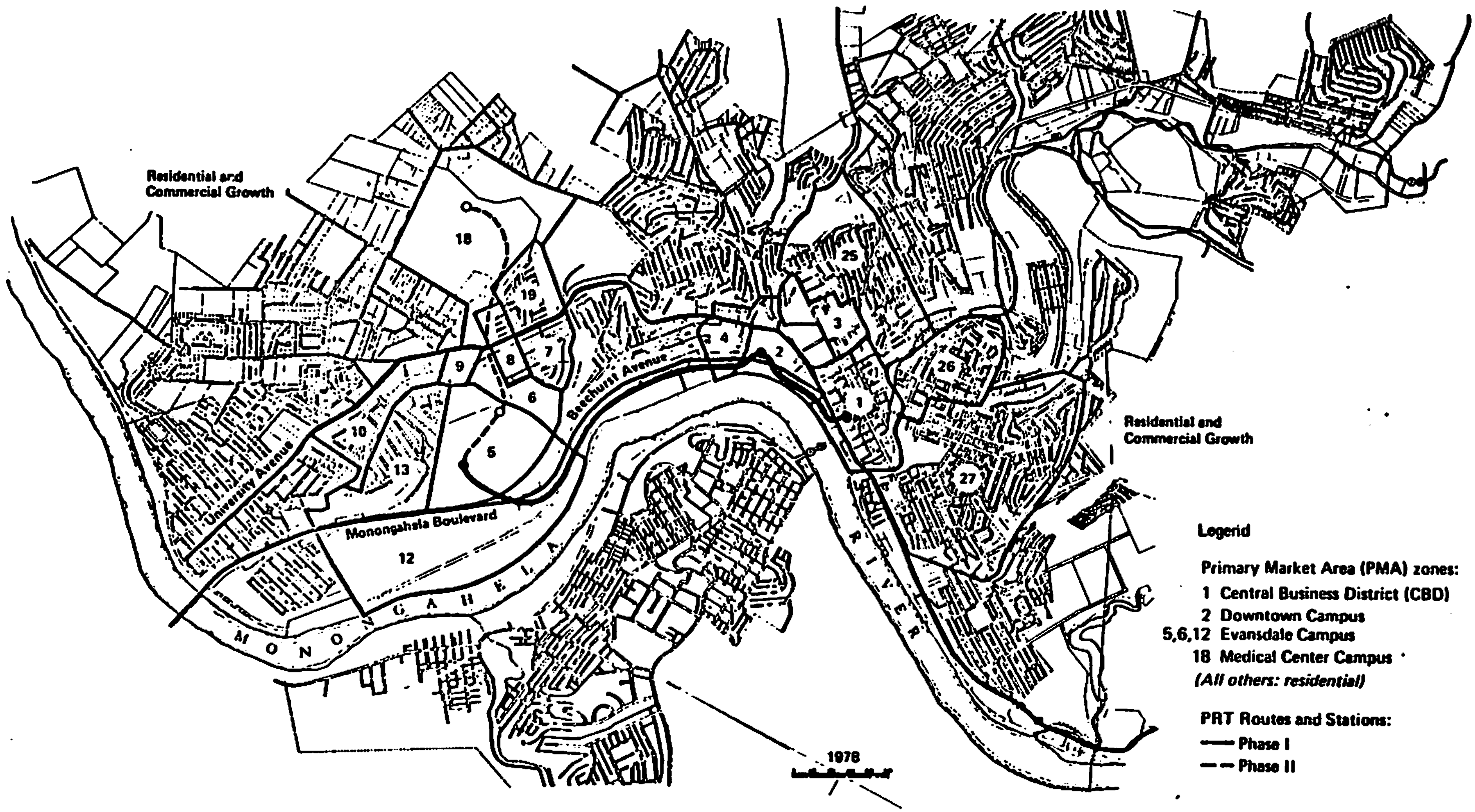
Operational testing of the Phase I MPM system was completed in August 1976. Since this time, the beginning of academic year 1976-1977, the MPM system provided normal passenger service and the university bus fleet was used only to provide MPM feeder service.

Phase I MPM service is available weekdays for 13 hours from 7:30 a.m. through 8:30 p.m. and weekends from 9:30 a.m. through 3:00 p.m. During the initial months of passenger service in academic year 1975-1976, the actual hours of operation were less than those scheduled because system operation was interrupted for periods of several hours due to winter problems and other start-up problems. This discrepancy between actual and scheduled service hours was narrowed considerably. This is discussed in detail in Appendix A, Section A.3.

1.4.2 Phase I MPM System Description

The Phase I MPM system consists of three stations connected by 2.1 miles of double lane, all weather guideway within an exclusive right-of-way. Approximately two thirds of the guideway is elevated with the remaining one third at grade. All weather guideway operation is maintained during severe winter weather by the circulation of a heated anti-freeze mixture through pipes imbedded below the guideway running surface.

Stations are presently located at Walnut Street in the Morgantown CBD, Beechurst Avenue across from Stansbury Hall on the Main Campus, and across from the Engineering Sciences Building on the Evansdale Campus. In addition to these stations, a maintenance shop, vehicle test facility, and the control center are located approximately halfway between the Beechurst Station and the Engineering Station. The route alignment, shown in Figure 1-1, parallels the railroad tracks along the Monongahela River from the Walnut Station to the Engineering Station.



Map used by permission of City of Morgantown

FIGURE 1-1. MORGANTOWN ROUTE ALIGNMENT

Electrically powered, rubber tired vehicles which are under computer control operate between the stations. Non-stop service between origin and destination is provided normally in a scheduled mode for periods of predictable travel demands or in a demand mode for periods of variable demands. Remote mode operation when the central operator controls the destination of a vehicle for security or maintenance purposes is also possible. Manual mode operation with an on-board operator is used for the recovery of a disabled vehicle. The vehicles are relatively small in comparison with conventional transit vehicles. Each vehicle has a capacity of 8 seated passengers and 13 additional standees. The vehicles operate at a minimum headway of 15 seconds and at speeds of up to 30 miles per hour.

The automated control of the MPM system is the function of four principal components of the Control and Communication System. Their basic functions are:[4]

a. Central Control and Communication. Dual computers and peripheral equipment provide overall control and monitoring of all system operations. A closed circuit television system and voice and data communications circuit are included in the central console equipment. The movements of all vehicles in the system, scheduled service or on-demand operation, is managed by software routines within the central computer.

b. Station and Guideway Control Communication Sub-system. Dual station computers control and monitor local transit operations at the three passenger stations. These functions include local vehicle operations such as switching, stopping, door operations, vehicle dispatch and station graphics.

c. Vehicle Control and Communication Sub-System. The control equipment which is carried on board the vehicles responds to guideway inductive communications to regulate the vehicle. The vehicle propulsion and braking controls are operated by this sub-system in order to control speed and guideway position. Thus, once a vehicle is dispatched, station and central computers only monitor its performance and direct switching where required. The control of the vehicle speed and position is the sole responsibility of this sub-system. However, an errant vehicle can be stopped by station and central computers.

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[4]Boeing Aerospace Co., Morgantown Personal Rapid Transit System, November 1975, p. 42-80.

d. Collision Avoidance System. An independent, failsafe sub-system is used to prevent vehicle collisions in the event of failure of primary vehicle controls. This redundant system divides the guideway into segments or blocks. Vehicle-borne magnets activate detectors embedded in the guideway segment which automatically turn off the "safe tone" signal in the segment of guideway behind the vehicle. If a vehicle attempts to pass through this segment, the lack of "safe tone" signal will cause it to automatically apply its emergency brakes.

The scheduled hours of operations extend from 7:15 a.m. to 8:30 p.m. Monday through Friday and 9:30 a.m. to 3:00 p.m. Saturday and Sunday. Bus service is provided from the closing time of MPM operations until 11:15 p.m. on weekdays, midnight on Fridays, 12:30 a.m. on Saturdays, and 11:30 p.m. on Sundays. After the initial year of operation, MPM service hours were extended to coincide with special university events such as basketball and football games.

The MPM fare structure is unique in that the vast majority of potential users, university students, have available pre-paid farecards. A transportation fee is included as part of the regular university fees paid by all full time students. For the first academic year of operation, 1975-1976, the same transportation fee, $4.25, assessed for previous bus service was kept. This fee was increased to 15 dollars for both the 1976-1977 and 1977-1978 school years. One-way trip farecards could be purchased at the stations for 25 cents. In addition, Morgantown residents, faculty, staff, etc. could purchase semester passes from the University at the same price as the semester transportation fee. For the first academic year of operation, however, the price of the semester pass for the public and WVU faculty and staff was ten dollars.

To use the system, passengers enter the stations at street level. Operating instructions on how to use the MPM system are posted in the unpaid area. In addition, a machine that gives visual as well as audible instructions on how to use the system is provided. An emergency telephone connecting to the central control operations is also available in the unpaid area. Also available is an automatic fare card dispenser which requires exact change for single one way trip farecards.

To pass from the unpaid area to the paid area, a passenger must insert a valid magnetically coded farecard into the turnstile. The desired passenger destination is selected by the passenger by pushing the appropriate button on top of the turnstile. If the system is in the scheduled mode, this information is kept by central control for adjusting schedules.

If the system is in the demand mode, the information is used by central control to route a MPM vehicle to the station. The passenger retrieves the farecard from a slot in the top of the turnstile and proceeds through the now unlocked turnstile.

The platform area is separated from the guideway by a barrier except at boarding and deboarding berths. Along the platform of a station, no boarding signs are displayed over the deboarding berths. Dynamic boarding signs placed over the boarding berths provide destination information for the vehicle in the berth. Passengers board the appropriate MPM vehicle. If the capacity of the vehicle is exceeded, a horn will sound and the vehicle doors will not close until enough passengers have left the vehicle.

Upon arrival at their destination, passengers exit the vehicles at the deboarding berths and exit the paid area through separate turnstiles in a direction away from the entrance turnstiles.

All stations are monitored by TV cameras from central control. Public address speakers for announcements from the central control operator are also located in the station.

2. PHASE I MPM RIDERSHIP

This portion of the report examines the MPM ridership of the Phase I system. Although aggregate MPM ridership is presented, the major effort is concentrated on examining MPM ridership on a disaggregate basis. Choice and captive ridership characteristics of the Phase I MPM users are compared. Section 2.1 describes aggregate MPM ridership. Section 2.2 presents a general analysis of MPM ridership defining choice and captive riders. An analysis of the MPM users disaggregated by choice and captive users is presented in Section 2.3. Section 2.4 examines the MPM users' trip patterns. An examination of the MPM users' trip purposes is discussed in Section 2.5.

2.1 Aggregate MPM Ridership

MPM ridership increased very rapidly; by the third operating year, mean weekday and daily ridership increased 101 percent and by the third academic year, mean weekday ridership increased 187 percent and daily ridership, 182 percent. (See Table 2-1).

Because the academic year generates varying amounts of activity, maximum ridership levels monitor system attractiveness during these peak activity periods. For example, the peak ridership on weekdays occurred during the second operating year; however, third operating year data are truncated at June 1978, omitting the peak level of campus activity in August during fall semester registration.[5]

By contrast, academic year data contain ridership during fall semester registration; these data show that the maximum daily ridership continued to increase over time, having reached 18,228 by the fall of 1977.

Table 2-1 shows that maximum weekday ridership for any given time period always equals maximum ridership. The MPM ridership patterns are very subject to the weekday university class schedule.

It is useful to examine predicted daily ridership levels for the six station MPM system originally planned. The feasibility study stated that, by 1980, ridership would range between a daily low of 17,670 and a high of 50,180; by 1990, these daily figures would be 23,270 and 67,780 (West Virginia University, 1970). Using the mean weekday academic year ridership for 1976-1977 and 1977-1978 in Table 2-1, it is possible to extrapolate a 1979-1980

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[5]Data was only available through June 1978 at the time this analysis and report was prepared.

TABLE 2-1. PHASE 1 MPM RIDERSHIP[1]

Daily Ridership	Operating Years[2] 1st. Oct 75-76	2nd. Oct 76-77	3rd. Oct 77-Jun 78	Academic Years[3] 1st. Oct 75-Apr 76	2nd. Aug 76-May 77	3rd. Aug 77-Apr 78
Weekdays						
Mean	4,008	7,703	8,046	3,784	8,870	10,847
Maximum	17,116	18,228	15,745	10,588	17,116	18,228
All Days						
Mean	3,037	5,728	6,121	2,891	6,685	8,162
Maximum	17,116	18,228	15,745	10,588	17,116	18,228

1, 2, 3 See footnotes 1, 2, 3 in Table A-4.

and 1980-1981 Phase I MPM ridership of 16,144 and 19,695.[6] Thus, the three station system ridership could match the low estimate for the six station system. This convergence suggests the three station Phase I MPM system is attracting ridership at a rate comparable to the forecasted rate.[7]

To provide another perspective on the Phase I MPM ridership, the composition of the MPM ridership by user categories can be examined on an aggregate basis. From the MPM on-board survey, 86 percent of the riders were students. The remaining 14 percent of the riders were divided equally between WVU faculty and staff users and non-university users.

2.2 Disaggregate MPM Ridership

2.2.1 Definition of Choice and Captive MPM Riders

Whereas previous studies and the previous section addressed MPM ridership on an aggregate basis, the sections to follow seek to examine MPM ridership disaggregated by choice and captive riders. By disaggregating MPM ridership data into these two categories, analysis of choice rider characteristics and behavior are possible. It is from these analyses that potentially useful information may be extracted concerning the behavior of choice riders of other AGT systems.

A MPM choice rider is defined as one having an auto available as a driver or as a passenger for the MPM trip taken. Although a city bus route did operate within the MPM corridor, its service characteristics made its consideration as another alternative mode unjustified. Thus, captive MPM riders are considered to be those without an auto available either as a driver or as a passenger for the MPM trip taken. Similarly, choice and captive auto users are defined. Auto users are defined to be captive users if MPM was unavailable as an alternative mode with the availability of MPM being determined by the auto user's trip origin and destination and the time of the trip. Trips with either origins or destinations outside the Primary Market Area (PMA-Morgantown areas within a ten-minute walking distance of a MPM station) do not have MPM as an available mode and an auto user with these trip characteristics

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[6]This extrapolation assumes a continuation of the 22% annual ridership growth rate which occurred between academic years 1976-1977 and 1977-1978.

[7]Because the decision to reconfigure the MPM into a five station Phase I and Phase II system was made subsequent to the feasibility study, there are no comparable ridership estimates available.

is not defined as a choice user. Additionally, certain O&D pairs within the PMA were not viably served by the MPM. This can be seen from the MPM travel time matrix presented later in Table 3-3 with the blanks within the matrix denoting the O&D pairs for which MPM is not a viable mode. Thus, trips falling within these O&D pairs do not have MPM as an alternative mode. Further, trips whose start time fall outside the MPM's hours of service also do not have MPM as an available mode. Auto users with these characteristics are considered captive users.

2.2.2 Choice Versus Captive MPM Ridership

A preliminary assessment of the choice MPM ridership was made by examining the results of the MPM on-board survey, Table 2-2. Of the riders surveyed only 25 percent were found to be in the choice category. The survey sample was further disaggregated into three user categories: students, WVU faculty and staff, and non-university users. Within the student category, only 21 percent of the riders surveyed were considered to be choice riders. However, for the other two categories, WVU faculty and staff and non-university users, over half of the riders, 52 percent and 58 percent respectively, were choice riders.

A further assessment of MPM ridership can be obtained by examining the PMA telephone survey, Table 2-3. The survey provides a different perspective in contrast to the choice-based MPM on-board survey since it is a random sample of dormitory students and non-dormitory residents of the PMA. Of the total trips taken by the persons interviewed with bicycle and hitchiking trips excluded, 34 percent were made by MPM; only 7 percent of the total trips were choice MPM trips. In contrast, auto trips accounted for 61 percent of the total with 36 percent being choice trips. Of the MPM trips recorded in the telephone survey, all were made by students with dormitory students accounting for 89 percent of the total MPM trips and 80 percent of the choice MPM trips.

2.2.3 Comparison with Bus and Auto

In this section, the above preliminary assessment of MPM ridership is compared with preliminary assessments of users of the city bus system as well as auto users. Not suprisingly, the composition of the city bus ridership was markedly different from the MPM system. Whereas 86 percent of the MPM riders were students, only 28 percent of the city bus riders were students. The remaining city bus ridership were almost split equally between WVU faculty and staff (34 percent) and non-university (38 percent) users.

TABLE 2-2. MPM ON-BOARD SURVEY

	Choice	Captive	Total	Percentage	Choice Percentage
Students	304	1165	1469	86%	21%
WVU Faculty & Staff	61	57	118	7%	52%
Non-University	65	48	113	7%	58%
TOTAL	430	1270	1700		25%

TABLE 2-3. PMA TELEPHONE INTERVIEW: MPM TRIPS

	MPM TRIPS		AUTO TRIPS		OTHER	TOTAL	PERCENTAGE MPM		PERCENTAGE AUTO	
	Choice	Captive	Choice	Captive	Trips	Trips	Choice	Captive	Choice	Captive
Dorm Students	76	319	197	113	31	736	10%	43%	27%	15%
Non-Dorm Students	19	30	148	95	8	300	6%	10%	49%	32%
WVU Faculty & Staff	0	0	22	31	6	59	0	0	37%	52%
Non-University	0	0	96	79	7	182	0	0	58%	43%
TOTAL	95	349	463	318	52	1277	7%	27%	36%	25%

From the city bus on-board survey, Table 2-4, 58 percent of the riders surveyed on the route within the MPM corridor were choice riders, that is, riders with either MPM or auto available as an alternative mode. Within the student users category, 67 percent of the riders surveyed were choice riders. By comparison, only 25 percent of the MPM riders surveyed were choice riders, and only 21 percent of the student users were choice riders. Similar percentages of choice riders for the categories of WVU faculty and staff (55 percent) and non-university (53 percent) users occurred for the city bus route surveyed.

Data for the comparison of auto users with the preliminary assessment of MPM ridership were obtained from a telephone interview survey of PMA residents. Based on the results of this survey, Table 2-5, 59 percent of the auto trips were choice trips. Within the student users' category, 62 percent of the auto trips made were choice. The percentage of choice trips made by WVU faculty and staff (42 percent) and non-university (55 percent) users were generally comparable to the MPM percentages for the same user groups.

The proportion of auto trips by individual user category was comparable to that of MPM. Seventy-one percent of the auto trips were made by students; 7 percent were by WVU faculty and staff; and 22 percent were by non-university related users.

Further details are provided by examining the trip making within the respondent categories from Table 2-3. For dormitory students, 54 percent of their trips were made by MPM with 10 percent of the total trips being choice trips. The auto only accounted for 42 percent of the trips made by dormitory students. However, 22 percent were choice trips. In sharp contrast to the dormitory students' trip making were the revealed trip making of students living off-campus. For these non-dormitory students, only 16 percent of their trips were made using MPM with only 6 percent of the total being choice trips. The auto was by far the predominant mode of travel accounting for 81 percent of the total trips. And as previously noted, no MPM trips were recorded for WVU faculty and staff and non-university users. Auto trips accounted for 90 percent and 96 percent of their respective trip making. Thus, the results indicate that the auto was the predominant mode chosen by PMA residents except for students living on campus.

2.2.4 Modelling Travel Behavior

2.2.4.1 Introduction - In the modeling of mode choice, the revealed preferences of choice riders are examined since captive riders' mode choices are, by definition, governed by their lack

TABLE 2-4. CITY BUS ON-BOARD SURVEY

	Choice	Captive	Total	Percentage	Choice Percentage
Students	31	15	46	28%	67%
WVU Faculty & Staff	31	25	56	34%	55%
Non-University	34	30	64	38%	53%
TOTAL	96	70	166		58%

TABLE 2-5. PMA TELEPHONE INTERVIEW: AUTO TRIPS

	Choice	Captive	Total	Percentage	Choice Percentage
Students	345	208	553	71%	62%
WVU Faculty & Staff	22	31	53	7%	42%
Non-University	96	79	175	22%	55%
TOTAL	463	318	781		59%

of more than one modal alternative. Choice riders, however, have available at least two modal alternatives. It is their revealed preferences given the modal alternatives' level of service attributes and the attributes of the riders that provide the basis for the modeling of individual mode choice behavior. This disaggregate, behavioral approach offers the potential for extrapolation of the modeling results to other settings where riders are faced with similar modal alternatives.

2.2.4.2 Data - Data from the Primary Market Area (PMA) telephone survey were used to calibrate logit modal choice models. To perform the calibration, an adequate number of MPM choice trips as well as choice auto driver and auto passenger trips, the other two modes considered, were required. Only for returning home and school related trip purposes were there an adequate number of MPM choice trips. Thus, the models derived were for these two purposes only. In addition, all of the MPM choice trips contained in the survey were made by West Virginia University students. Thus, the models derived were based only on their travel behavior.

A total of 107 choice trips were recorded for the returning home trip purpose. Out of this total, 32 were MPM trips, 44 were auto driver trips, and 31 were auto passenger trips. Of the total 93 choice trips for school related purposes, 37 were MPM trips, 35 were auto driver trips, and 21 were auto passenger trips.

Since the PMA telephone survey was not intended to be used as the basis of modeling mode choice, certain desirable individual attributes and level of service attributes were not collected. No measure of the competition for the use of the auto in a household, such as autos owned per household, per licensed driver, per worker/student, or autos available per household, etc., were collected in the survey. Only the number of autos owned by the respondent and spouse and the number of autos available for the respondent's personal use were collected. To measure the relative economic status of the student, a respondent's average expenses per semester measure was collected. The measure was based on the respondent's monthly expenses for rent, food, and other expenses (transportation, recreation, clothes, records, etc.) excluding tuition expanded to a four month or semester total. This provided a measure comparable to the household annual income measure typically used as an individual attribute. Since no measures of the level of service attributes of the modes being modeled were collected in the survey, total travel time as generated by West Virginia University was used. Total travel time could not further be disaggregated into in-vehicle time and access time since no matrix of auto access times was contained in the West Virginia reports. To reflect the additional time needed to pick up and drop-off passengers, three minutes were added to the auto total travel time to generate a total travel time for the auto passenger mode. Travel cost was not considered due to conceptual problems with out-of-pocket MPM costs. Unlike a typical transit system where the out-of-pocket cost is the transit fare, all of the riders in the modeling sample had a semester pass since they were all university students. It is not intuitive as to how these riders perceived their cost to be on a trip by trip basis. It was felt that this issue could be more adequately addressed as part of the Phase II evaluation. To summarize, the variables available for use in the modeling of mode choice for the Phase I MPM system were: number of autos owned by respondent and spouse, number of autos available for respondent's personal use, respondent's average expenses per year, and total travel time.

2.2.4.3 Model Calibration: School Related Trip Purpose - The program &LOGIT of the TROLL package of programs from the National Bureau of Economic Research was used to perform the model calibration. The &LOGIT program readily allows numerous calibrations to be conducted once the appropriate TROLL files have been built. Appropriate evaluative statistics and a tabulation of the predicted mode choice versus the actual mode chosen are included as part of the &LOGIT program to aid model evaluation.

As an initial point in the calibration of the model of mode choice for school related trips, all of the previously listed variables were included in the utility functions of the modes. Travel time was included as a generic variable; it was assumed that the travel time coefficient was the same for all three modes. Stated another way, it was assumed that university students valued equally a minute of travel time spent traveling by MPM as a minute spent traveling by auto as a driver or as a passenger. Socio-economic variables, attributes of the individual, were used as alternative specific variables since their values do not vary across modal alternatives. Thus, auto ownership would have an effect on MPM's utility function different from its effect on the auto driver or auto passenger modes' utility functions.

The results of the initial calibration are shown in Tables 2-6 and 2-7. RHO^2 was calculated to be 0.34 and 67 percent of the individual's actual mode choice were correctly predicted. All of the signs of the coefficients that were significant at the 90 percent confidence level were conceptually correct.

Although the initially calibrated model was both statistically significant and conceptually sound, two specific areas of adjustments were made in an attempt to improve the model calibrated. One, since auto ownership and auto availability are highly correlated, only one of these variables should be included

TABLE 2-6. INITIAL CALIBRATION RESULTS

	COEF.ESTIMATE	ST.ERROR	RATIO	GRADIENT
-LN LKLHD	67.6649	NA	NA	NA
TTIME2A	-0.188145	0.046541	-4.04258	0.000
AOWN2_ALT1	0.106448	0.556303	0.19135	-4.178761E
AOWN2_ALT2	-1.91594	0.780055	-2.45616	7.106231E
AVAIL2_ALT1	-0.302985	0.425364	-0.712296	-6.020349E
AVAIL2_ALT2	-1.63773	0.676962	-2.41924	9.517861E
EXPYR_ALT1	0.059072	0.208596	0.283188	-0.000
EXPYR_ALT2	-0.816965	0.465882	-1.75358	0.000
CONSTANT_ALT1	0.420839	1.01928	0.412877	-5.109281E
CONSTANT_ALT2	5.1703	1.7101	3.02338	8.475069E

-LN LKLHD (0) = 102.171

ALT1 - AUTO DRIVER

ALT2 - AUTO PASSENGER

ALT3 - MPM

TABLE 2-7. INITIAL CALIBRATION SUMMARY OF PREDICTED VERSUS ACTUAL

CROSSTAB_ACTUAL_VS_PREDICT

	PRED.--TOTAL	ALT.1	ALT.2	ALT.3
ACTUAL-TOTAL	93.	29.	21.	43.
ALT.1	35.	20.	5.	10.
ALT.2	21.	2.	14.	5.
ALT.3	37.	7.	2.	28.

ALT1 - AUTO DRIVER

ALT2 - AUTO PASSENGER

ALT3 - MPM

in the utility functions of the modes. Conceptually, auto availability provides a better measure than auto ownership of the competition for use of automobiles in a household. Further, because many university students owned automobiles but did not have them available on campus, it was decided to include only auto availability as a variable in the utility functions. Two, because of the lack of other measures of the level of service of the modes, travel time should be an alternative specific variable. This would imply that a minute of travel time would not be valued equally for the three alternative modes. Thus, inherent level of service differences between the three modes in terms of comfort, cost, reliability, etc., not captured by measures collected in the PMA telephone survey and, therefore, not included in the utility functions may be accounted for by the different valuation of travel time possible under an alternative variable specification.

The results of these two changes on the model are shown in Tables 2-8 and 2-9. RHO^2 was 0.40 and 73 percent of the individual's actual mode choice were correctly predicted. Equally as important, the signs of the coefficients significant at the 90 percent confidence level were conceptually correct.

The results indicated that total travel time was the most significant factor in the choice of MPM and auto driver trips for school related purposes. Auto availability, however, was the most significant factor in the choice of the auto passenger mode.

2.2.4.4 Model Calibration: Returning Home Trip Purpose - The calibration of a mode choice model for trips for returning home purposes followed a similar procedure. Based on the improved results obtained from the use of only auto availability and the alternative specific specification of travel time for the school related mode choice model, the initial calibration attempt for returning home trips used an identical formulation of the utility functions.

The calibration results, however, were not as statistically significant. RHO^2 was calculated to be only 0.24. Moreover, of the coefficients significant at the 90 percent confidence level, the coefficient of auto driver travel time had a conceptually incorrect sign. The coefficient for expenses per year was also insignificant at the 90 percent confidence level.

Due to the lack of significance of the expenses-per-year coefficients in the initial calibration, this variable was dropped from the utility function for the second calibration. RHO^2, however, was calculated to be even lower, 0.03. The coefficient of auto driver travel time was still conceptually incorrect.

TABLE 2-8. FINAL CALIBRATION RESULTS

	COEF.ESTIMATE	ST.ERROR	RATIO	GRADIENT
-LN LKLHD	67.8295	NA	NA	NA
AVAIL2_ALT1	-0.419989	0.491939	-0.853741	4.131451E
AVAIL2_ALT2	-2.53703	0.683794	-3.71023	-3.256283E
EXPYR_ALT1	0.151125	0.221057	0.683649	-1.056578E
EXPYR_ALT2	-0.578389	0.422097	-1.37028	-4.985347E
CONSTANT_ALT1	-5.12014	2.44742	-2.09206	-2.375699E
CONSTANT_ALT2	-2.35554	2.80923	-0.838499	-1.684945E
TTIME2A_ALT1	-0.132813	0.061675	-2.15342	6.594812E
TTIME2A_ALT2	-0.089756	0.071351	-1.25795	-1.216150E
TTIME2A_ALT3	-0.431709	0.12147	-3.55403	0.000

-LN LKLHD (0) = 112.191

ALT1 - AUTO DRIVER
ALT2 - AUTO PASSENGER
ALT3 - MPM

TABLE 2-9. FINAL CALIBRATION SUMMARY OF PREDICTED VERSUS ACTUAL

%

CROSSTAB_ACTUAL_VS_PREDICT

	PRED.--TOTAL	ALT.1	ALT.2	ALT.3
ACTUAL-TOTAL	93.	25.	19.	49.
ALT.1	35.	21.	3.	11.
ALT.2	21.	2.	14.	5.
ALT.3	37.	2.	2.	33.

ALT1 - AUTO DRIVER

ALT2 - AUTO PASSENGER

ALT3 - MPM

One further attempt was made to calibrate a model for returning home trips. A new variable was created by multiplying the expenses per year variable by total travel time. Whereas before, the expenses per year variable was considered in the conceptual sense that given all things to be equal, respondents who have high average expenses per year would have a greater preference for the auto driver mode; now, the concept is that students with different expenses per year place different values on travel time. Although the signs of the coefficients significant at the 90 percent confidence level were conceptually correct, the model's predictive capability was low. RHO^2 was calculated to be only 0.14. Only 34 percent of the individual's actual mode choice were correctly predicted.

The lack of success in calibrating a mode choice model for returning home trips may be attributed to two major factors. One, returning home trips from the PMA survey are comparable to the non-home based trips category from other urban travel demand studies. These are generally the most difficult to model. Since these trips have diverse origins, the traditional explanatory variables of home based travel are less effective. This leads to the second reason; since the survey was not designed specifically for modelling study, data for variables that may have had a greater impact on the choice of modes for non-home based trips were not collected in the survey.

2.3 MPM Users

2.3.1 MPM User Characteristics

In addition to the examination of MPM choice and captive ridership on an aggregate basis, the individual characteristics of choice and captive MPM users are examined. Characteristics of MPM choice and captive riders that are compared include marital status, age, sex, and possession of a driver's license (Table 2-10).

In examining the four characteristics to be compared between choice and captive users, two prior hypotheses can be stated. First, given all things to be equal, it was expected that a greater proportion of choice MPM riders would have driver's licenses as compared to captive MPM riders. The results from the MPM on-board survey indicate this to be the case for each of the three categories of users, but to varying degrees (Table 2-10). The largest difference in proportion of drivers licenses occurred for non-university related users. Thirty-seven percent of those defined as captive MPM riders did not have a driver's license as compared to only 8 percent for choice MPM riders. Although proportionately more captive riders did not have driver's licenses than choice riders for the other two categories, the

TABLE 2-10. CHARACTERISTICS OF MPM RIDERS

	STUDENTS				WVU FACULTY & STAFF				NON-UNIVERSITY			
	CHOICE		CAPTIVE		CHOICE		CAPTIVE		CHOICE		CAPTIVE	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Driver's License	292	97%	1049	93%	49	84%	36	80%	55	91%	27	62%
No Driver's License	7	2%	73	6%	9	15%	9	20%	5	8%	16	37%
Female	86	28%	585	50%	13	23%	16	34%	29	46%	23	50%
Male	216	71%	572	49%	43	76%	30	65%	34	53%	23	50%
<14	2	0	3	0	3	5%	3	6%	3	4%	6	12%
15-19	128	42%	706	60%	10	16%	19	38%	17	26%	15	31%
20-24	135	44%	384	33%	9	15%	12	24%	16	24%	16	33%
25>	38	12%	65	5%	38	63%	16	32%	29	44%	11	22%
Married	40	13%	41	3%	33	54%	15	31%	19	30%	12	25%
Single	256	84%	1095	94%	26	43%	28	59%	43	68%	30	62%
Other	6	1%	21	1%	1	1%	4	8%	1	1%	6	12%

differences between the two were not as great. The results indicate that although almost all students had driver's licenses, the limited availability of autos resulted in a low percentage of choice riders. In other words, the possession of a driver's license was not highly correlated with auto availability for students. For non-university related users, however, the lack of a driver's license did appear to be a good indicator of a captive rider.

Second, it was expected that captive MPM riders' ages would correspond to conventional transit captive riders' ages; that is, the very young (under 16) and the very old (over 65). However, the limited extent of the Phase I MPM is not conducive to the testing of this hypothesis. With 93 percent of the MPM trips made by university related users, either students, faculty, or staff, it is unlikely that the traditional transit captive age groups would be found in these categories. Additionally, the age categories specified within the survey, under 15, 15-19, 20-24, and 25 and greater, do not readily enable this issue to be adequately addressed. Thus, the distribution of these age groupings within the university related user categories, Table 2-10, reflect the age distribution to be expected in an university environment. It cannot be determined from the available data that age is causally related to choice or captive riders.

Although no prior hypothesis can be stated concerning the gender or marital status of choice and captive MPM users, the results of the on-board survey provide some preliminary indications. Within the student category, the larger proportion of choice riders were male; captive riders were almost equally divided between male and female (Table 2-10). Of the WVU faculty and staff users surveyed, the large proportion of choice and captive riders were male. Non-university related users were also predominantly male, although the percentage difference between male and female were not as great as in the university related categories. Captive riders were equally divided between male and female. It should be noted that for the semester of the on-board survey 43 percent of the student body were female and only 20 percent of the WVU faculty were female.

Similarly, no prior hypothesis can be made concerning the relationship between marital status and the determination of a choice or captive MPM rider. Within each of these categories, a proportionately larger percentage of married users were choice riders (Table 2-10). Conversely, except for the non-university related category, a proportionately larger percentage of single users were captive riders. The available data, however, were insufficient for conclusions to be drawn concerning the relationship between marital status and choice or captive riders.

2.3.2 Reason for Mode Choice

The reason for the choice of MPM as the mode taken can also be compared between MPM choice and captive users (Table 2-11). Distinct differences are to be expected and were found for the reason MPM was chosen between choice and captive MPM riders. As expected, captive students and WVU faculty and staff riders gave as the predominant reason for choosing MPM that no other mode was available (73 percent and 51 percent, respectively). The reason second to this was, surprisingly, convenience (14 percent and 16 percent, respectively). For non-university related captive riders, however, no one decisive reason was apparent, 31 percent cited convenience as the reason while 25 percent gave other as their reason for choosing MPM. Only 22 percent of the respondents gave as the reason for choosing MPM that no other mode was available. The great variety of reasons for MPM choice cited may have been the result of trips taken by non-university related users simply for the sake of riding the MPM system.

The predominant reason given by university related choice MPM riders for their choice of MPM was convenience; 46 percent for students and 57 percent for WVU faculty and staff. A surprisingly large percentage of these riders cited the lack of another available mode as the reason for the choice of MPM, 28 percent for students and 11 percent for faculty and staff. Although 38 percent of the non-university related MPM choice riders cited convenience as the reason for choosing MPM, 50 percent have other as their reason for choosing MPM. This, again, may have been the result of trips taken simply to ride the MPM.

2.3.3 Attitudinal Responses

Insight into whether differences exist between choice and captive MPM riders' perceptions of modal level of service (LOS) characteristics is provided by the responses of these riders to attitudinal questions regarding these LOS characteristics. Seven specific characteristics were addressed: safety, reliability, comfort, convenience, time, expense, and pleasantness. Respondents were asked to rank three modes, MPM, auto, and bus from best to worst for the above seven characteristics. By numerically weighting the respondents rankings (3 for best, 2 for second, 1 for worst), a cumulative ranking for each mode for each attribute was obtained.

From the MPM on-board survey, no differences were noted between the best modal rankings of student choice and captive MPM riders except for the expense attribute (Table 2-12). Student choice riders considered the MPM to be the best in that category. Captive riders, however, rated the bus as the best in terms of expense. Of the other categories, both student choice and

TABLE 2-11. REASONS FOR MPM CHOICE

	STUDENTS				WVU FACULTY & STAFF				NON-UNIVERSITY			
	Choice		Captive		Choice		Captive		Choice		Captive	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Convenience	139	46%	168	14%	31	57%	8	16%	24	38%	15	31%
Low Cost	17	5%	12	1%	4	7%	2	4%	2	3%	4	8%
Speed	10	3%	27	2%	2	3%	3	6%	0	0	1	2%
Safety	9	3%	7	0	0	0	3	6%	1	1%	0	0
No Other Mode	84	28%	846	73%	6	11%	25	51%	2	3%	11	22%
Do Not Drive	10	3%	58	5%	3	5%	4	8%	2	3%	5	10%
Other	27	9%	29	2%	8	14%	4	8%	31	50%	12	25%

TABLE 2-12. ATTITUDINAL RESPONSES

	SAFETY		RELIABILITY		COMFORT		CONVENIENCE		TIME		EXPENSE		PLEASANTNESS	
	CHOICE	CAPTIVE	CHOICE	CAPTIVE	CHOICE	CAPTIVE	CHOICE	CAPTIVE	CHOICE	CAPTIVE	CHOICE	CAPTIVE	CHOICE	CAPTIVE
Students	PRT BUS CAR	PRT BUS CAR	CAR BUS PRT	CAR BUS PRT	CAR PRT BUS	CAR PRT BUS	PRT CAR BUS	PRT CAR BUS	CAR BUS PRT	CAR PRT BUS	PRT BUS CAR	BUS PRT CAR	CAR PRT BUS	CAR PRT BUS
WVU Faculty & Staff	PRT BUS CAR	PRT BUS CAR	CAR PRT BUS	CAR BUS PRT	CAR PRT BUS	PRT CAR BUS	PRT CAR BUS	CAR PRT BUS	CAR PRT BUS	CAR PRT BUS	PRT BUS CAR	BUS CAR PRT	CAR PRT BUS	PRT CAR BUS
Non-University	PRT BUS CAR	PRT BUS CAR	CAR BUS PRT	CAR BUS PRT	PRT CAR BUS	CAR BUS PRT	BUS CAR PRT	PRT CAR BUS	BUS CAR PRT	PRT BUS CAR	BUS PRT CAR	BUS CAR PRT	CAR PRT BUS	CAR PRT BUS
Students/MPM	PRT BUS CAR	PRT BUS CAR	CAR BUS PRT	CAR BUS PRT	CAR BUS PRT	CAR PRT BUS	PRT CAR BUS	PRT CAR BUS	PRT CAR BUS	CAR PRT BUS	PRT BUS CAR	PRT BUS CAR	CAR PRT BUS	CAR PRT BUS
Students/Auto	PRT BUS CAR	PRT BUS CAR	CAR BUS PRT	CAR BUS PRT	CAR PRT BUS	CAR PRT BUS	CAR BUS PRT	CAR BUS PRT	CAR PRT BUS	CAR PRT BUS	BUS PRT CAR	BUS PRT CAR	CAR PRT BUS	CAR PRT BUS

captive riders ranked the auto as the best in terms of reliability, comfort, time, and pleasantness. The MPM was ranked as the best in terms of safety and convenience. The auto was ranked worst in the areas of safety and expense by both student choice and captive MPM riders. Both groups also ranked the MPM as the worst in terms of reliability.

The results of the student's attitudinal responses from the on-board survey are compared with the results of the WVU faculty and staff and non-university related users' attitudinal responses from the on-board survey (Table 2-12). The much lower number of MPM users in total and who actually responded to the attitudinal questions from these groups, however, limit the ability to compare these responses with those from student MPM riders. For certain modal attributes, the numerical sources for each mode were such that a ranking of modes could not be reliably determined.

Additionally, the results of the student's responses from the on-board survey are compared with the responses of student MPM riders as well as auto users from the telephone survey. In general, the ranking of student MPM riders, both choice and captive, were identical to that of the students' rankings from the on-board survey. For two modal attributes, time and expense, however, the numerical scores from the telephone survey were such that the best ranking could not be reliably determined. The rankings of student auto users for the telephone survey were also identical to that of student MPM riders with one major exception. Student auto users, both choice and captive, ranked the car as the best in terms of convenience. In contrast, student MPM riders ranked the MPM as the best in terms of convenience.

2.4 MPM User Trip Patterns

2.4.1 Time Period for Travel

The time of day during which choice and captive MPM riders travel are compared in Table 2-13. Further, they are compared with the time of day during which choice and captive bus riders travel.

Generally comparable distributions of MPM trips within the time periods noted were observed for choice and captive student MPM riders. Just under half (47 percent) of the student choice trips occurred at times other than the morning, evening or mid-day peaks. In comparison, just over half (51 percent) of the student captive trips occurred outside the peak periods. The distribution of student choice and captive trips within these peak periods were also similar.

TABLE 2-13. TIME PERIOD OF TRAVEL: MPM

	STUDENTS				WVU FACULTY & STAFF				NON-UNIVERSITY			
	CHOICE		CAPTIVE		CHOICE		CAPTIVE		CHOICE		CAPTIVE	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
7 a.m. - 9 a.m.	84	27%	276	23%	11	18%	14	24%	2	3%	3	6%
11 a.m. - 1 p.m.	4	1%	35	3%	7	11%	0	0	10	15%	5	10%
4 p.m. - 6 p.m.	71	23%	252	21%	14	22%	11	19%	7	10%	12	25%
Other	145	47%	602	51%	29	47%	32	56%	46	70%	28	58%

TABLE 2-14. TIME PERIOD OF TRAVEL: CITY BUS

	STUDENTS				WVU FACULTY & STAFF				NON-UNIVERSITY			
	CHOICE		CAPTIVE		CHOICE		CAPTIVE		CHOICE		CAPTIVE	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
7 a.m. - 9 a.m.	2	6%	4	26%	9	29%	8	32%	9	26%	13	43%
11 a.m. - 1 p.m.	5	16%	3	20%	2	6%	0	0	5	14%	3	10%
4 p.m. - 6 p.m.	3	9%	0	0	4	12%	1	4%	1	2%	4	13%
Other	21	69%	8	53%	16	51%	16	64%	19	55%	10	33%

The distributions of WVU faculty and staff choice and captive trips were also generally comparable and similar to the distribution of student MPM trips. Forty-seven percent of the choice WVU faculty and staff trips occurred in the non-peak period and 56 percent of the captive trips were made in the non-peak period. The major difference between the choice and captive riders' distribution occurred for the mid-day peak period. Eleven percent of the choice trips were made during that period, but no captive trips were recorded.

Major differences were noted between the distribution of choice and captive non-university related MPM riders as well as between these travel distributions and the distributions of university related MPM riders. Seventy percent of the non-university related choice MPM riders traveled at times other than the peak periods as contrasted with only 58 percent for captive riders. Differences were also noted for the distribution of travel within the peak periods for choice and captive riders.

By comparison, with the exception of non-university related bus riders, over half of the bus trips for all other categories occurred in the non-peak period (Table 2-14). Major differences were also noted between the distribution of bus trips and MPM trips within the peak periods. A substantially greater proportion of student bus trips, both choice and captive, were recorded for the mid-day peak period as contrasted with student MPM trips. For WVU faculty and staff and non-university related bus riders, a greater proportion of their trips occurred in the morning peak period as compared with these groups respective MPM trips. Lower proportions of bus travel were noted for all bus users for the evening peak period.

2.4.2 Wait Times

The wait times experienced by choice and captive MPM riders are compared in Table 2-15. Additionally, the wait times experienced by city bus riders are also compared.

No major differences were reported in the wait times experienced between MPM choice and captive riders among all three user categories. Well over 80 percent of the MPM riders reported wait times of 5 minutes or less. In general, from 5 percent to 10 percent of the MPM riders experienced wait times of between 6 to 10 minutes. Generally, less than 5 percent of the MPM riders experienced wait times greater than 10 minutes. In comparison, only 52 percent to 73 percent of the bus riders experienced wait times of 5 minutes or less (Table 2-16). A higher percentage of bus riders, from 13 percent to 32 percent, however, experienced wait times within the 6 to 10 minute range.

TABLE 2-15. MPM WAIT TIMES

MINUTES	STUDENTS				WVU FACULTY & STAFF				NON-UNIVERSITY			
	CHOICE		CAPTIVE		CHOICE		CAPTIVE		CHOICE		CAPTIVE	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
0-2	163	55%	662	57%	35	61%	27	55%	48	76%	29	63%
3-5	88	29%	321	27%	16	28%	14	28%	10	15%	12	26%
6-10	35	11%	122	10%	5	8%	5	10%	3	4%	3	6%
11>	10	3%	46	3%	1	1%	3	6%	2	3%	2	4%

TABLE 2-16. CITY BUS WAIT TIMES

MINUTES	STUDENTS				WVU FACULTY & STAFF				NON-UNIVERSITY			
	CHOICE		CAPTIVE		CHOICE		CAPTIVE		CHOICE		CAPTIVE	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
0-5	19	61%	10	66%	22	73%	16	69%	18	52%	21	70%
6-10	9	29%	3	20%	7	23%	3	13%	11	32%	6	20%
11-15	2	6%	2	13%	1	3%	3	13%	3	8%	2	6%
16-20	1	0	0	0	0	0	1	4%	0	0	1	3%
20>	1	3%	0	0	0	0	0	0	2	4%	0	0

In comparison, the distribution of wait times experienced by Pre-MPM U-bus riders was similar to that of MPM riders. Eighty-seven percent of the riders surveyed had wait times of 5 minutes or less. Another 8 percent experienced wait times between 6 and 10 minutes. Approximately 5 percent of the U-bus riders waited longer than ten minutes.

2.5 MPM User Trip Purposes

2.5.1 Choice Versus Captive Riders

The trip purposes of choice and captive riders from the on-board survey are compared in Table 2-17. For university related users, students and WVU faculty and staff, no major differences were noted between the trip purposes of choice and captive riders. As expected, the predominant trip purpose for these riders was school related, 65 percent for students and 43 percent for WVU faculty and staff. Returning home was the second most frequent trip purpose observed for university related users, 23 percent for students and 21 percent for WVU faculty and staff. The major difference between these university related user groups was the large percentage of trips for other purposes by WVU faculty and staff users. Also as expected, non-university related users' predominant trip purpose was not school related. The predominance of travel for discretionary purposes, shop, social/recreational, and other, by these users reflect the limited extent of the Phase I system. Data from the MPM on-board survey indicate that similar proportions of choice and captive users ride the MPM for the same purpose. Given the limited extent of the system, the key factor in determining the use of the MPM for differing purposes is the distinction between university related and non-university related users.

2.5.2 Comparison with Bus and Auto

The distributions of bus users' and auto users' trip purposes are compared with MPM riders trip purposes in Table 2-18 and Table 2-15. Since the survey formats were slightly different with regard to the categorization of trips purposes, some minor difficulties were encountered in the comparison.

As in the MPM on-board survey, no major differences were observed between choice and captive bus riders' trip purposes. The predominant trip purpose of student bus riders was school related as expected. A significant proportion of student work trips by bus was also recorded. The predominant trip purpose cited by WVU faculty and staff bus riders, in contrast to WVU faculty and staff MPM riders, was work and not school related. However, this difference may have simply been the result of the

TABLE 2-17. MPM TRIP PURPOSE

PURPOSE	STUDENTS				WVU FACULTY & STAFF				NON-UNIVERSITY			
	CHOICE		CAPTIVE		CHOICE		CAPTIVE		CHOICE		CAPTIVE	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Returning Home	74	24%	254	22%	13	22%	11	21%	5	7%	12	25%
School Related	197	65%	762	66%	25	43%	23	44%	11	17%	8	16%
Shopping	5	1%	36	3%	5	8%	3	5%	8	12%	3	6%
Social/Recreational	11	3%	63	5%	3	5%	4	7%	30	46%	16	33%
Other	14	4%	36	3%	12	20%	11	21%	10	15%	9	18%

TABLE 2-18. CITY BUS TRIP PURPOSE

PURPOSES	STUDENTS				WVU FACULTY & STAFF				NON-UNIVERSITY			
	CHOICE		CAPTIVE		CHOICE		CAPTIVE		CHOICE		CAPTIVE	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Returning Home	6	19%	2	13%	4	13%	3	12%	3	8%	5	16%
School Related	17	54%	10	66%	1	3%	0	0	5	14%	0	0
Work Related	4	12%	2	13%	18	62%	16	66%	10	29%	11	36%
Shopping	1	3%	0	0	1	3%	0	0	8	23%	7	23%
Social/Recreational	1	3%	0	0	0	0	1	4%	2	5%	3	10%
Other	2	6%	1	6%	5	15%	4	16%	6	16%	4	12%

difference between the format of the two survey questions regarding trip purposes. Since work was not one of the 5 trip purpose category in the MPM on-board survey, WVU faculty and staff work trips may have been listed as school related or other trips. For the bus on-board survey, 11 categories of trip purposes were included with work as a separate trip category. For non-university related bus riders, the largest proportion of bus trips was for work purposes. A significant proportion of shopping trips was also noted. A lower proportion of social/recreational trips by bus was observed in comparison to the MPM on-board survey. The differences in the distribution of bus and MPM trip purposes for non-university related users is another indication of the limited extent of the Phase I MPM system for non-university use.

The comparison between the distributions of auto and MPM users trip purposes used data derived from the telephone survey. Too few WVU faculty and staff trips, however, were contained in the telephone survey to enable meaningful comparisons within this user group. Additionally, no MPM trips by non-students were recorded in the telephone survey. Thus, the comparison of the distribution of trip purpose between auto and MPM users utilized data from the MPM on-board survey as a basis of comparison.

For students, a greater difference was noted between the distribution of auto and MPM users' trip purpose than between choice and captive users' distributions of trip purposes within these groups (Table 2-19). Student MPM users trips consisted primarily of (95 percent for choice users and 89 percent for captive users) school related, returning home, and work trips. Only 4 percent of the student's MPM trips, both choice and captive, were for the purpose of shopping. Further, only 1 percent of the choice students MPM trips and 5 percent of the captive student's MPM trips were for other purposes. In contrast, only 56 percent of choice and 61 percent of captive student auto trips were for school related, returning home and work purposes. Fifteen percent of the choice and 18 percent of the captive student auto trips were for the purpose of shopping. Additionally, 18 percent of the choice and 19 percent of the captive student auto trips were for other purposes.

Some differences were noted between the distribution of trip purposes for non-university choice and captive users. Sixty-four percent of the auto captive users trips were for the purpose of returning home, school, or work as contrasted with only 52 percent for auto choice users. Although the proportion of social/recreational trips were greater than that of choice users (14 percent vs. 8 percent), a greater proportion of auto trips for other purposes was observed for choice users as compared with captive users (40 percent vs. 72 percent).

TABLE 2-19. COMPARISON OF AUTO & MPM PURPOSE

PURPOSES	STUDENTS MPM				STUDENTS AUTO			
	CHOICE		CAPTIVE		CHOICE		CAPTIVE	
	Total	%	Total	%	Total	%	Total	%
Returning Home	42	45%	132	38%	135	39%	91	44%
School Related	47	50%	173	50%	86	25%	27	13%
Work Related	0	0	3	1%	7	2%	8	4%
Social/Recreational	4	4%	14	4%	51	15%	40	19%
Other	1	1%	22	5%	63	19%	42	19%

TABLE 2-20. PRE-MPM U-BUS TRIP PURPOSE[1]

PURPOSES	TOTAL	%
Returning Home	556	32%
School Related	908	52%
Work Related	45	3%
Shopping	20	1%
Social/Recreational	56	3%
Other	144	8%

1) Table adapted from West Virginia University Pre-PRT Reports.

In comparing distributions of non-university auto users trip purposes with that of MPM users, the most significant differnece was between the proportion of social/recreational trips taken. For MPM users, both captive and choice, the largest proportion of trips were social/recreational (33 percent and 46 percent respectively). To a large extent, these trips can be considered as ones made simply for the sake of riding the MPM rather than trips where the MPM serves as the mode by which the riders used to reach their social/recreational functions. The mode appears to be the social/recreational function. On the other hand, as previously noted, only 14 percent and 8 percent of the captive and choice auto users' respective trips were social/recreational.

2.5.3 Comparison with Pre-MPM University Bus

As a further basis of comparison, the distribution of student MPM trip purposes from the MPM on-board survey and telephone survey are compared with the distribution of student trip purposes for the Pre-MPM University-bus system (Table 2-20). As in the above comparisons, differences in the categorizations of trip purposes between the survey formats presented slight difficulties in the comparison.

An overwhelming proportion of University-bus trips (87%) were for returning home, school, and work purposes. Only 1 percent and 3 percent of the University-bus trips surveyed were for shopping and social/recreational purposes respectively. Eight percent of the University-bus trips surveyed were for other miscellaneous purposes. Comparable proportions of returning home, school, and work purpose trips were recorded for both the MPM on-board as well as the telephone surveys. Eighty-nine percent of the student trips surveyed from the MPM on-board survey were for returning home or school related purposes. Choice and captive rider statistics were combined. Similarly, 91 percent of the student trips from the telephone survey were for returning home, school, and work trip purposes. Slightly higher percentages were noted for MPM shopping and social/recreational trips, 3 percent and 5 percent respectively, from the on-board survey. Four percent of the student MPM trips surveyed from the telephone survey were social/recreational purposes.

3. PHASE I MPM IMPACTS

This portion of the report examines what impacts have occurred as a result of the Phase I MPM system. Section 3.1 examines the impacts on the users of the various modes available in Morgantown. Provider impacts are detailed in Section 3.2. Impacts affecting the Morgantown community are examined in Sections 3.3, traffic impacts; 3.4, environmental impacts; and 3.5, university/community impacts. Site specific impacts are discussed in Section 3.6.

3.1 Modal User Impacts

3.1.1 MPM Users

The Phase I MPM system has had major impacts on the users of the MPM system. The change in transit service results in travel time changes for not only former users of the Pre-MPM U-bus system, but also for former auto users. For the former riders of the U-bus system, the travel time changes can be examined on a total travel time basis as well as disaggregated by travel time and walk and wait time.

Selected O&D pairs of interest, those that contain Phase I MPM stations or are WVU related, can be compared. The difficulties described in previous sections concerning the incomparabilities of the two systems for certain O&D pairs are also applicable for this comparison. Thus, certain desirable O&D pairs are omitted from the comparison shown in Table 3-1. However, preliminary implications as to the effect of the Phase I system on the MPM users' travel time may be drawn from the O&D pairs listed. As expected the travel times for trips with origins or destinations in zone 1, the Morgantown CBD, are much lower for the MPM system. The access times (walk and wait time) for MPM users exhibit especially dramatic reductions since the U-bus system's closest stop to the CBD was a quarter to a half mile away. The comparison of access times for the other O&D pairs, however, indicates a surprising increase for the MPM system. Although the travel times for the U-bus system are slower for each of the O&D pairs and thus produce mixed results in the comparison of total travel times, the relative importance of access times should be noted. It is generally accepted that users place a greater weight, typically 2.5 times, on access time relative to running time. Given this to be the case, the differences in total travel time listed will be dramatically influenced.

In addition to the travel time impacts on MPM users, changes in the travel cost also affected MPM users. For full-time students, the change has been from $4.25 per semester for the U-

TABLE 3-1. COMPARISON OF TRANSIT TRAVEL TIMES

	ACCESS TIME				RUN TIME				TOTAL TRAVEL TIME			
	MPM	UBUS	MPM - UBUS	MPM/UBUS	MPM	UBUS	MPM - UBUS	MPM/UBUS	MPM	UBUS	MPM - UBUS	MPM/UBUS
1-5	3.7	10	-6.3	.37	6.7	6	0.7	1.12	10.4	16	-5.6	.65
5-1	4.6	10	-5.4	.46	5.1	10	-4.9	.51	11.7	20	-8.3	.59
1-6	10.6	12	-1.4	.88	6.7	7	-0.3	.96	17.3	19	-1.7	.91
6-1	10.9	12	-1.1	.41	7.1	10	-2.9	.71	18.0	22	-4.0	.82
1-8	10.3	12	-1.7	.86	6.7	9	-2.3	.74	17.0	21	-4.0	.81
8-1	10.2	12	-1.8	.85	7.1	7	0.1	1.01	17.3	19	-1.7	.91
1-13	9.3	20	-10.7	.47	6.7	12	-5.3	.56	16.0	32	-16.0	.50
13-1	9.6	20	-10.4	.48	7.1	10	-2.9	.71	16.7	30	-15.3	.56
2-5	6.1	3	3.1	2.03	5.1	6	-0.9	.85	11.2	9	2.2	1.24
5-2	4.7	5	-0.3	.94	5.1	10	-4.9	.51	9.8	15	-5.2	.65
2-6	13.4	5	8.4	2.68	5.1	7	-1.9	.73	18.5	12	6.5	1.54
6-2	11.9	5	6.9	2.38	5.1	10	-4.9	.51	17.0	15	2.0	1.13
2-8	12.7	5	7.7	2.54	5.1	9	-3.9	.57	17.8	14	3.8	1.27
8-2	12.9	3	9.9	4.30	5.1	7	-1.9	.73	18.0	10	8.0	1.80
2-13	12.1	11	1.1	1.10	5.1	12	-6.9	.43	17.2	23	-5.8	.75
13-2	12.3	11	1.2	1.12	5.1	10	-4.9	.51	17.4	21	-3.6	.83
3-5	9.7	3	6.7	3.23	5.1	6	-0.9	.85	14.8	9	5.8	1.64
5-3	12.7	6	6.7	2.12	5.1	10	-4.9	.51	17.8	16	1.8	1.11
3-6	17.0	5	12.0	3.40	5.1	7	-1.9	.73	22.1	12	10.1	1.84
6-3	17.0	5	12.0	3.40	5.1	10	-4.9	.51	22.1	15	7.1	1.47
3-8	16.3	5	11.3	3.26	5.1	9	-3.9	.57	21.4	14	7.1	1.53
8-3	20.9	3	17.9	6.97	5.1	7	-1.9	.73	26.0	10	16.0	2.60
3-13	15.7	11	4.7	1.43	5.1	12	-6.9	.43	22.3	23	-0.7	.97
13-3	20.3	12	8.3	1.69	5.1	10	-4.9	.51	25.4	22	3.4	1.15

1 - WALNUT STATION
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13 - MEDICAL CENTER

bus system in 1975 to a $20 per semester fee required for the 1978-1979 academic year. Whereas the WVU faculty and staff were entitled to free rides on the Pre-MPM U-bus systems, a semester farecard must be purchased at the same fee of the students for riders of the system. The MPM service has also been opened to those not affiliated with the University. For infrequent users, individual trip farecards may be purchased in the MPM stations for 25 cents. Regular users may also purchase a semester farecard at the standard fee.

An added benefit to the student users is the improved flexibility with which their activities may be scheduled as a result of the MPM system. This is especially true for the off-peak hours where the MPM system provides much improved service as compared to the U-bus system. With the U-bus system operating on long headways in the off-peak, students had to adapt their schedule to those headways. With the MPM system, greater flexibility is provided. Further, as the reliability of the MPM system improved, the selection of classes scheduled consecutively on different campuses by students became practical. The U-bus system's frequent delays due to traffic congestion made this impractical.

3.1.2 Auto Users

Auto users are also impacted by travel time changes. The same selected O&D pairs can be compared for implications as to the effect of travel time changes on auto users (Table 3-2). In all of the O&D pairs compared, the auto travel time increased from the Pre-MPM period to the Phase I period. Times generally increased by 1 to 2 minutes for the northbound direction of travel (from zones 1, 2, and 3 to all other zones). Travel in the southbound direction(to zones 1, 2, and 3), however, showed travel time increases of 9 to 10 minutes. This is surprising considering that southbound ADT decreased from the Pre-MPM period to the Phase I period on the two major north-south arterials.

The absolute changes in auto travel times noted above cannot be attributed to the installation of the MPM system. The minor increases in northbound travel times appear to be the result of the increase in ADT in that direction resulting in additional congestion and delays. As for the major increase in southbound travel times, one possible explanation is that the re-routing of the CBD street network under the TOPICS program resulted in travel patterns that hindered southbound flow in the CBD area.

Certain observations can also be made concerning the comparison of the change in relative travel times between auto and transit for the two periods. As previously noted, the MPM travel times are always faster than U-bus travel times for trips

TABLE 3-2. COMPARISON OF AUTO TRAVEL TIMES

	PHASE I						PRE-MPM	
	AUTO	MPM	AUTO-MPM	AUTO / MPM	AUTO	U-Bus	AUTO-U-Bus	AUTO / U-Bus
1-5	16.8	10.4	6.4	1.62	15.6	16	-0.4	0.98
5-1	28.6	11.7	16.9	2.44	18.6	20	-1.4	0.93
1-6	14.1	17.3	-3.2	0.82	13.0	19	-6.0	0.68
6-1	26.9	18.0	8.9	1.49	17.0	22	-5.0	0.77
1-8	14.3	17.0	-2.7	0.84	13.5	21	-7.5	0.64
8-1	26.2	17.3	8.9	1.51	16.5	19	-2.5	0.87
1-13	18.4	16.0	2.4	1.15	16.6	32	-15.4	0.52
13-1	30.3	16.7	13.6	1.81	20.2	30	-9.8	0.67
2-5	14.2	11.2	3.0	1.27	13.3	9	4.3	1.48
5-2	26.0	9.8	16.2	2.65	16.3	15	1.3	1.09
2-6	11.9	18.5	-6.6	0.64	11.1	12	-0.9	0.93
6-2	23.9	17.0	6.9	1.41	14.3	15	-0.7	0.95
2-8	13.2	17.8	-4.6	0.74	11.6	14	-2.4	0.83
8-2	24.0	18.0	6.0	1.33	14.6	10	4.6	1.46
2-13	15.7	17.2	-1.5	0.91	14.6	23	-8.4	0.63
13-2	27.5	17.4	10.1	1.58	17.6	21	-3.4	0.84
3-5	15.4	14.8	0.6	1.04	14.3	9	5.3	1.59
5-3	29.0	17.8	11.2	1.63	19.1	16	3.1	1.19
3-6	12.9	22.1	-9.2	0.58	12.0	12	0.0	1.00
6-3	27.4	22.1	5.3	1.24	17.8	15	2.8	1.19
3-8	13.3	21.4	-8.1	0.62	12.5	14	-1.5	0.89
8-3	26.9	26.0	0.9	1.03	17.3	10	7.3	1.73
3-13	12.8	20.8	-8.0	0.62	11.5	23	-11.5	0.50
13-3	30.3	25.4	4.9	1.19	20.3	22	-1.7	0.92

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8 - TOWERS
13 - MEDICAL CENTER

with origins or destinations in zone 1, the CBD. Thus, the increase in auto travel times between the two periods increases the ratio of auto to transit times for the Phase I period. Thus, the travel time competitiveness of transit is improved. Mixed results are obtained for other O&D pairs. In some cases, the U-bus travel times are faster than MPM travel times. The increase in auto travel times, however, offsets the U-bus advantage to the point where the ratio of autos to transit times still increased. Thus, the travel time competitiveness was also improved. Other comparisons where the U-bus was faster than the MPM showed a decrease in the ratio of auto to transit travel time since the increase in auto travel times was not enough to offset the U-bus advantage. For these O&D pairs, the competitiveness of transit in terms of travel time deteriorated.

For the above comparisons, it is obvious that the relative attractiveness of transit in terms of travel times is dependent not only on the relative travel times of the MPM system and the U-bus system, but also on the relative travel times for the auto between the two periods. It should be noted that in many of the above cases, the relative improvements in the attractiveness of transit resulted from major increases in auto travel times rather than decreases in transit travel times.

3.2 Provider Impacts

3.2.1 Operations

Of equal importance to the impacts of the Phase I MPM system on the users of the system are the impacts of the Phase I system on the provider of the MPM service, West Virginia University. Definite impacts to the provider in terms of the operation of the transit service result from the changing of service from conventional buses to an AGT system. The provider's labor requirements for the operation of transit service has certainly changed between the two systems. Where, in the Pre-MPM period, drivers were required to operate the bus service, the MPM service being completely automated requires no drivers. In place, the operation of the MPM system is the function of systems engineering personnel and computer specialists. This can be seen from the MPM organization chart, Figure B-1, as shown in Appendix B, Section B.2. Under the MPM operations manager are one computer engineer and a systems programmer. Additional operations personnel include 4 operations shift supervisors and 8 communications console operators. Under the system engineering manager are one mechanical, electrical, and industrial system engineer and an engineering aide. Needless to say, the MPM operating personnel is quite different from the Pre-MPM U-bus labor force which consisted primarily of drivers. The contrast in operating personnel is even greater considering that the Pre-

MPM U-bus drivers were simply University workers who could readily be assigned to other duties as the need arose. The MPM personnel, however, were specifically assigned to the MPM system and did not perform any other duties.

The change in technology has also produced other changes to West Virginia University's operations of its transit servcie. Although still essentially serving mainly University oriented travel, the Phase I MPM service was available to all Morgantown regardless of University status. As a result, valid semester farecards are sold to non-students at certain WVU locations. The novelty of the system has also had an impact on WVU's transit service operations. The attraction of the MPM system to both the scientifically oriented and the average tourist has resulted in the establishment of a special tour office with a full time tour leader. The novelty of the system apparently had not worn off after two years of system operation as rides simply for the experience of riding the MPM system were still quite common at that time.

3.2.2 Maintenance

The provider's maintenance requirements are also impacted by the change in transit service from conventional buses to an AGT system. The change in technology resulted in changes to the composition of the maintenance personnel. From Figure B-1 in Appendix B, it can be seen that technicians with electronic and electrical backgrounds are required for the Phase I MPM system that would not be required for a bus system. The requirement for boiler mechanics to maintain the heating plants which generate heat for the guideway during wintery conditions was another unique requirement of the Phase I MPM system. As noted previously, the MPM maintenance staff listed represented an increase from initial forecast requirements due to unexpected problems encountered with the vehicles. These problems are expected to decrease and thus, the size of the maintenance staff, when the vehicles are modified in Phase II.

3.2.3 O&M Cost

It is difficult to assess the O&M cost impact to the provider resulting from the change in transit service at this time. First, in examining this impact area and the previous impact areas, it is important to keep in mind the differences in the levels of service offered by the two systems. The changes in cost impacts to the provider are not only the result of the change in transit service technology, but also are the result of the increased level of service provided by the Phase I MPM system. To compare the Phase I MPM system's O&M cost with the

Pre-MPM U-bus' O&M cost without considering the differences in service levels would yield conclusions with little meaning.

Second, the magnitude of certain O&M costs associated with the Phase I system are the result of the MPM system not yet having reached a steady state of operations. The three station Phase I system is generally recognized as being an incomplete system that will not be completed until the Phase II expansion. Only when the Phase II system has reached maturity can the magnitude of certain O&M costs be reliably determined. Prior to then, the O&M cost impacts to WVU can only be estimated.

A final factor to be considered is the funding mechanism that has existed for the Morgantown MPM system. With the Phase I portion of the MPM system constructed with Section 6 UMTA Research and Development funds, WVU has had to contribute relatively very little funds to meet capital or operating expenses for the Phase I operation.

3.3 Traffic Impacts

3.3.1 Exogenous Factors

One of the major objectives of the MPM system in Morgantown was to provide some relief for the traffic congestion existing on its two major thoroughfares. In assessing the impact of the Phase I MPM system on traffic congestion on University Avenue and Monongahela Boulevard/Beechurst Avenue eight factors must be taken into consideration. First, the Phase I MPM system lacks facilities for the coordinated transfer between the auto and the MPM. Clearly, the major function of the Phase I system judging by the ridership data on trip purpose has been to serve University oriented trips. Thus, what reductions in auto travel which were expected from the Phase I system can only be primarily expected to come from these trips. The diversion of non-University trips cannot be assessed prior to Phase II.

Second, changes in the composition of vehicular trips in the corridor must be taken into account. From the Pre-MPM, 1975 survey, 32 percent of the average weekday traffic on the two thoroughfares was through traffic; that is, trips with neither origin nor destination within the Primary Market Area. However, in the 1977 Phase I MPM survey, through trips accounted for only 11 percent of the average weekday traffic on the two arterials. The reduction in through traffic between these two years is probably the result of diversion of through traffic onto the portion of I-79 that acts as a Morgantown by-pass. Although opened prior to 1975, the adjustment of traffic to the new link in the area-wide network probably was not complete at the time of the Pre-MPM survey.

A third factor to be considered is the change in the average vehicle occupancy for the corridor between the two survey periods. In 1975, the average vehicle occupancy was calculated to be approximately 1.4 persons per car. The 1977 survey, however, calculated an increase to 1.6 persons per car. Thus, even if vehicular travel within the corridor remained stable over the two years, person travel would have increased.

A fourth factor to consider is the overall growth in the Morgantown area resulting in increases to auto traffic. The population of Morgantown increased from about 29,000 for Pre-MPM to about 32,000 for Phase I MPM with a large proportion of this growth occurring the in the residential section north of the city beyond the Evansdale Campus. Since University Avenue and Monongahela Boulevard/Beechurst Avenue are the only practical arterials connecting this growth area and the south side of the city including the CBD, traffic volume increases along these two arterials are to be expected. Because there were no auto to transit transfer facilities (the first factor), it cannot be expected that the Phase I MPM system would have a delaying effect on the two arterials' traffic growth as Metropolitan Transit Commission researchers found with BART and the San Francisco-Oakland Bay Bridge.

Fifth, differences between the extent of the two systems result in major difference in the service areas. This is evident from the travel time and trip matrices for the Phase I MPM and U-bus shown in Tables 3-3, 3-4, 3-5, and 3-6. Trips with both origins and destinations within zones 5 to 13 inclusive are clearly not served by the MPM system. U-bus service for these origin and destination zones was available in the Pre-MPM period. Similarly, certain O-D zone pairs in the four quadrants marked in Table 3-5 were not served by U-bus, but had MPM service available.

Sixth, it should be noted that the MPM service has been opened to all of Morgantown. Whereas the U-bus service was limited to WVU students, faculty, and staff, the MPM system can be used by everyone without regard to University affiliation.

Seventh, the PMA population not only changed between the Pre-MPM and Phase I-MPM in absolute numbers, but also in its composition (Table 3-7). Although the overall PMA population increased by 26 percent, segments that generally have a greater propensity for generating auto trips decreased while the segment of population that generally exhibits a lower propensity for auto trips increased. Non-student residents in the PMA decreased by 3 percent while dormitory students increased by 26 percent.

The eighth factor is the change in the level of service of the auto between Pre-MPM and Phase I MPM. As previously noted,

TABLE 3-3. TOTAL MPM TRAVEL TIME (MINUTES)[1]

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.-
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	1710	17.7	25.7	25.7	-	-	-	-	-	-	0	-	-	31.7	31.0	33.0
12	18.2	19.9	22.3	22.3	-	-	-	-	-	-	-	0	-	33.0	32.2	34.0
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

[1]Table from West Virginia University Phase I PRT Reports.

TABLE 3-4. MPM WEEKDAY PMA TRIP MATRIX BY RESIDENTS OF THE PMA[1]

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

[1]Table from West Virginia University Phase I PRT Reports.

TABLE 3-5. U-BUS TOTAL TRAVEL TIME[1]

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	0	0	16	19	23	21	24	24	20	21	32	0	0	0
2	0	0	0	0	9	12	16	14	17	24	20	21	23	0	0	0
3	0	0	0	0	9	12	16	14	17	24	20	21	23	0	0	0
4	0	0	3	0	14	12	16	24	20	24	20	6	12	0	0	0
5	20	15	16	16	0	4	10	8	10	0	13	0	16	22	23	24
6	22	15	15	15	4	0	8	3	10	0	13	0	16	21	22	23
7	22	17	18	18	13	14	0	0	0	0	18	0	15	22	23	24
8	19	10	10	10	15	17	0	0	0	0	18	0	15	21	22	23
9	7	7	7	7	3	4	0	0	0	0	6	0	3	7	7	7
10	7	7	7	7	3	4	0	0	0	0	6	0	3	7	7	7
11	21	22	23	23	13	14	19	21	6	6	0	0	24	24	25	26
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	30	21	22	22	16	15	13	15	16	3	24	0	0	31	32	33
14	0	0	0	0	20	22	24	22	25	8	22	0	31	0	0	0
15	0	0	0	0	21	23	25	23	26	8	23	0	33	0	0	0
16	0	0	0	0	21	23	26	24	27	8	24	0	33	0	0	0

ZONE NUMBER REFERS TO ANALYSIS ZONE

[1] Table from West Virginia University Pre-PRT Reports.

TABLE 3-6. UNIVERSITY BUS TRIP MATRIX[1]

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL
1	0	0	0	0	42	50	0	91	0	0	5	0	7	0	0	0	195
2	0	0	0	0	573	245	105	1612	52	4	52	4	48	0	0	0	2695
3	0	0	0	0	197	94	0	83	0	0	8	0	6	0	0	0	388
4	0	0	0	0	100	81	0	48	0	0	8	0	6	0	0	0	243
5	56	553	172	105	0	278	114	144	61	0	212	0	195	41	61	50	2042
6	0	22	40	47	65	0	0	0	0	0	25	0	45	10	10	15	279
7	15	123	0	0	0	124	0	0	0	0	15	0	30	0	0	0	307
8	11	1867	52	30	200	0	0	0	30	0	160	0	177	21	6	3	2557
9	0	3	0	0	0	0	0	0	0	0	0	0	2	0	0	0	5
10	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	8	86	65	19	42	2	15	25	10	0	0	0	35	12	15	10	344
13	41	155	48	47	25	35	35	180	30	0	25	2	0	10	15	10	698
14	0	0	0	0	20	20	22	0	0	0	2	0	0	0	0	0	64
15	0	0	0	0	7	12	0	5	5	0	0	0	2	0	0	0	31
16	0	0	0	0	0	9	0	0	3	0	0	0	0	0	0	0	12
	131	2852	377	248	1271	950	291	2188	191	4	512	6	553	94	107	88	9863

ZONE NUMBER REFERS TO ANALYSIS ZONE

[1] Table from West Virginia University Pre-PRT Reports.

TABLE 3-7. A COMPARISON OF DISSAGGREGATE POPULATION ESTIMATES FOR THE PRIMARY MARKET AREA[4]

PMA Zone	Dorm[1] Student Pre	Dorm[1] Student Oper.[3]	Non-Dorm[1] Student Pre	Non-Dorm[1] Student Oper.	Fac/Staff Pre	Fac/Staff Oper.	Residents Pre	Residents Oper.	Total[2] Pre	Total[2] Oper.
1	0	0	967	513	35	27	860	860	1862	1400
3	50	1630	710	478	30	27	160	160	1850	2295
4	670	734	110	489	60	53	430	430	1270	1706
7	0	0	80	58	120	69	80	80	280	207
8	1733	1860		0		5	0	0	1733	1865
9	0	0		0	10	0	130	130	140	130
10	0	0	90	93	70	53	120	120	280	266
11	0	0		12	25	0	105	0	130	12
13	0	0	40	70	40	21	55	55	135	146
18	0	0	90	42	25	48	220	220	335	310
19	0	0	500	634	45	27	20	20	565	681
25	0	0	730	932	120	133	2547	2547	3397	3612
26	0	0	370	396	100	74	1253	1253	1723	1723
27	0	0	650	746	345	329	2005	2005	3000	3080
Total	3353	4224	4337	4463	1025	866	7985	7880	16,510	17,433

[1]Total Student Enrollment - Pre = 16,210
OI = 17,020

[2]Total for the City of Morgantown - Pre = 28,872
OI = 31,908

[3]Oper. is abbreviation for Operational Phase PRT.
[4]From West Virginia University Phase I PRT Report

the auto travel times between origin and destination zone pairs within the PMA have increased from 1975 to 1977. The increase in auto travel times compared to transit travel times serves to reduce auto person trips and increase transit person trips.

3.3.2 Congestion Relief

Table 3-8 presents a summary of the comparison of traffic on the two major Morgantown thoroughfares for the 1975 Pre-MPM condition and for the 1977 Phase I MPM condition. On a corridor totals basis, traffic volume increased by 20 percent from 1975 to 1977 with the largest proportion of this increase along Monongahela Boulevard/Beechurst Avenue. This increase, accounting for the changes in average auto occupancy, reflects a 37 percent jump in person travel by autos through this corridor.

The level of congestion along the two arterials was unchanged. Although the traffic volume to capacity ratios are all quite low, bottlenecks at intersections and interference from pedestrian traffic serve to cause delays and unstable flows in the traffic stream. One specific bottleneck, the intersection of University, Campus, and Stewart, was noted as being susceptible to improvements resulting from the institution of MPM service. Since University bus traffic that normally would turn right onto Campus Drive from southbound University Avenue would be eliminated, it was reasoned that the intersection level of service would improve. However, the slight decrease in peak hour traffic has not been enough to change the Pre-MPM level of service, E, of the intersection.

3.3.3 Modal Share

Although daily auto vehicle trips increased by only 20 percent on a MPM corridor basis from the Pre-MPM period to the Phase I MPM period, auto person trips increased by 37 percent due to the increase in vehicle occupancy rate from 1.4 to 1.6 (Table 3-9). In contrast, daily transit person trips increased on a MPM corridor basis by 46 percent from U-bus to MPM for average total daily ridership.

Through trips, trips with both origins and destinations outside the PMA, clearly are not divertable. Furthermore, trips with only one end within the PMA have limited diversion opportunities to MPM given the lack of transfer facilities in Phase I. Trips internal to the PMA are clearly the most susceptible to diversion to MPM. Due to the factors previously noted and the factors listed in Section 3.3.1, a more representative comparison of the change in the transit modal shares can be obtained by examining the changes within the PMA

TABLE 3-8. COMPARISON OF CORRIDOR TRAFFIC VOLUMES

	ADT 1975	1977	1977-1975	1977/1975
UNIVERSITY AVE.				
Northbound	6,041	7,487	1446	1.24
Southbound	6,836	6,735	-101	0.88
Total 2-Way	12,877	14,222	1345	1.10
7-9 AM	1,380	1,499	69	1.05
11-1 PM	1,487	1,552	65	1.04
4-6 PM	1,653	1,628	-25	0.98
BEECHURST AVE.				
Northbound	12,818	19,416	6598	1.51
Southbound	11,717	11,295	-422	0.96
Total 2-Way	24,535	30,711	6176	1.25
7-9 AM	2,902	3,567	665	1.23
11-1 PM	3,079	3,806	727	1.24
4-6 PM	3,699	4,124	425	1.11
CORRIDOR TOTAL	37,412	44,933	7521	1.20
7-9AM	4,282	5,016	734	1.17
11-1PM	4,566	5,016	792	1.17
4-6 PM	5,346	5,5725	406	1.08
PERSON TRIPS	52,377	71,893	19,516	1.37

TABLE 3-9. COMPARISON OF MODAL UTILIZATION

	PRE-MPM	PHASE I	PHASE I/PRE-MP
MPM CORRIDOR			
AUTO:			
VEHICLE TRIPS	37,412	44,933	1.20
PERSON TRIPS	52,377	71,893	1.37
TRANSIT:			
AVG. TOT. DAILY RIDERSHIP	10,722	15,675	1.46
PRIMARY MARKET AREA			
AUTO:			
VEHICLE TRIPS	7,408	5,392	0.73
PERSON TRIPS	10,371	8,627	0.83
TRANSIT:			
UNADJUSTED PERSON TRIPS	9,863	8,698	0.88
ADJUSTED FOR SERVICE AREAS	7,525	8,341	1.11
ADJUSTED FOR SERVICE CLIENTELE	7,525	7,757	1.03
MODE SPLITS (TRANSIT PERSON TRIPS/TOTAL PERSON TRIPS)			
UNADJUSTED PRT CORRIDOR	.17	.18	1.06
UNADJUSTED PMA	.49	.50	1.02
ADJUSTED PMA SERVICE AREA	.42	.49	1.17
ADJUSTED PMA SERVICE CLIENTELE	.42	.47	1.12

(Table 3-9). Daily auto vehicle trips decreased by 27 percent resulting in a reduction of 17 percent in auto person trips between the Pre-MPM and Phase I periods. Transit person trips, however, also decreased from the U-bus to the MPM ridership by 12 percent.

It should be realized, however, that this is based on significantly different service areas between the two systems. From Table 3-3, the blanks in the MPM travel time matrix denote O&D pairs for which MPM is not an available alternative mode. Thus, no MPM trips appear for these O&D pairs in the Phase I MPM trip matrix (Table 3-4). Similarly, certain O&D pairs were not viably served by the Pre-MPM U-bus system. These pairs are denoted by zeroes in the U-bus travel time matrix (Table 3-5) and accordingly, no U-bus trips appear for these O&D pairs in the U-bus trip matrix (Table 3-6). Since the areas of non-viable service varies from the U-bus system to the Phase I MPM system, a more comparable basis for the assessment of the modal share captured by each system can be obtained by omitting those O&D pairs for which transit was not a viable alternative mode. This results in a decrease of daily U-bus trips to 7525 and daily MPM trips to 8341. With this adjustment, the daily transit person trips increased by 11 percent from the Pre-MPM to the operational MPM period with a 17 percent increase in modal share for transit within the PMA.

A further adjustment can be made to account for the differences between the two systems' service clientele. Using a further adjustment factor based on the estimation that 7 percent of the Phase I MPM trips were made by non-University related users, a total of 7757 MPM trips, a 3 percent increase from the Pre-MPM period is estimated. The transit modal share, however, does increase by 12 percent.

Another perspective is provided by the PMA telephone survey. The modal shares calculated from the telephone survey were 35 percent for MPM, 61 percent for auto, and 4 percent for other modes. By comparison, the modal shares calculated from the Pre-MPM telephone survey were 31.4 percent for U-bus, 63.1 percent for auto, and 5.5 percent for other modes.

3.3.4 Modal Share by O&D Basis

The modal share captured by each of the two systems can also be compared on an individual origin and destination basis. It can be seem from Table 3-10 that the analysis zones containing the MPM station, zones 1 (Walnut), 2 (Beechurst) and 5 (Engineering) all exhibit not only an increase in transit trip origins, but also an increase in the transit share of the trip origins. The other analysis zones that are WVU related all

TABLE 3-10. TRIP ORIGINS

Zone	AUTO Pre-PRT	AUTO Phase I	AUTO Phase I / Pre-PRT	TRANSIT Pre-PRT	TRANSIT Phase I	TRANSIT Phase I / Pre-PRT	TOTAL Pre-PRT	TOTAL Phase I	TOTAL Phase I / Pre-PRT	MODE SPLIT Pre-PRT	MODE SPLIT Phase I
1	1593	1265	0.79	195	324	1.66	1788	1589	0.89	0.11	0.20
2	1096	937	0.85	2695	2736	1.02	3791	3673	0.97	0.71	0.74
3	507	501	0.99	388	372	0.96	895	873	0.98	0.43	0.43
4	307	627	2.04	243	444	1.83	550	1071	1.95	0.44	0.41
5	641	480	0.75	1038	1714	1.65	1679	2194	1.31	0.62	0.78
6	278	369	1.33	144	213	1.48	422	582	1.38	0.34	0.37
7	418	425	1.02	138	0	0.00	556	425*	0.76	0.25	0.00
8	792	652	0.82	1990	1813	0.91	2782	2465	0.88	0.72	0.74
9	233	85	0.36	3	0	0.00	236	85*	0.36	0.01	0.00
10	173	163	0.94	3	14	4.67	176	177	1.01	0.02	0.08
11	249	376	1.51	0	0	-	249*	376*	1.51	0.00	0.00
12	84	30	0.36	215	0	0.00	299	30*	0.10	0.72	0.00
13	810	736	0.91	366	339	0.93	1176	1075	0.91	0.31	0.32
14	1107	650	0.59	64	132	2.06	1171	782	0.67	0.05	0.17
15	845	407	0.48	31	144	4.65	876	551	0.63	0.04	0.26
16	1238	924	0.75	12	96	8.00	1250	1020	0.82	0.01	0.09
	10,371	8627	0.83	7525	8341	1.11	17,896	16,968	0.95	0.42	0.49

(ADJUSTED)

increased or maintained the same share of transit trip origins. Analysis zones 3 and 8 with dormitory concentration in each zone, however, did show a decrease in number of transit trip origins as did analysis zone 13, the Medical Center Campus.

Discounting analysis zones located at the fringes of the PMA, one of the largest relative increase in transit trip origins occurs in analysis zone 1, the Morgantown CBD. This is not surprising considering that the use of the U-bus system from the CBD by University students required a quarter to half mile walk to the nearest U-bus stop. With the Phase I MPM system, however, not only is a station situated in the CBD, but Morgantown residents other than students may also use the system.

Similar increases in the modal share captured by the MPM system occur for trips destined for MPM station zones (Table 3-11). In all of these MPM zones, the number of transit trip destinations also increased. With the exception of the Medical Center Campus zone, the other WVU related zones exhibited a decrease in the transit modal share.

The transit modal share of travel can also be compared on an individual origin-destination pair basis (Table 3-12). However, over half (52%) of the O&D pairs are incomparable due to differences in the service areas of the two systems. Another 18 percent of the O&D pairs show no transit trips for both U-bus and Phase I MPM. Further, 11 percent of the remaining O&D pairs have no transit trips for either U-bus or Phase I MPM. Some key O&D pairs, however, may be compared (Table 3-13). For the MPM station O&D pairs, only the modal share of transit trips from zone 2 to 5, Beechurst to Engineering decreased (-2%). The other MPM O&D pairs that could be compared show substantial gains in the transit modal share.

The compairson of WVU related O&D pairs (Table 3-14) produces mixed results. The modal share of transit for trips with origins in zone 1, the Morgantown CBD, and destinations in zone 13, the Medical Center Campus, increased by 18 percent for the MPM system. However, the reverse O&D trip pair from the Medical Center Campus to the CBD decreased by 21 percent. Similar results also occur for other O&D pairs.

As expected, the above comparison of modal shares captured by the Phase I MPM system and the U-bus system show that the more significant increases have occurred in the zones where the MPM stations are located. The impact of the Phase I MPM system on the transit modal share of travel between WVU related zones, however, is not as definitive. Differences between the service area of the two systems caused by the two phase staging of the MPM system clearly contributed to the mixed results obtained in the comparison of transit modal share for some of the WVU related

TABLE 3-11. TRIP DESTINATIONS

Zone	AUTO Pre-PRT	AUTO Phase I	AUTO Phase I / Pre-PRT	TRANSIT Pre-PRT	TRANSIT Phase I	TRANSIT Phase I / Pre-PRT	TOTAL Pre-PRT	TOTAL Phase I	TOTAL Phase I / Pre-PRT	MODE SPLIT Pre-PRT	MODE SPLIT Phase I
1	1688	997	0.59	131	189	1.44	1819	1186	0.65	0.07	0.16
2	1252	1151	0.92	2852	3150	1.10	4104	4301	1.05	0.69	0.79
3	482	506	1.05	377	294	0.78	859	800	0.93	0.44	0.37
4	329	587	1.78	248	266	1.07	577	853	1.48	0.43	0.31
5	615	530	0.86	939	1644	1.75	1554	2174	1.40	0.60	0.76
6	255	433	1.70	511	420	0.82	766	853	1.11	0.67	0.49
7	623	397	0.64	127	24	0.19	750	421	0.56	0.17	0.06
8	820	552	0.67	1839	1536	0.84	2659	2088	0.79	0.69	0.74
9	240	241	1.00	60	12	0.20	300	253	0.84	0.20	0.03
10	245	123	0.50	4	0	0.00	249	123*	0.49	0.02	0.00
11	307	416	1.36	75	48	0.64	382	464	1.21	0.20	0.10
12	70	37	0.53	4	120	30.00	74	157	2.12	0.05	0.76
13	812	723	0.89	69	444	6.43	881	1167	1.32	0.08	0.38
14	912	924	1.01	94	45	0.48	1006	969	0.96	0.09	0.15
15	624	383	0.61	107	68	0.64	731	451	0.62	0.15	0.15
16	1097	627	0.57	88	81	0.92	1185	708	0.60	0.07	0.11
	10,371	8627	0.83	7525	8341	1.11	17,896	16,968	0.95	0.42	0.49

(ADJUSTED)

TABLE 3-12. PHASE I - PRE-MPM MODE SPLIT

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1					0.37	-0.26	0	0.07	0	0	-0.38*	0.71*	0.18			
2					-0.02	-0.15	-0.65	-0.03	-0.91*	-0.13*	-0.64*	0.77	-0.03			
3					-0.72	-0.73	0.18*	0.07	0	0	0.20	1	0.25			
4					-0.21	-0.30	0	0.10	0.26*	0	-0.29*	0	0.18			
5	0.22	0.25	-0.17	-0.29										-0.05	0.30	0.26
6	0.33*	0.48	-0.89*	-0.36										-0.30	-0.45*	0.08
7	-0.08*	-0.05*	0	0										0	0	0
8	0.28	-0.02	-0.23	-0.01										-1	-0.09*	-0.03*
9	0	-0.25	0	0										0	0	0
10	0	-0.13*	0	0										0	0	0
11	0	0	0	0										0	0	0
12																
13	-0.21	-0.01	-0.39	-0.53										-0.04*	0.00	0.10
14					0.41	-0.36	-1	0	0	0	-0.17*					
15					0.62	0.17	0	-0.08*	-0.16*	0	0		0.06			
16					0.36*	0.31	0	0	-0.17	0	0		0			

* - PRT or U-bus mode split was zero

0 - Both PRT and U-bus mode split was zero

TABLE 3-13. COMPARISON OF MPM STATIONS O&D MODAL SHARES

	PHASE I	U-BUS	PHASE I - U-BUS
WALNUT - ENGINEERING (1-5)	0.79	0.42	+0.37
BEECHURST - ENGINEERING (2-5)	0.96	0.98	-0.02
ENGINEERING - WALNUT (5-1)	0.63	0.41	+0.22
ENGINEERING - BEECHURST (5-2)	0.98	0.73	+0.25

TABLE 3-14. COMPARISON OF WVU O&D MODAL SHARES

	PHASE I	U-BUS	PHASE I-U-BUS
WALNUT STATION - EVANSDALE CAMPUS (1-6)	0.50	0.76	-0.26
" " - TOWERS (1-8)	0.42	0.35	+0.07
" " - COLISEUM (1-11)	0	0.38	-0.38
" " - MEDICAL CENTER (1-13)	0.37	0.19	+0.18
BEECHURST STATION - EVANSDALE CAMPUS (2-6)	0.77	0.92	-0.15
" " - TOWERS (2-8)	0.81	0.84	-0.03
" " - COLISEUM (2-11)	0	0.64	-0.64
" " - MEDICAL CENTER (2-13)	0.84	0.87	-0.03
DORM CONCENTRATION - EVANSDALE CAMPUS (3-6)	0.17	0.90	-0.73
" " - TOWERS (3-8)	0.43	0.36	+0.07
" " - COLISEUM (3-11)	0.33	0.13	+0.20
" " - MEDICAL CENTER (3-13)	0.71	0.46	+0.25
" " - ENGINEERING STATION (3-5)	0.76	0.98	-0.22
ENGINEERING STATION - DORM CONCENTRATION (5-3	0.80	0.97	-0.17
EVANSDALE CAMPUS - WALNUT STATION (6-1)	0.33	0	+0.33
" " - BEECHURST (6-2)	0.83	0.35	+0.48
" " - DORM CONCENTRATION (6-3)	0	0.89	-0.89
TOWERS - WALNUT STATION (8-1)	0.34	0.06	+0.28
" - BEECHURST STATION (8-2)	0.85	0.87	-0.02
" - DORM CONCENTRATION (8-3)	0.14	0.37	-0.13
MEDICAL CENTER - WALNUT STATION (13-1)	0.12	0.33	-0.21
" " - BEECHURST STATION (13-2)	0.90	0.89	+0.01
" " - DORM CONCENTRATION (13-3)	0.37	0.76	-0.39

zones. The large percentage of O&D pairs that are incomparable due to differences in service areas makes it impossible to draw definitive conclusions as to the impact of the MPM system on the transit modal share of travel between these zones.

3.3.5 Modal Share by Time Period

It is also useful to assess the transit modal share of travel by time period for the two systems. However, the differences in service areas between the two systems also present difficulties with this comparison.

To account for the differences in service areas, two comparisons can be made. First, the two systems can be compared on a total transit ridership basis by hourly intervals (Table 3-15). In this comparison, to account for the inclusion of all Pre-MPM U-bus routes and their ridership, the Phase I U-bus shuttle service ridership was added to the MPM ridership. Although this adjustment equalizes the two systems' service areas, it also introduces a bias to the Phase I total transit ridership derived. Since riders of the Phase I U-bus shuttle service who transferred to MPM would in effect be counted twice, the total transit ridership derived for Phase I would be greater than that of the Pre-MPM period where only one U-bus trip would be required. This should be kept in mind in examining the comparison of the modal shares presented in Table 3-15. Slight to no increases in the transit modal share of travel occur for the hourly intervals after 11:00AM. The largest gain in transit modal share occurs in the 8 to 9 period. Decreases in the modal share of transit surprisingly occur for the period between 9 and 11.

A second comparison can be made by adjusting the Pre-MPM U-bus ridership to include only the riders from routes within the Phase I MPM corridor. Thus, only riders boarding the Tower-Campus Drive route at the Towers and the Campus Drive-Towers route at Campus Drive are included in the Pre-MPM transit ridership. The comparison presented in Table 3-16 is then between this adjusted Pre-MPM transit ridership and only the Phase I MPM ridership. In contrast with the previous comparison, the results here indicate slight decreases or no changes to the modal share of transit for the time periods after 11:00 a.m. Where the previous comparison showed the largest increase in the transit modal share between 8 and 9, this comparison indicates a slight decrease. Further, greater decreases in the modal share of transit is shown for the time periods between 9 and 11.

Given the contrasting results of the two comparison, it is difficult to assess the impact of the Phase I MPM system on the transit modal share of travel by the various time periods used in

TABLE 3-15. COMPARISON OF MODAL SHARES BY TIME PERIOD: UNADJUSTED

	PRE-MPM				PHASE I				
Time	U-Bus	Auto Veh. Trips	Auto Pers. Trips	U-Bus / Tot. Pers. Trips	Transit	Auto Veh. Trips	Auto Pers. Trips	Transit / Tot. Pers. Trips	Δ%
8-9	864	2269	3177	0.21	1623	2544	4070	0.29	+0.08
9-10	1221	1840	2576	0.32	1626	2395	3832	0.30	-0.02
10-11	1329	1849	2589	0.34	1754	2453	3925	0.31	-0.03
11-12	1050	2030	2842	0.27	1623	2636	4218	0.28	+0.01
12-1	1440	2536	3550	0.29	2086	2722	4355	0.32	+0.03
1-2	1307	2318	3245	0.29	1875	2721	4354	0.30	+0.01
2-3	1093	2472	3461	0.24	1481	2825	4520	0.25	+0.01
3-4	1157	2712	3797	0.23	1418	2975	4760	0.23	0.00
4-5	808	2841	3977	0.17	1005	2973	4757	0.17	0.00

A - Includes all U-bus ridership on all routes

B - Includes U-Bus ridership of Phase I system

TABLE 3-16. COMPARISON OF MODAL SHARES BY TIME PERIOD: ADJUSTED

	PRE-PRT				PHASE I				
Time	U-Bus[A]	Auto Veh. Trips	Auto Veh. Trips	U-Bus Tot. Pers. Trips	Transit[B]	Auto Veh. Trips	Auto Pers. Trips	Transit Tot. Pers. Trips	%
8-9	670	2269	3177	0.17	735	2544	4070	0.15	-0.02
9-10	1006	1840	2576	0.28	966	2395	3832	0.20	-0.08
10-11	995	1849	2589	0.28	1150	2453	3925	0.23	-0.05
11-12	745	2030	2842	0.21	1053	2636	4218	0.20	-0.01
12-1	1033	2536	3550	0.23	1262	2722	4355	0.22	-0.01
1-2	958	2318	3245	0.23	1302	2721	4354	0.23	0.00
2-3	736	2472	3461	0.18	926	2825	4520	0.17	-0.01
3-4	819	2712	3797	0.18	911	2975	4760	0.16	-0.02
4-5	547	2841	3977	0.12	625	2973	4757	0.12	0.00

A - Includes only riders boarding Towers-Campus Drive Route to Towers and Campus Driver-Towers Route at Campus Drive

B - Includes PRT ridership only

the comparisons. It does appear that very minor changes, if any, occurred for the time periods, after 11:00 a.m. Surprising decreases in the transit modal share appear to occur between 9 and 11. The resulting fluctuations in modal share between the two comparison for the 8 to 9 period cannot be readily interpreted.

3.3.6 Accidents

The effect of the Phase I MPM system on auto accidents within the MPM corridors can be evaluated by examining standard police accident records. From Table 3-17, the total number of accidents within the PMA increased by 88 percent between the Pre-MPM 18 month period, January 1, 1974 to June 30, 1975, and the Phase I MPM period, January 1, 1976 to June 30, 1977. The total number of vehicular accidents causing injury, however, declined 45 percent. To attribute this increase or decrease to the operation of the MPM system is unreasonable given other causal factors. 1974 was an atypical year statistically for Morgantown as well as the nation due to the acute gasoline shortage during the first few months of 1975. The resulting reduction in vehicle miles of travel yielded a drop in the number of accidents for that year. Additionally, the completion of the TOPICS program in 1974 in Morgantown resulted in significant traffic engineering improvements to safety. Improved channelization, new traffic signs, widening of streets, and the coordination of signals served to help reduce the number of accidents for the base period of comparison.

Additional data provide details concerning accidents by selected zones and intersections within the PMA. To draw conclusions as to any causal effects of the Phase I system based on this data is not possible. Other factors, such as changes in weather conditions, highway geometrics, signalization, vehicle miles of travel, etc. can be expected to have a more meaningful correlation with the accident rate. The data were inadequate to permit valid multivariate analyses to test the potential impact of the MPM system. Since it can be seen from the previous section that the MPM system did not reduce total vehicular travel within the corridor, it would be unreasonable to conclude that the MPM system had any positive impacts on accidents. To summarize, there is no reason to conclude that the MPM system had any significant impacts on accidents.

TABLE 3-17. TRAFFIC ACCIDENTS WITHIN PMA[1]

	PRE-MPM			PHASE I		
	1-1 to 12-31 1974	1-1 to 6-30 1975	TOTAL	1-1 to 12-31 1976	1-1 to 6-30 1977	TOTAL
TOTAL NO. OF ACCIDENTS	395	225	620	808	358	1165
TOTAL NO. WITH INJURY	80	54	134	112	25	137
% WITH INJURY	20.2	24	22	13.9	7	12
TOTAL COST OF DAMAGE	$186, 835	143,858	330,693	404,028	223,372	627,400
AVERAGE COST PER ACCIDENT	$473	639	533	500	624	538

[1]From West Virginia University Phase I PRT Report

3.4 Environmental Impacts

3.4.1 Air Quality

Since quantitative data on ambient air quality are unavailable, the assessment of the impact of the Phase I MPM system on Morgantown's air quality will be qualitative and subjective in nature. Because the vehicles are electrically powered with the energy being generated at a remote location, the system is virtually pollution free to Morgantown. The heating plants that provide heating for the guideways use natural gas, a clean burning fuel. Thus, on a qualitative basis, the MPM system does not negatively impact Morgantown's air quality.

Although it can be reasoned that the Phase I MPM system has not detrimentally affected the air quality in Morgantown, improvements to the air quality as a result of the system cannot be quantitatively supported and are difficult to qualitatively support. Despite the elimination of U-bus traffic between the two campuses, traffic volume through the MPM corridor has increased. Without data concerning the mix of the vehicle types and their ages for the Pre-MPM and the Phase I MPM period, it cannot be determined whether improvements to air quality have been made. It should be noted, however, that auto trips generated by PMA residents have decreased. This drop in vehicular travel can be expected to enhance air quality.

3.4.2 Noise

Only limited data are available concerning the impact of the Phase I MPM system on noise. On a qualitative basis, the system is inherently quiet with the rubber tired vehicles operating smoothly on the guideways. Additionally, the alignment of the guideway along the railroad right-of-way west of Monongahela Boulevard and Beechurst Avenue and on University property results in low noise intrusions to the community. Thus, on a qualitative basis, the Phase I MPM system has not adversely impacted the noise level in Morgantown.

In addition to the noise impacts generated by the MPM system, the effect of replacing the University bus traffic and changes in the traffic volume resulting from the MPM system needs to be evaluated. A separate study was specifically aimed at evaluating this impact. Two of the area's six noise monitoring sites were within the MPM corridor, one along each of the two major arterials. The results of the "continuous, 24 hour outdoor sound recordings for seven days"[8] are given in Figures 3-1 and 3-2. It should be noted that data for the after period of the study were taken when the U-bus system was not completely replaced, but was running at a reduced service level (33%) in parallel with MPM as a back-up. Nevertheless, the study concluded that the replacement of the University bus system, although incomplete, had accounted for a decrease in the community noise level.

3.4.3 Other

Other environmental impacts resulting from the Phase I MPM system have been small. As previously noted, the guideway location relative to the Morgantown community has resulted in a low impact of the MPM system on the community. Only temporary disruptions of traffic during the construction period at the four major highway crossings occurred. No permanent neighborhood disruption or diversion of existing movement patterns resulted.

The aesthetic/visual impacts of the MPM system have also been slight. Some community reactions to the seemingly massiveness of the guideways have been noted. The overly massiveness of the guideway can be attributed to the overdesigned guideway structure necessary to insure that the finalized vehicle design would not exceed the guideway's structural load capacity. A trimmer guideway structure will be used in the Phase II expansion.

3.5 University/Community Impacts

3.5.1 University Layout

In evaluating the impact of the Phase I MPM system on University development, certain issues should be considered. It is important that developmental decisions be distinguished from locational decisions. Developmental decisions can be defined as those leading to new development as a result of the MPM system. For developmental decisions the decision to build a new facility is influenced by the existence of the MPM system or station. In contrast, locational decisions are the selections of facility sites as a result of the MPM systems existence. The decision to build the new facility has previously been made; only its location has been influenced.

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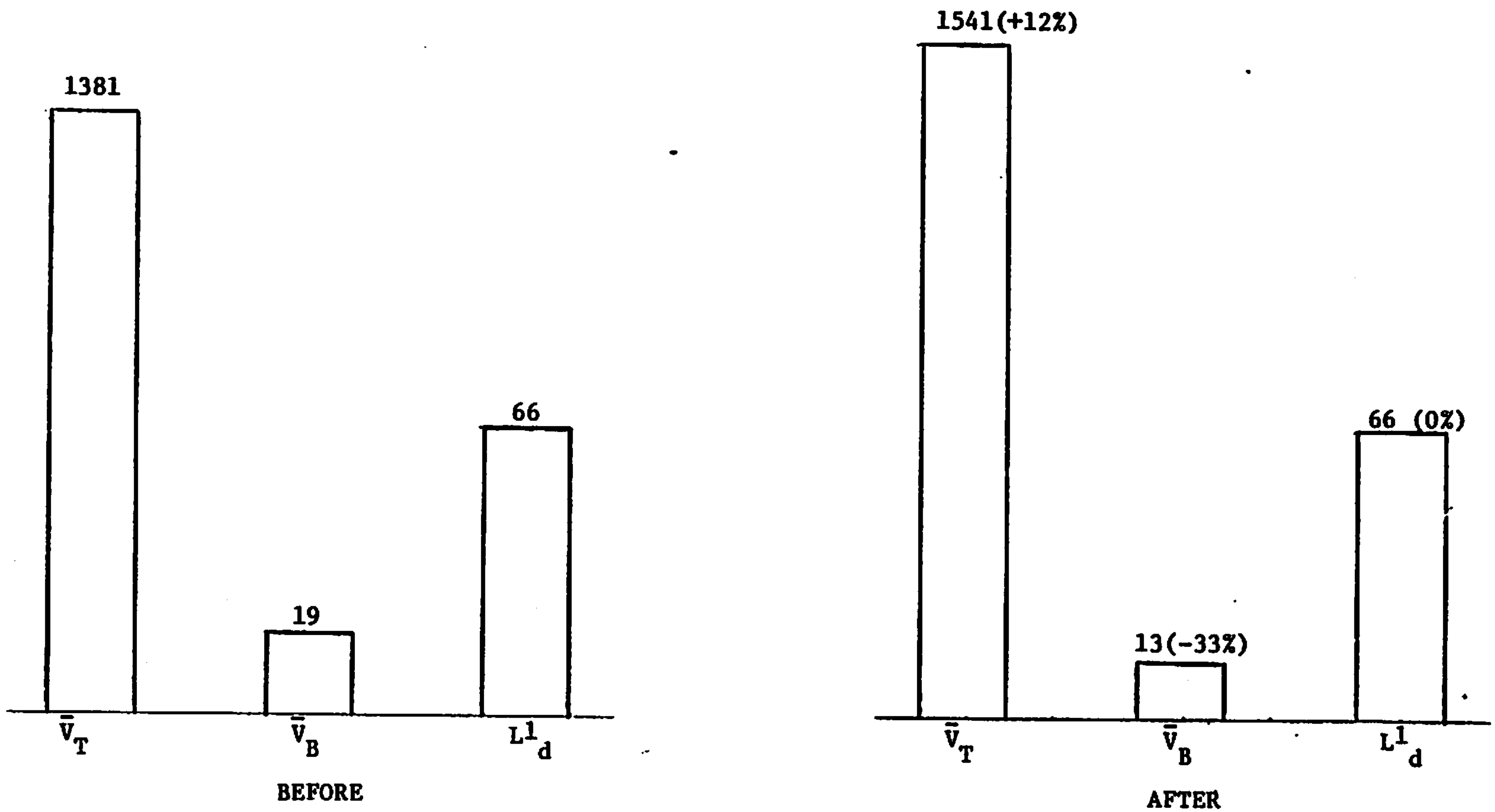
[8]Elias, Samy, E.G., et al., PRT Impact Study, The Phase I PRT Impact on Morgantown Travel, Traffic and Associated Activities, p. 46.



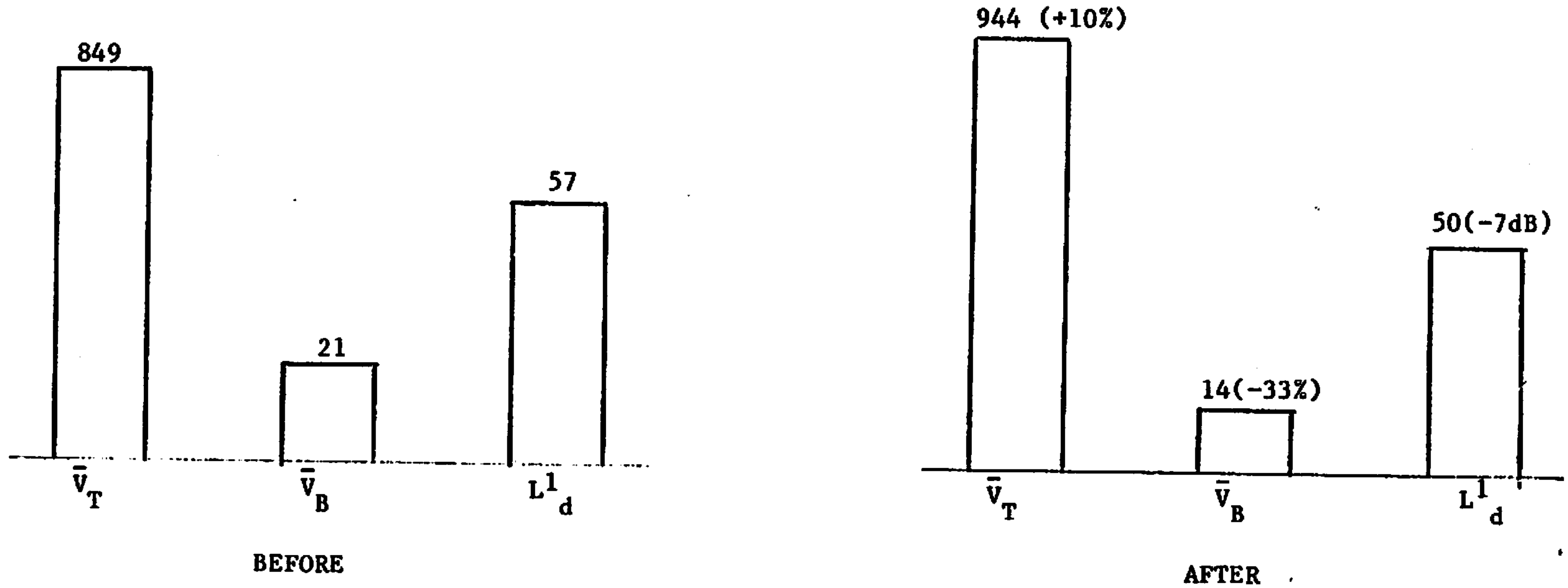
$\bar{V}_T$ - Average weekday hourly total traffic

$\bar{V}_B$ - Average weekday hourly bus traffic

L^1_d - Academic day energy equivalent sound level

[1]From West Virginia University Phase I PRT Report

FIGURE 3-1. COMPARISON OF BEFORE AND AFTER NOISE READINGS AT UNIVERSITY AVENUE[1]



$\bar{V}_T$ - Average weekday hourly total traffic

$\bar{V}_B$ - Average weekday hourly bus traffic

L^1_d - Academic day energy equivalent sound level

[1]From West Virginia University Phase I PRT Report

FIGURE 3-2. COMPARISON OF BEFORE AND AFTER NOISE READINGS AT MONOGAHELA BOULEVARD[1]

Another issue is the availability of data to rationally assess this impact area. Development impacts resulting from transportation systems occur later than most other impacts. Interim findings from the BART impact study showed that "BART had little perceptible impact on development of office and home construction."[9] BART officials, however, have countered by stating that it would take years before the full impact of the system is realized.

A further issue is that University development is typically influenced by other factors. The construction of new facilities is usually in response to needs generated by increased enrollment or replacement of existing facilities. Unlike the private sector in which a transportation system may spur new development, the influence of the MPM on the generation of new University development is unclear given the other factors involved.

Although developmental decisions may be difficult to assess, it is apparent that the MPM system had influenced certain locational decisions. The opinions of the University Office of Facilities Analysis and Utilitization and the University Architect indicated that the location of the new Engineering Library, now under construction near the Engineering station, was decided taking the MPM system into consideration. Similarly, the MPM system was taken into consideration in the location of a new Medical Center garage and a new University stadium to be built near the Medical Center station.

No discernible influence by the MPM system has been noted on the University parking situation. Table 3-18 shows that no changes have occurred since 1968 in the number of decal or free spaces for the Downtown and Medical Center campuses. The fluctuations in free parking spaces on the Evansdale Campus are the results of parking for newly constructed facilities. 1200 free spaces were added in 1970 when the Coliseum was built. Similarly 400 spaces were added with the Natatorium in 1977. The reduction in spaces between 1977 and 1978 was the result of 250 spaces taken during MPM construction work at the Twin Towers.

Although the use of University buildings on both the Downtown and Evansdale campuses have been changing, the changes have occurred for reasons that do not appear to be MPM related.

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[9]Engineering News Record, "BART Scores Low on Report Card, Could Up Grades Over Long Term," Nov. 3, 1977, Page 14.

TABLE 3-18. WVU PARKING SPACES

	EVANSDALE		DOWNTOWN		MEDICAL	
	DECAL	FREE	DECAL	FREE	DECAL	FREE
1968	1400	600	500	500	800	500
1969		600				
1970		1800				
1971		1800				
1972		1800				
1973		1800				
1974		1800				
1975		1800				
1976		1800				
1977		2200				
1978		1950				

3.5.2 Morgantown Changes

Similar consideration should be given to the issues raised earlier in assessing the impact of the MPM system on changes in Morgantown. It is equally important to be able to distinguish between developmental decisions in the private sector resulting from the MPM system and locational decisions based on the MPM system. The difficulty imposed by the longer time frame of these impacts, as noted previously, is compounded by the lack of a single, comprehensive data source for these impacts. Various records are kept by the City and County Planning Commissions, the County Assessor, and the City Engineer with sometimes conflicting data. Furthermore, with only the Walnut station located on non-University property, private development opportunities have been limited by the extent of the Phase I system.

Two locational decisions, however, have been influenced by the Phase I MPM system. A new county office building and a 420-car parking garage were both built near the Walnut Station. It should be noted that these were public and not private investments.

No reduction to the city parking spaces resulted from the MPM system. Parking spaces for all existing lots have remained stable for the past ten years. Only two new lots added in 1971 and the garage near the Walnut station added in 1978 have been built. Table 3-19 presents a summary of the city parking situation.

Building permit data were available from both the City Engineer's Office and County Assessor's Office. Table 3-20 presents a summary of building permits and their values for the period between 1970 and 1977 obtained from the City Engineer's Office. Tables 3-21 and 3-22 show building permit data from the County Assesscr's Office on a more disaggregate basis. The data from these sources, however, do not match. Although the average value of building permits within a one quarter mile of the MPM are higher than those outside, no conclusions as to the effect of the MPM on this trend can be stated without knowing the possible influences of other market force variables.

Records of property sales that occurred within a one quarter mile of the MPM between 1967 and 1978 were analyzed. In general, the average sale price has increased with time for all cases. As before, without knowing the other market force variables at work, it cannot be concluded that MPM was responsible for the sale price increases. It was, however, the opinion of the County Assessor's office that the MPM did not directly impact the value of the properties significantly.

TABLE 3-19. MORGANTOWN PARKING[1]

LOCATION		NUMBER OF METERS
ON STREET PARKING		284
PARKING LOTS:		
#1	Spruce Street and Fayette Street	74
#2	Chestnut Street and Fayette Street	82
#3	Spruce Street and Pleasant Street	67
#4	Chestnut Street and Pleasant Street	67
#5	Chestnut Street and Wall Street	22
#6	Spruce Street at Spruce Street Methodist Church	71
#7	Willey Street and Episcopalian	43
#8	Chestnut Street and Forest Avenue	87
#9	Spruce Street and Wall Street	25
#10	Chestnut Street, University and Wall (1971)	71
#11	Forest, High, and Chestnut (1971)	87
#12	University, Walnut, and Chestnut (1978) (New Parking Parage)	421
PARKING LOTS TOTAL		1,117
GRAND TOTAL		1,401

[1]From West Virginia University Phase I PRT Report

TABLE 3-20. BUILDING PERMIT SUMMARY

YEAR	NUMBER	VALUE	AVERAGE
1970	1074	$13,547,556	$12,614
1971	1090	8,795,575	8,069
1972	1093	9,872,964	9,033
1973	1141	7,333,310	6,427
1974	1043	5,786,303	5,548
1975	1074	13,547,556	12,614
1976	1119	9,397,257	8,398
1977	1316	37,917,274	28,813
TOTAL	8895	$94,222,773	$10,593

TABLE 3-21. BUILDING PERMITS FOR 1977[1]

Location	Permits for New Construction			Permits for Remodeling			All Permits		
	Number	Value	Average Value	Number	Value	Average Value	Number	Value	Average Value
1st Ward	18	11,700,214	650,012	52	287,795	5,535	70	11,988,099	171,257
2nd Ward	33	1,301,400	39,436	201	455,079	2,264	234	1,756,479	7,506
3rd Ward	2	190,000	95,000	121	2,058,217	17,010	123	2,248,217	18,278
4th Ward	8	255,000	31,875	204	450,648	2,209	212	705,648	3,329
5th Ward	13	4,102,919	315,609	146	425,343	2,913	159	4,528,262	28,480
6th Ward	20	849,083	42,455	18	720,376	40,021	38	1,569,459	41,302
7th Ward	16	1,438,250	89,891	196	1,248,177	6,368	212	2,686,427	12,672
Sub Total	110	19,836,866	180,335	938	5,645,635	6,019	1,048	25,482,501	24,315
Star City	14	1,187,000	84,786	49	99,057	2,022	64	1,286,057	20,414
Westover	31	820,200	26,458	121	306,113	2,530	152	1,126,313	7,410
Granville	3	109,000	36,333	34	86,439	2,542	37	195,439	5,282
Grand Total	158	21,953,066	138,943	1,142	6,137,244	5,374	1,300	28,090,310	21,608

[1] From West Virginia University Phase I PRT Report

TABLE 3-22. 1977 BUILDING PERMITS WITHIN 1/4 MILES OF THE MPM[1]

Location	No. New	Value New	Average Value	No. Old	Value New	Average Value	No. Total	Value New	Average Value
7th Ward	8	931,750	116,469	16	383,545	23,972	24	1,315,395	54,804
4th Ward	1	37,000	37,000	22	106,231	4,829	23	143,231	6,227
3rd Ward	1	150,000	150,000	31	774,644	24,989	32	924,644	28,895
Total	10	1,118,750	111,875	69	1,264,420	18,325	79	1,383,170	30,167

[1] From West Virginia University Phase I PRT Report

3.5.3 Student Activity Patterns

The Phase I MPM system has also had definitive as well as potentially beneficial impacts on the activity patterns of WVU students. From previous sections, it can be seen that the student's accessibility to the Morgantown CBD has definitely been improved. As a result, the proportion of students making trips by transit for the purpose of shopping increased from 1.2 percent for the U-bus system to 3.0 percent for the MPM system. Similarly, social-recreational trips by transit also increased from 3.2 percent to 5.0 percent.

Potential impacts to the activity patterns of WVU students can be conceptualized. The flexibility with which students are able to schedule their school related activities has been improved as a result of the MPM system. As previously noted, in the off-peak hours, the provision of more frequent MPM service (demand-responsive possible) enables students to have greater flexibility in their activities. Prior to MPM, students had to match their activity schedules to that of the U-bus system. The MPM system, however, has the capability to dynamically adapt to changes in the students' schedules. Furthermore, as the reliability of the MPM system has improved, the variability of inter-campus travel, given the time allowance for class changes, becomes less of a factor to consider in the selection of class schedules.

3.6 Site Specific Impacts

3.6.1 Demand Patterns

The pulsating demand pattern exhibited by the Phase I MPM system is uniquely characteristic of this system being located in an university environment. As a consequence, approximately 86 percent of the Phase I MPM trips are made by West Virginia University students. The concentration of MPM trips coincide with class changes on the two campuses resulting in five peaks from mid-morning to mid-afternoon. This multi-peaking characteristic which results in relatively short periods between off-peak and peak demand is quite different from that of typical urban areas. One of the resultant impacts is to <u>not</u> change the size of the vehicle operating fleet to match the peak and off peak periods unlike typical urban transit systems. Instead it was found to be more advantageous to manage the vehicle fleet by essentially storing vehicles in the stations by allowing in station dwell times to increase. The duration of each of the peak periods in the MPM system is also short relative to the typical urban morning or evening peak periods. Another distinct characteristic that is also University related is the change in MPM schedules on a daily basis. To match West Virginia

University's class schedules, the MPM operates on one schedule Tuesdays and Thursdays and on another Mondays, Wednesdays, and Fridays.

The total number of MPM trips is also highly influenced by the University environment in which it operates that is not typical of urban areas. As noted previously, peaks in MPM ridership occur on a daily basis that coincide with class changes on the two campuses. The combination of delays caused by congestion on the two arterials connecting the two campuses and limited parking supply with the limited time between class changes results in the auto being an unattractive alternative for inter-campus travel. With the MPM being the only other viable mode, most inter-campus trips for the purpose of meeting consecutively scheduled classes on different campuses are expected to be made by MPM. Therefore to a certain extent, those trips can be considered generated. To the extent that inter-campus trips can be reduced through class scheduling, then it follows that MPM ridership would also be reduced. Conversely, if class scheduling changes were made to disperse classes and increase inter-campus trip making, MPM ridership would increase.

In examining numerous alternatives for the Morgantown MPM system, Barton-Aschman examined an alternative to reduce inter-campus trip-making. This alternative would use communication systems and policies for the allocation of classroom and dormitory space to reduce travel demand between campuses. Specifically, in the analysis, the alternative assumed that closed-circuit TV facilities would be installed linking major lecture halls with TV monitor rooms on the various campuses. In conjunction, it was also assumed that a space allocation policy would be instituted that would schedule freshmen and sophomore classes as well as their dormitory spaces on the Downtown campus and junior and senior classes and their dorms on the Evansdale campus.

With this alternative, Barton-Aschman estimated that a reduction of 20 percent of total MPM trips could be achieved (Table 3-23). A third of all student trips could be eliminated. It should be noted that the estimates refer to a six station MPM system. The numbers given indicate the magnitude of the reduction in trip-making that may be possible for the Phase I, three station configuration.

3.6.2 Fare Pre-Payment

Another distinctive feature of the Morgantown People Mover system is the fare system. Full time University students are required to pay a transportation fee each semester along with their other registration fees. In return, each student receives

TABLE 3-23. REDUCED TRAVEL DEMAND ALTERNATIVE[1]

1972 PRT TRAVEL ESTIMATES PREPARED BY WVU STAFF

Trip Classification		1972 Daily Trips
Medical Center Trips		4,536
Non-University Related Trips		11,136
Faculty and Staff Trips		16,173
University Student Class Trips		33,561
University Student Non-Class Trips		4,200
	TOTAL	69,606

ESTIMATED DAILY INTER-CAMPUS TRIP REDUCTIONS - REDUCED DEMAND ALTERNATIVE

Trip Type		1975 Daily Trips Estimated
Student trips to and from campus		8500
Inter-class trips		4000
Non-class trips		1600
	TOTAL	14100

[1]Table from Barton-Aschman Associates, Inc., Evaluation of Alternatives.

a magnetically encoded pass valid for that semester. In addition, semester passes are available for the same transportation fee to other users. With the predominance of MPM trip-making by University students, it is not surprising that 95 percent of the riders use the pre-paid passes. This percentage surpasses what is collected by most transit authorities through conventional fare collection machinery.

With such an extremely high proportion of users having pre-paid passes, an honor fare system could be possible. Under this system, the turnstiles could be removed, although a destination selector would be kept for demand-mode operations. The elimination of the unnecessary farecard and turnstiles with the honor fare system would also eliminate the problems associated with the fare collection sub-system noted previously.

Although the mandatory transportation fee along with certain other required fees is not popular with those students who perceive little use of the University transportation system, it has not been challenged. This combination of a mandatory transportation fee paid by the majority of system users is not expected to be duplicated in a typical urban setting.

3.6.3 Experimental Nature of System

The experimental nature of the Morgantown system and the uncertainty of its permanence also contributed to impacts in Morgantown that are not likely to be duplicated in other urban settings. As will be discussed in Appendix B, the experimental nature of the system has clearly influenced the capital cost of the system. It was calculated that approximately one third of the cost could be partially attributed to research and development costs.

The influence on ridership, however, is not as definitive, nor as quantitative. The early bugs experienced and the prolonged shakedown period resulting from Morgantown being the first true application of an AGT system in an urban setting certaintly impacted MPM ridership during that period. What is not certain is the impact of this period of unreliable service on the MPM ridership in the later stages of the Phase I operations. Although ridership has increased substantially from the initial year of operations, it is apparent that the ridership has not reached the level expected. The prolonged shakedown period required and the apparent subsequent long term carry-over effect on ridership is not expected (nor planned) to be duplicated. Although new transit systems typically go through such a break-in period, the period is usually considerably shorter than that experienced by the MPM system.

The two phase staging of the total MPM system is also unique, and not expected to be replicated in other urban settings. The uniqueness lies not in the multi-staged phasing, but in the system shutdown for a year required to achieve the expansion of the system. Clearly, this would be unacceptable in a more typical urban setting and should be avoided. On a subjective basis, this shutdown period will also have an influence on MPM ridership in that potential users may not be willing to make long term decisions on places of residence or purchases of automobiles and other such decisions that have strong implications on their mode choice given this year long gap in service.

The uncertainty as to the permanence and the extent of the Morgantown system may also have contributed to the relative lack of development in response to the MPM system. With publicity concerning the possible removal of the Phase I MPM system surfacing in Congressional hearings, the permanence of even the Phase I portion of the system was once in doubt. This and the coincident uncertainty associated with the second phase of the system clearly was a disincentive to investors contemplating commitments for development in the vicinity of the MPM system.

4. SUMMARY AND CONCLUSIONS

This portion of the report provides a synposis of the previous sections of the evaluation. Experiences that may prove useful to other applications of AGT technology are also described. The summary of findings from the previous section is presented in Section 4.1. Transferable lessons gained from the Morgantown experience are documented in Section 4.2.

4.1 Summary of Findings

This section provides a summary of the previous substantive sections of this evaluation. Specifically, Section 4.1.1 summarizes Section 2, Phase I MPM Ridership and Section 4.1.2 summarizes Section 3, Phase I MPM Impact.

4.1.1 Phase I MPM Ridership Summary

Phase I MPM ridership was examined from both an aggregate as well as a disaggregate perspective. The disaggregate analysis was focused on the choice rider's characteristics and travel behavior.

MPM ridership had shown a rapid increase; mean weekday and daily ridership had increased 101 percent to 8,046 and 6,121 passenger on an academic year basis, mean weekday ridership had increased 187 percent to 10,847 passengers per day day and mean daily ridership had increased by 192 percent to 8,162 passengers per day by the third academic year.

Extrapolation of ridership trends for the these academic years of operation indicated that the three station system ridership did match the planning estimate for low ridership for the six station system.

Indication of the primary university orientation of the Phase I MPM system was noted from the composition of MPM riders. Data from the MPM on-board survey indicated that 86 percent of MPM trips were made by students; the remaining proportion of trips were equally divided between WVU faculty and staff users and non-university related users.

Only 25 percent of the MPM trips recorded from the MPM on-board survey were choice trips. Data from the Primary Market Area (PMA) telephone survey were used to provide another perspective on MPM ridership. Only 35 percent of the trips recorded from the random based sample of PMA residents, both dormitory students and non-dormitory residents, were by MPM; only 7 percent of the total trips surveyed were choice MPM trips. On the other hand auto trips accounted for 61 percent of the total trips. It was noted that for dormitory students, MPM was used for 54 percent of their trips. For non-dormitory students, however, only 16 percent of their trips were made using MPM.

Certain characteristics of choice and captive MPM riders were compared. The differences between choice and captive rider characteristics for university related users were often masked by the common characteristics of the university population in general. Thus, the age distribution of university riders, both captive and choice, reflected the age distribution to be expected in an university environment. Similarly, although the proportions of choice riders who had drivers' licenses were slightly greater than captive riders for university related users, almost all students, faculty, and staff members were licensed drivers. The limited choice MPM trips recorded were the result of the limited availability of autos. No definitive conclusions could be drawn with the available data concerning the relationship between gender or marital status and choice or captive ridership.

As expected, the primary reason cited by university related captive riders for using MPM was that no other mode was available. The second most cited reason, however, was surprisingly convenience. For choice riders, convenience was the primary reason given for using the MPM. A surprising proportion of these riders cited the lack of another mode as the reason for the choice of MPM. The reason cited by non-university related users, both choice and captive, indicated that a large proportion of their trips may have been made simply for the sake of riding the MPM.

Data were only available to allow the comparison of the relative ranking of the three modes, MPM, auto, and bus, for student respondents. Only one difference was noted between choice and captive riders' rankings of seven modal attributes. Student choice riders considered the MPM to be the best in terms of expense while captive riders rated the bus as the best. Both groups ranked the auto as the best in terms of reliability, comfort, time and pleasantness. The MPM was ranked as the best in terms of safety and convenience. By comparison the ranking of student auto users were identical to that of MPM users with one major exception. Student auto users ranked the auto as the best in terms of convenience.

The time of day during which the MPM trips were made was also compared for choice and captive riders. Only minor differences were noted between the travel time patterns of choice and captive riders for university related users. Approximately 50 percent of the university related MPM trips were made during the morning, mid-day, and evening peak periods. The large proportion of trips occurring outside the peak periods probably resulted from trips to meet class changes during the day (between 9 a.m. and 11 a.m. and between 1 p.m. and 4 p.m.). In comparison, a greater proportion of non-university related users traveled during the off-peak periods.

No major differences were noted between the wait times experienced by choice and captive MPM riders. Well over 80 percent of the MPM riders surveyed reported wait times of 5 minutes or less. This was comparable to the wait times experienced by Pre-MPM university bus riders; 87 percent reported wait times of 5 minutes or less.

No major differences were noted between choice and captive MPM riders trip purposes. Differences were expected and noted between different user groups' trip purposes. University related riders predominant trip purpose was school related. In contrast, non-university related users trips were predominantly for discretionary purposes, such as shopping, social/recreational, and other purposes. Only a small proportion, 3 to 5 percent, of the MPM trips made by students were for shopping or social/recreational purposes. Although student auto users predominant trip purpose was also school related, 15 to 18 percent of their trips were for the purpose of shopping. Another 18 percent of student auto trips were for other discretionary purposes. The data again indicated that MPM served primarily university oriented trips. It was noted, however, that slightly higher proportions of trips for shopping and social/recreational purposes were made by MPM in comparison to the Pre-MPM University Bus.

4.1.2 Phase I MPM Impacts Summary

User as well as provider impacts were examined. Impacts affecting Morgantown that were examined included traffic, environmental, and university/community impacts. Site specific impacts were also addressed.

4.1.2.1 Transit User Impact Summary - Transit users experienced general improvements in travel times from the previous University bus system. Transit running times were better in all cases due to the exclusive right-of-way operation of the MPM system. The greater access times experienced in some cases were the result of the limited operating vehicles available and the extent of the Phase I MPM system. Improvements are expected with the Phase II expansion increasing both the service area of the system as well as the operating fleet. A significant improvement in the accessibility to the Morgantown CBD to transit users was noted. User costs increased along with the increased level of service provided.

4.1.2.2 Transit Provider Impact Summary - The change in the composition of the labor force required to provide the transit service was noted to be the major impact to the provider, West Virginia University. With the MPM system completely automated, no vehicle drivers were required. The operation of the MPM system instead was the function of systems engineers and computer specialists. Due to unexpected problems encountered with the vehicles, the MPM maintenance staff was increased over original estimates. However, as the vehicles undergo modifications as part of the Phase II expansion, these problems are expected to be resolved and the size of the maintenance staff is expected to decrease. The magnitude of the O&M costs associated with the Phase I MPM system was the result of the incomplete nature of the Phase I MPM system. Although only after the Phase II system has reached maturity can the magnitude of O&M costs be reliably determined, it was noted that the existing Phase I trends indicated that the MPM O&M costs would be within the same order of magnitude as conventional transit systems. The projected O&M costs would also place Morgantown in the mid-range of other AGT systems O&M costs.

4.1.2.3 Traffic Impact Summary - Certain factors made it difficult to assess the impact of the Phase I MPM system on Morgantown traffic. Primarily, the limited extent of the Phase I MPM system coupled with the lack of transfer facilities for autos limited the extent to which the MPM system could provide relief to the traffic congestion on Morgantown's two major thoroughfares. Additional factors included the change in the composition of traffic, the change in the auto occupancy rate, the overall growth in the Morgantown area, the differences in the service areas, the availability of the MPM to the general public, the change in composition of the PMA population, and the change in the level of service.

4.1.2.4 Transit Modal Share Impact Summary - The comparison of transit modal utilization between the Phase I MPM systems and the Pre-MPM University bus systems was made on a MPM corridor basis as well as on a Primary Market Area basis. Differences in the service areas between the two systems were noted in this assessment and adjusted where possible.

On a corridor basis, average daily auto vehicle trips increased by 20 percent resulting in a 37 percent increase in auto person trips due to the increased auto occupancy rate observed. Average total daily transit ridership also increased by 46 percent. It was also noted that the Phase I daily transit total included average daily University bus shuttle ridership. Thus, a rider taking University bus to transfer to MPM and then riding MPM to a destination was counted as having made two transit trips. A similar trip in the Pre-MPM period, however, may have required only one University bus trip. Therefore, some incompatibilities between these two transit totals were apparent.

On a Primary Market Area basis, auto vehicles trips decreased by 27 percent resulting in a 17 percent decrease in auto person trips. Unadjusted transit person trips, however, also decreased by 12 percent. Since these totals were unadjusted for differences in the areas served by the two systems, they were not considered to be valid comparisons of the actual changes in transit trip making. The PMA transit total adjusted for service area differences resulted in an increase of 11 percent of transit person trips. Adjusting further, since the MPM system was avaiable to the general public, a three percent increase in transit person trips was calculated. Thus, the adjusted PMA transit modal share increased from 42 percent to 47 percent.

Changes in the transit modal share were also compared on an individual origin and destination basis. Zones containing MPM stations exhibited an increase in the modal share captured by transit. Mixed results from other O&D pairs coupled with the large proportion of O&D pairs that were incomparable due to differences in service areas prevented any conclusive assessment of the specific changes in the transit modal shares.

Changes in the transit modal share by time period were also compared. Differences in the service areas forced two comparisons to be made since no one comparison was intuitively better. The contrasting results of the two comparisons made it difficult to assess the changes in transit modal share by time period. It did appear that little or no change occurred for the time periods after 11 a.m.. Decreases in the transit modal share appeared to have occurred between 9 a.m. and 11 a.m.. It should be noted that data were not available to allow a comparison of the changes in transit modal share for the evening period of service. It was expected that significant gains in the modal share captured by transit would occur due to the much improved level of service offered by the MPM system.

4.1.2.5 Environmental Impacts Summary - Although the MPM system had not adversely impacted Morgantown in terms of air quality, noise, and other environmental considerations, improvements in the above areas resulting from the change in transit service were difficult to quantify. Although University bus traffic was eliminated, the increase in corridor traffic and the lack of data concerning the mix of vehicle types and their ages for the Pre-MPM and the Phase I MPM period prevented the analysis of whether air quality had improved. The limited data that was available on noise impacts indicated that the replacement of University bus traffic had accounted for a reduction in the community noise level.

4.1.2.6 Community Impacts Summary - The assessment of university/community impacts resulting from the Phase I MPM system was limited since these impacts occur much later than others. It was noted, however, that the locations of the new Engineering Library, the new Medical Center garage, and the new University Stadium were decided with the MPM system taken into consideration. Similarly, the locations of the new County Office Building and a 420 car parking garage near the Walnut Station were influenced by the MPM system.

4.1.2.7 Site Specific Impacts Summary - Impacts that were specific to the location of the MPM system in a university environment were also addressed. The pulsating demand pattern exhibited was one unique characteristic that was the result of the university environment. With MPM trips serving primarily university travel between the two campuses, five peak periods resulted. The atypical demand pattern resulted in operations that were atypical in urban transit systems. The MPM system operated on one schedule Tuesdays and Thursdays and on another Mondays, Wednesdays, and Fridays to match West Virginia University's class schedules. The multiple peaks of demand and the relatively short periods between peak and off-peak periods resulted in not changing the vehicle fleet size to match peak and off-peak conditions. Instead, the vehicle fleet was managed by essentially storing vehicles in the stations by allowing in-station dwell times to increase.

The Morgantown fare structure was another characteristic unique to this university environment. All full time students were required to pay as part of their registration fees a transportation fee. In return, a valid farecard was received. Thus, with the overwhelming proportion of trips being made by students, 95 percent of the riders of the system used pre-paid passes.

The experimental nature of the system and the uncertainty of its permanence generated impacts that were also site specific. The impact on the capital cost of the system was calculated in appendix B to be approximately one third of the total system cost.

The impact on ridership, however, could only be qualitatively addressed. The prolonged shakedown period required had a definite impact on ridership during that period. It was also apparent that some long term carry-over effect from this shakedown period on ridership existed.

Also, on a qualitative basis, the uncertainty of the permanence of the system impacted development potential around MPM stations. The atmosphere was a disincentive to investors contemplating commitments for development in the vicinity of the MPM system.

4.2 Transferable Lessons

4.2.1 Start-up Experience

The Morgantown start-up experience offers valuable lessons for the start-up of operations of new transit systems, especially DPM systems. As learned from the Phase I MPM start-up, a new transit system is likely to contain systems bugs that were not uncovered during the system testing and simulation of revenue operations, but that are quickly exposed when subjected to the rigors of actual wear and tear in passenger service. The more advanced the technology, the more exhaustive are the needed procedures for testing prior to passenger service.

This has strong implications for the initial operating period of DPM systems. Since the Morgantown system represents the first actual application of an AGT system to an urban area, it may be argued that the prolonged period required for the system to mature and reach stability will not be duplicated in DPM systems. However, even in the case of the initial operation of some heavy rail systems, such as BART and Washington Metro, with the use of proven technology, system bugs have contributed to highly unreliable service. The influence of poor service resulting from the initial system debugging period is quite evident from the Morgantown experience. Equally as important is the probable long term influence of the initial operating period on future ridership. Users lost because of unsatisfactory experiences with the initial operation may never seek to use the system even after the system has achieved its expected performance level. Since DPM systems can be expected to generally have a greater percentage of choice users than the Phase I MPM system, the importance of the length of the initial shakedown period is even greater.

The experiences with the fare collection system in the Phase I MPM system also have application to DPM systems as well as other transit systems. Although the use of farecards to eliminate both the need for station attendants and the need to have cash at the station is conceptually sound, the practical problems encountered with the farecard vending machinery for users without semester passes and with the turnstiles which rejected valid farecards are not acceptable. The problems with the fare collection machinery transcended those normally associated with the system start-up as indicated by the need for frequent maintenance of the fare collection system which continued past the stage when the MPM system had reached stability. Similar vexing problems with farecard machinery have also been experienced by Washington's Metro system with the problems being compounded by the need for almost all users to purchase farecards. This resulted in long delays caused by the queues of users at the one or two operational farecard vending machines and at the one or two operational turnstiles.

One lesson from Morgantown's experience with the Phase I fare collection system is that the expected benefits from one type of system must be weighed against the added maintenance required and the user inconvenience to be expected. It should be noted that the fare collection machinery is to be changed when Phase II of the MPM system is completed. The turnstiles have been changed to accept the semester passes as well as coins. This eliminates the need for the balky farecard vending machinery that were a major part of the problems associated with the Phase I fare collection system.

4.2.2 Urban/CBD Settings

Other experiences gained from the Phase I MPM system at Morgantown have similar applications to other potential installations in different urban and/or CBD settings. One important consideration is the passenger safety experience of the Morgantown MPM system and its implication for other applications of AGT techonology. With the conception of a transit system without station attendants or drivers, there has always existed a concern over the safety of the passengers of such systems. This was found to be the case in Morgantown. Prior to the introduction of MPM service, Morgantown residents were most concerned about its safety characteristics. The experience with the Phase I MPM system, however, indicated a complete change in that respect. Following introduction of MPM, people perceived the MPM system as being safer than either bus or auto.

One apparent reason for the absence of crime in the MPM system is that the majority of the riders are a homogenous group, WVU students, generally not inclined towards crime. An equally important reason is the closed-circuit TV surveillance provided for each station platform and the area around the fare gates. An emergency telephone is also located at each station that is accessible from both the paid and unpaid areas of the stations.

Further, a two-way radio with a link to central control is also located within each vehicle for emergency use.

Although these security features have served to provide Morgantown with a perfect safety record, additional security precautions should be considered in other settings. Not only should the platform and fare gate areas be monitored, but other station areas such as passage ways and stairs should also be under closed-circuit TV surveillance. The importance of maintaining a crime-free system without station attendants and drivers is one of the key implications of the Phase I Morgantown experience. Extrapolation of this security experience from Morgantown to large urban areas, however, is a major question which will be addressed in the DPM program.

In addition to the issue of safety from crime, other experiences from the Phase I MPM system in other areas of passenger safety should be noted. As previously noted, a barrier along the platform separates the passengers from the guideway and vehicles. Openings are provided in the barriers at the loading and unloading berths along the platform. These openings, however, also allow passengers to freely intrude onto the guideway. A number of incidents where passengers have stepped onto the guideway have been recorded in the system logs. Without station attendants or drivers in heavy rail transit systems, consideration should be given to the coordination of vehicle doors with platform doors to prevent the occurrence of these incidents.

Important implications as to the effect of station design on the functional performance of the station can also be obtained from the operating experience of the MPM system at Morgantown. With all of the Phase I MPM stations located in an open environment, the relative lack of protection from inclement weather conditions offered by the stations should be corrected in applications to other sites. It was noted that the passenger platform was open to the cold and wind during stormy weather. Additionally, water puddles and ice or snow accumulations indicate deficiences in the design of the station's all weather protection. Adequate consideration should be given to passenger protection from these conditions prior to station design. It should be noted that the relative lack of protection from inclement weather will be corrected as part of the Phase II construction.

The system graphics at Morgantown, while generally adequate for the Phase I system and primarily university oriented travel, would need improvements in an urban AGT system. The location of the Walnut station in the CBD to first time users is obscured by the lack of directional signs from Morgantown's main street. Clearly, stations for other urban applications such as DPMs should be distinctly signed. The system maps were noted to be graphically complicated with conflicting colors. The reflecting surface cover of the maps also made it difficult to read. Improved system maps with additional displays in both the paid and free areas, as well as in the vehicles are needed in typical urban settings where a variety of trips would be served.

The Phase I stations themselves offer useful insight to the design of stations for other urban settings. All of the Phase I stations have center island platforms which necessitate vertical access through central stairwells from underpasses or overpasses. The Morgantown stations are also designed with the intent of separating arriving passengers from departing passengers to provide directional flow. Consideration should be given to alternative platform designs with access from the side. In some cases, this would eliminate the need to negotiate the vertical transition to the platform level. Where opportunities exist for direct access from adjoining buildings, existing building stairs, escalators, or elevators may be incorporated into the station design, thus reducing station costs. Further, in typical urban applications where space is generally at a premium, bi-directional flow, though not as convenient as separated flow should be considered given the relative magnitudes of AGT passenger flows.

4.2.3 Travel Behavior

The analyses of choice travelers were conducted in order that potentially useful information may be extracted concerning the travel behavior of choice travelers of other AGT systems, especially future DPM systems. A disaggregate, behavioral mode choice model was calibrated to further enhance this transferability potential since biases resulting from the aggregate representation of travel behavior under localized conditions were avoided.

Certain factors should be noted prior to the extrapolation of results to other AGT systems. The mode choice model was developed from a sample of university students whose characteristics are relatively more homogenous than those of the population of potential riders of a DPM system. Although school related trip purpose was comparable to the home-based work trip purpose which would be more typical of urban travel demand studies, differences were apparent. Only three alternative modes were modeled: auto driver, auto passenger, and MPM. It is likely that DPM systems will have bus transit as an additional alternative mode. The model's potential transferability was also limited by the omission of out-of-pocket travel cost from the alternative modes' utility functions. Since it was expected that all university students had pre-paid semester passes, the perceived out-of-pocket cost of a single MPM trip was not intuitive. Thus, the significance of out-of-pocket cost was not tested. In a DPM setting, however, it is likely that out-of-pocket cost will be a significant factor in the individual traveler's choice of mode.

Nevertheless, the results of the analyses of travel behavior of choice travelers provided some preliminary indications of what may be expected for other AGT systems. The mode choice model developed was both statistically and conceptually valid. Coefficients that were significant had conceptually correct signs. RHO^2 was calculated to be 0.40 and 73 percent of the actual mode choices were correctly predicted using the model. The results indicated that total travel time was the most significant factor in the choice of the auto driver mode and MPM. MPM mode choice was highly sensitive to total travel time. A one percent increase in MPM total travel time resulted in a two percent decrease in the predicted usage of the MPM mode. Auto availability was noted as the most significant factor in the choice of the auto passenger mode.

APPENDIX A

PHASE I MPM SYSTEM AND SERVICE

A.1 Phase I MPM System Performance

This section describes the system performance of the Phase I MPM during its first years of operation from October 1975 through June 1978. Aspects of MPM performance discussed include levels of actual system functioning and comparisons with expected or capacity measures.

A.1.1 Reliability

Measuring the reliability of the Phase I MPM is complex because of the vehicle-system interdependence characteristic of People Mover or AGT type systems. For this reason, it is useful to examine three reliability measures to report the quality of MPM performance. These three reliability measures are analytical constructs derived from the relationship between several data sets. In addition to these three constructs, reliability can also be described using facets of system operation affecting a user. This reliability discussion concludes with an evaluation of PRT reliability based on operating characteristics related to users.

There are four reliability constructs commonly used to monitor People Mover system operation; they are conveyance dependability, system availability, and trip reliability. The TSC report on the operating, dependability, and maintenance history of the Phase I system reports the levels achieved by the Phase I MPM on these facets of reliability and their agreement with system design specifications developed by Boeing.

Conveyance dependability is defined as the product of system/vehicle availability and trip reliability (Boeing Aerospace Co., 1973). It captures the vehicle-system interdependence characteristic of MPM operations. System design specifications required a conveyance dependability of .96 with mean downtime not to exceed one hour, an academic year conveyance dependability of .967, and a conveyance dependability of .981 at system maturity (Boeing Aerospace Co., 1973).

The reliability measure, system availability, reflects the ratio of actual operating hours to scheduled hours.

The reliability measure, system/vehicle availability includes adjustment of system availability for the fleet size available relative to the demand of passengers.

The fourth reliability construct, trip reliability, is the ratio of trips between Beechurst and Engineering stations and the numbers of corresponding dispatches made (C. W. Watt, July 1979, p. 5). This measure is sensitive to the user's experience of riding without disruption. Due to the disproportionate volume of travel between these two stations, it is reasonable to express reliability only in terms of this link.

Table A-1 shows reliability levels since the initiation of passenger service. The three operating years show steady improvement for all reliability measures. Conveyance dependability met one of its specifications, a .96 level, during the third operating year. By contrast, trip reliability was high even in the first year and has continued to improve.

Because intense system usage occurs during the academic year, it is useful to focus on academic year reliability and reliability performance during the winter months (November - February). Note all three reliability measures during the third academic year approximately converge at the level achieved for the simultaneous operating year; this differs from previous years. However, conveyance dependability fell just short, in the third academic year, of the .967 specification.

A second result to note is that the winter months' differential declined markedly by the third year. Many MPM operating problems stemmed from winter weather; it appears that these weather related problems were nearly resolved by the third academic year.

It is also useful to examine MPM service characteristics which impact users. These are measures of service continuity or, alternatively, service disruption. These user-oriented measures locate the actual type and extensiveness of the system reliability problems. Table A-2 enumerates these measures and their change during the system's operating history. These reliability measures include mean daily incidence and duration of downtime or system failure, extensiveness of actual system operation versus scheduled operation, and actual vehicle utilization or fleet mileage.

Incidence and duration of downtime declined markedly since the MPM began passenger service. By the third operating year, the number of downtime events decreased 53 percent and their mean duration declined even more, 70 percent. Downtime events decreased even more by the third academic year, 57 percent, and their duration dropped 78 percent. It appears that the user's experience with system reliability was more positive by the third academic year.

TABLE A-1. RELIABILITY[1]

Reliability Measure	Operating Years[2] 1st. Oct 75-76	2nd. Oct 76-77	3rd. Oct 77-Jun 78	Academic Years[3] 1st. Oct 75-Apr 76	2nd. Aug 76-May 77	3rd. Aug 77-Apr 78
System Availability	87.7%	96.5%	97.4%	80.8%	94.9%	97.2%
System/Vehicle Availability	88.1%	96%	97%	79% (72)	93% (91)	96% (96)
Trip Reliability	98.9%	99%	99.5%	97% (95)	99% (88)	99% (99)
Conveyance Dependability	85.7%	99%	96%	78% (1)[4]	92% (90)	96% (95)

1. Data is from Procaccia, The Morgantown PRT File, 1978.
2. Operating years are defined as follows; year 1 is October 23, 1975 to October 22, 1976; year 2 is October 23, 1976 to October 22, 1977; year 3 is October 23, 1977 to June 30, 1978.
3. Academic years are as follows; October 23, 1975 to April 28, 1976, August 22, 1976 to May 7, 1977 and August 20, 1977 to April 30, 1978.
4. Numbers in parentheses are corresponding values for the winter months of November through February inclusive, omitting percentage signs.

TABLE A-2. SELECTED RELIABILITY COMPONENTS

Reliability	Operating Years			Academic Years		
	1st. Oct 75-76	2nd. Oct 76-77	3rd. Oct 77-Jun 78	1st. Oct 75-Apr 76	2nd. Aug 76-May 77	3rd. Aug 77-Apr 78
Mean Downtime Events Per Day	2.8	1.4	1.3	3.5 (4.4)	2.14 (2.1)	1.5 (1.6)
Mean Downtime Per Downtime Event Per Day	.44	.24	.13	.68 (87)	.36 (.54)	.15 (.15)
Mean Scheduled Hours Per Day	10	10.997	10	9.88 (9.8)	11 (11)	10 (10.7)
Mean Actual Operated Hours Per Day	9.8	10.5	10.8	9.1 (8.5)	10.37 (10.1)	10.7 (10.8)
Mean Fleet Mileage Per Day	1746	1722	1706	1486 (1379)	1991 (1845)	1931 (1916)

1. See footnotes 1, 2, 3, and 4 Table A-1.. Data is for a seven day week.

The number of hours the MPM was scheduled to operate, as compared with the hours actually operated, conveys system availability. The actual number of hours operated increased during each of the three operating and academic years. The number of hours scheduled varied by year, probably due to the scheduling of MPM for special campus events.

Fleet mileage by operating year declined over the three years; however, fleet mileage by academic year peaked in the second year and then remained level. This decline by operating years represented a better matching of vehicle dispatching to actual demand and a decreased need for testing of empty vehicles. It is likely that the MPM user would experience fleet mileage shifts as increased vehicle availability when service was requested.

The Phase I MPM showed marked improvement in reliability by the third operating year. Some, but not all, reliability specifications have been achieved and the remaining difference between reliability performance and goals appears small.

A.1.2 Frequency and Capacity

The utilization of Phase I MPM service is also addressed. Utilization of the Phase I MPM in spring 1977 is contrasted with utilization of the prior bus service in spring 1975.

Table A-3 compares MPM vehicle utilization with the prior bus service. This analysis assumes a MPM vehicle capacity of 21 and a bus capacity of 70.[10]

It is interesting to note the substantially higher daytime MPM vehicle utilization. This higher level reflects the MPM's capability to tailor service to meet demand. This capability results from its demand responsiveness and also from its smaller size vehicles which allow greater efficiency. By contrast, the bus data reflects service to the entire campus; inclusion of data for less densely traveled routes depresses the overall utilization rate and masks the over crowding that occurred on the bi-directional Campus-Towers route.

The analysis in Table A-3 highlights areas of high potential efficiency resulting from MPM operation. West Virginia University calculated that, at the MPM's 1976-1977 operating expense level, the cost per capacity passenger trip is $.16

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[10]Average bus in West Virginia University Fleet had 50 seats and a load factor of 1.4, yielding a capacity of 70 for calculation purposes.

TABLE A-3. VEHICLE UTILIZATION: PHASE I MPM VERSUS INTER-CAMPUS UNIVERSITY BUS [1,2]

Hours	Utilization	
	Phase I MPM	Inter-Campus University Bus
8 - 9	.25	.09
9 - 10	.36	.11
10 - 11	.38	.12
11 - 12	.34	.09
12 - 1	.36	.12
1 - 2	.36	.12
2 - 3	.29	.10
3 - 4	.25	.10
4 - 5	.17	.07
Weekday Mean	.31	.10

1. Vehicle utilization is calculated as follows; number of vehicles dispatched per hour x vehicle capacity divided by number of passengers per hour. Data is for 5 weekdays for MPM and 4 weekdays for bus, but average weekday value is entered in calculation.

2. Data used in analysis is from Elias, Samy E. G., et.al. PRT Impact Study, Operational Phase and Pre-PRT Phase, Volume I, p. 49 f.f. and 52.

(Elias, Samy E. G. et. al., The Phase I MPM Impact on Morgantown Travel, Traffic and Associated Activities, p. 52). Therefore, if it is possible to fine-tune MPM system operation to respond to demand, operating cost levels could be very low.

A.1.3 Expected and Actual Performance

The discussion of the Phase I MPM performance will address actual and expected performance levels. Table A-4 shows the Phase I MPM's performance from October 1975 through June 1978, by operating and academic years. Additionally, this table reports performance measures for an average weekday; selection of a weekday focus permits examination of service characteristics when the system was providing maximum output.

The first performance measure included, conveyance dependability, was discussed in Section A.1.1; it is presented in Table A-4 using weekday baseline data. Although the mean weekday conveyance dependability increased steadily through the operating and academic years, 13 percent and 19 percent respectively, it was not unil the second operating and the second academic years that perfect (1.00) weekday conveyance dependability was reported. Finally, conveyance dependability attained a weekday average exceeding the specification of .96 in the third operating year. However, the academic year specification of .967 had not been attained for the mean academic weekday by the end of the third operating year.

Comparison of mean scheduled with actual operating hours shows the success of system operation. System specifications call for a 13.25 hour long weekday operation; this was scheduled in the second operating year but reduced in length during the third year. However, by the third operating and academic years, actual operating hours averaged very close to, or even longer than, scheduled hours. It is clear that the Phase I MPM was able to deliver its expected or scheduled daily quota of service by the third year of operation.

The three downtime measures show a considerable decline during the three year period; mean downtime per event declined 62 percent and 68 percent for the operating and academic years, respectively. Other downtime measures declined by similar or greater proportions. Additionally, the downtime specification of mean downtime per event equalling less than one hour has been achieved by the system (Boeing Aerospace Co., 1973).

It is interesting to note that the mean number of vehicles operated per weekday was relatively unchanged during the three year time span. Although a total of 45 vehicles were delivered, only 29 vehicles were used in the operational fleet. Seven

TABLE A-4. MPM PERFORMANCE MEASURES-WEEKDAYS

Performance Measures [1]	Operating Years [2] 1st. Oct 75-76	Operating Years [2] 2nd. Oct 76-77	Operating Years [2] 3rd. Oct 77-Jun 78	Academic Years [3] 1st. Oct 75-Apr 76	Academic Years [3] 2nd. Aug 76-May 77	Academic Years [3] 3rd. Aug 77-Apr 78
System Availability	.901	.954	.970	.840	.933	.967
Conveyance Dependability	.86	.94	.97	.80	.91	.95
Mean Scheduled Operating Hours Per Day	11.98	13.25	12.16	11.8	13.2	12.2
Mean Actual Operating Hours Per Day	11.7	12.63	12.23	11.03	12.3	12.2
Mean Downtime Per Downtime Event Per Day	.42	.32	.16	.60	.45	.19
Downtime Per Day	1.35	.67	.37	2.09	1.03	.40
Number of Downtime Events Per Day	3.5	1.8	1.6	4.2	2.8	1.9
Mean Number of Vehicles Operated Per Day	17.8	17.0	17.45	16.3	19.9	18.8
Fleet Mileage Per Day	2128	2171	2127	1797	2478	2433

1. Data is from analysis of Procaccia, The Morgantown PRT File, 1978.

2. Operating years are defined as follows; year 1 is October 23, 1975 to October 22, 1976; year 2 is October 23, 1976 to October 22, 1977; year 3 is October 23, 1977 to June 30, 1978.

3. Academic years are defined as follows: 1975-1976 is October 23, 1975 to April 28, 1976; 1976-1977 is August 22, 1976 to May 7, 1977; and 1977-1978 is August 20, 1977 to April 30, 1978.

vehicles were used as "spares" during normal operation. The remaining 16 vehicles were stripped for parts to keep the operational fleet functioning (N. D. Lea Associates, 1978). This obviously restricted the possibility of enlarging the vehicle fleet; it also hampered system responsiveness to peak period demand. As a result, passenger queueing during peak demand periods due to an inadequate number of operating vehicles in the fleet was observed.

Finally, mean weekday fleet mileage appears to have been relatively constant during the operating years but grew and stabilized by the third academic year. This data must be reviewed recognizing that, in the initial days of system operation, fleet mileage was often accrued for testing purposes, rather than to meet passenger demand.

A.2 Phase I MPM Service Characteristics

This section describes the service provided by the Phase I MPM during its initial two and one half years of passenger service. In order to provide a comparative baseline, MPM service is contrasted with that provided by the MPM's predecessor, the West Virginia University Inter-Campus University Bus (U-bus), whenever there is sufficient comparable data. Although the technological characteristics of the bus and the MPM differ by orders of magnitude, the comparison is a useful way to convey the experience base of the MPM system user.

This presentation focuses on seven service characteristics; they are presented in the following order: comfort, convenience, service availability, safety, user cost, special user service, and perceptions or attitudes toward service features. The discussion in Sections A.2.1 through A.2.6 presents objective measures of service by themselves, as they change over time, and by comparison with measures for alternative modes, principally, the former bus service and the automobile. The discussion then turns to the perceptions or attitudes towards these service characteristics; perceptions provide the personal significance of these characteristics. Finally, the consistency between objective and subjective service characteristics is explored.

A.2.1 Comfort

MPM comfort is measured as vehicle crowdedness or seat availability. This measure was selected because vehicle crowding was a frequent occurrence on the MPM's predecessor, U-bus, and, particularly on its Campus Drive-Towers route which corresponds to the Beechurst-Engineering link of the Phase I MPM.[11] Crowding is thus a comfort measure relevant to the MPM user's prior inter-campus travel experience. Additionally, a crowding comfort measure is salient to the MPM's operational capability which includes the ability to adapt readily to system usage by flexible adaptation of the vehicle dispatching patterns to changing demands.

For this discussion, MPM load factor has been calculated in two ways; first, based on the vehicle's 8 person seating capacity and second, based on the vehicle's total 21 person capacity which includes standees. Regardless of the calculation selected, Table A-5 shows that the MPM load factor increased rapidly during its three academic years of operation and in the third year exceeded the conventional urban transit load factor of 20-25 percent.

It is interesting to compare the MPM's load factors with those calculated for the prior bus service for a similar spring time period. To compare, an average bus seating capacity of 50 is used and a total capacity of 1.4 times greater than the seating capacity is assumed. The MPM begins to approach the 1974-1975 bus load factors by the third year of operation.

In academic year 1976-1977, the buses were reconfigured into a MPM shuttle service and the fleet size was halved. Load factors dropped markedly, indicating extensive use of the walking mode for access to MPM service.

Load factors by MPM link show the differential usage of the links. The bi-directional Beechurst-Engineering link accounts for 85 percent of passengers and 52 percent of vehicle trips. Tables A-6 and A-7 highlight these comparisons using capacity and seat defined load factors, respectively.

In Table A-6, data for the second operational year data reveal the wide variation in load factor by link, from 6 to 54 percent. However, data for an April week in that year reveal a narrower load factor range, 10 to 40 percent. The spring semester records lower campus enrollment and, thus MPM usage. Perhaps due to a seasonal pattern, there appears to be relatively more downtown or Walnut station trips.

Finally, Table A-7 compares MPM and bus load factors using seating capacity. The strong trip symmetry between Beechurst and Engineering is recent and did not appear so prominently when the bus was operating. This suggests the formation of new travel patterns.

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[11]Elias, Samy E. C. et. al., PRT Impact Study, Pre-PRT Phase, Volume I p. 40.

TABLE A-5. COMFORT BY MODE - LOAD FACTOR COMPARISONS[1]

Academic Year [2]	MODE: Phase I MPM Seat [3]	Phase I MPM Capacity [3]	Inter - Campus University Bus Seat [3]	Inter - Campus University Bus Capacity [3]
1977 - 78	91% [4]	35% [4]	N/A [5]	
1976 - 77	68%	26%	15%	11%
1975 - 76	37% [4]	14% [4]	N/A [5]	
1974 - 75	N/A [5]		60%	43%

1. Load factor is calculated as:

$$\frac{\text{No. of passengers/weekday}}{\text{No. of vehicles dispatched/weekday x Seats or Capacity}}$$

2. Academic year runs from late August through May 1, approximately. Specific dates for each year are contained in Table A-4.

3. MPM seats = 8, Capacity = 21. Bus seats average 50, capacity = 70.

4. These load factors are interpolated as follows due to data limitations. The 1976 - 1977 ratio between mean weekday vehicle availability and occupied vehicles dispatched (April 4-8, 1977) is used to establish the ratio between vehicle availability and dispatch rate for 1977-1978 and 1975-1976. The interpolated dispatch rate is multiplied by the seat capacity measure. The resultant total number of seats or capacity is divided into mean weekday passengers as shown in footnote 1.

5. N/A refers to data not available.

TABLE A-6. COMFORT LINK BY MODE - LOAD FACTOR COMPARISONS BASED ON VEHICLE CAPACITY*

Link	Phase I MPM Operating Year 2	April 77	Inter - Campus University Bus April 1975
Walnut-Beechurst	6% [1]	21%	N/A
Walnut-Engineering	14%	17%	N/A
Beechurst-Walnut	9%	7%	N/A
Engineering-Walnut	11%	10%	N/A
Beechurst-Engineering	54%	40%	66% [1,2]
Engineering-Beechurst	51%	39%	42% [1,2]

* See definition, Table A-5.

1. This assumes a bus capacity of 70, comparable to PRT capacity of 21.

2. Data is for Campus Drive - Towers route.

TABLE A-7. COMFORT LINK BY MODE - LOAD FACTOR COMPARISONS BASED ON VEHICLE SEATING*

Link	Phase I MPM April 1977	Inter - Campus University Bus April 1975
Walnut-Beechurst	13%	N/A
Walnut-Engineering	44%	N/A
Beechurst-Walnut	20%	N/A
Engineering-Walnut	25%	N/A
Beechurst-Engineering	104%	93% [1]
Engineering-Beechurst	102%	58% [1]

* See definition, Table A-5.

1. Data is from Towers-Campus Drive Route.

There appear to be marked variation in load factor by MPM segment. Also, the MPM was able to adapt to the high travel volumes between certain points eliminating the overcrowding problems of the prior bus service.

A.2.2 Convenience

The convenience of the Phase I MPM is measured in terms of travel time improvement offered over the prior bus and auto alternatives. Travel time is described in three ways: total travel time which is the time of travel in minutes between fixed destinations, vehicular miles per hour or in-vehicle travel time, and out of vehicle travel time or wait time.

The MPM's total travel time was lower than the auto alternative and that of the prior bus system (See Table A-8). This comparison includes in-vehicle as well as walk and wait times; the total auto travel time incorporates a factor for locating a parking space.[12] The analysis measures total travel time between destinations or zone pairs in which there is located a MPM station.

In analyzing total travel time, it should be noted that automobile travel time between MPM stations increased over the period from 1975 and 1977 following the introduction of MPM passenger service. Several exogeneous factors may have caused this automobile travel time increase. One factor may have been the institution of a TOPICS programs in the downtown which facilitated continuous traffic flow by rerouting to one-way streets and increased traffic signalization. Also Average Daily Trips (ADT) in the area increased 20 percent during this time suggesting increased congestion. Finally, the area experienced growth in regional shopping centers immediately outside the city limits.

It is clear that by 1977, the Phase I MPM offered a considerable time advantage over the automobile, even including MPM walk and wait time. The MPM also offered a time advantage over the prior bus service.

It is also useful to compare in-vehicle travel time by mode. This is expressed as travel time in minutes and as miles per hour (see Tables A-9 and A-10). Due to the degradation in auto travel time between 1975 and 1977, Phase I MPM vehicle travel time appears to replicate earlier auto travel time. Bus travel times

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[12]Elias, Samy E. G. et. al., PRT Impact Study, the Phase I PRT Impact on Morgantown Travel, Traffic and Associated Activities, p. 33-35.

TABLE A-8. TOTAL TRAVEL TIME BY MODE (IN MINUTES)[1]

Link	Phase I MPM (1977)	Automobile (1977)	Automobile (1975)	Inter- Campus University Bus (1975)
Walnut-Beechurst	4.6	19.7	10.7	N/A [2]
Beechurst-Walnut	4.6	19.7	10.7	N/A
Walnut-Engineering	10.4	16.8	15.6	16
Engineering-Walnut	11.7	28.6	18.6	20
Beechurst-Engineering	11.2	14.2	13.3	9
Engineering-Beechurst	9.8	26	16.3	15

1. This Table is adapted from Table V-2, Elias, Samy E. G., et al, PRT Impact Study; The Phase I Impact on Morgantown Travel, Traffic, and Associated Activities, p. 33. Additional entries in this Table are based on data reported in Pre-Impact Study, Operational Phase.

2. N/A indicates data not available.

TABLE A-9. IN-VEHICLE TRAVEL TIME BY MODE (IN MINUTES)[1]

Link	Phase I MPM (1977)	Automobile [2] (1977)	Automobile [2] (1975)	Inter- Campus [3] University Bus (1975)
Walnut-Beechurst	2.5	N/A	N/A	N/A
Beechurst-Walnut	3.0	N/A	N/A	N/A
Walnut-Engineering	6.7 (6.95)	N/A	6.51	7.17
Engineering-Walnut	7.1	N/A	9.75	7.71
Beechurst-Engineering	5.1 (5.25)	7.13	5.16	8.86
Engineering-Beechurst	5.1	9.93	7.72	6.77

1. Sources: MPM data in parentheses are Boeing's measurements which include time required to close vehicle doors. Automobile and MPM data from Elias, Samy E. G. et. al., PRT Impact Study, Operational Phase, Volume 1. p. 21, 28, 29 and Pre - PRT Phase, Volume II p. 23. Bus data from Elias, Samy E. G. et. al., PRT Impact Study, Pre - PRT Phase, Volume I, p. 54.

2. Equivalences are assumed as follows: Mountainlair to Towers and vice versa is assumed equivalent to Beechurst to Engineering. Walnut to Coliseum and vice versa is assumed equivalent to Walnut to Engineering link.

3. Equivalences are assumed as follows. Campus to Towers and vice versa is assumed equivalent to Beechurst to Engineering.

TABLE A-10. VEHICLE SPEED BY MODE (MILES PER HOUR)[1]

Link	Phase I MPM (1977)	Automobile [2] (1977)	Automobile [2] (1975)	Inter- Campus [3] University Bus (1975)
Walnut-Beechurst	N/A	N/A	N/A	N/A
Beechurst-Walnut	9.5	12.92	16.34	N/A
Walnut-Engineering	17.8	19.35	17.57	N/A
Engineering-Walnut	N/A	N/A	N/A	N/A
Beechurst-Engineering	18.6	12.62	18	14.2
Engineering-Beechurst	N/A	9.06	11.25	12.4
Mean Number of Vehicles Operating	17.5	-	-	13

1. Sources: Bus data from Elias, Samy E. G. et. al., PRT Impact Study, Pre - PRT Phase, Volume I, p. 54. Auto and MPM data from Elias, Samy, E. G. et. al., PRT Impact Study, Pre - PRT Phase, Volume II, p. 21, 23, 28, 29 and the Phase I PRT Impact on Morgantown Travel, Traffic, and Associated Activities, p. 34.

2. See footnote 2, Table A-9.

3. See footnote 3, Table A-9.

in 1975 were both better and worse than auto times depending on the link traveled. The limited data suggest that, in all cases, MPM travel time is superior to that of the prior bus service.

Table A-10 shows that the MPM had a speed advantage over both the auto and the bus on most links. This advantage has increased due to the marked decline in auto speed since 1975. The MPM speed in 1977 was actually only slightly better that 1975 auto speeds; but auto speed declined in that time period, thereby, enabling the MPM to have the clear speed advantage.

Wait time is the final aspect of travel time convenience examined. Wait time is determined by a combination of scheduled and actual headways as well as the mode's reliability.

Perceived wait time for both bus and MPM riders was similar; in 1975, 87 percent of the bus riders reported waiting less than 5 minutes and 86 percent of the MPM users reported a similar wait in 1977. More specifically, on the Beechurst-Engineering MPM link, a similar 86 percent of the MPM riders report a less than 5 minute wait. This link transported 85 percent of all Phase I MPM riders and accounted for 52 percent of the vehicles dispatched. Thus perceived wait time seems relatively constant despite differences in headways by mode.

The Phase I MPM offered more convenient service in terms of total travel time, in-vehicle time, and operating speeds. Concurrent with the introduction of MPM service, travel time in the area worsened, highlighting the MPM's advantage due to its reserved right of way. Yet, perceived wait time seems to be relatively constant over time. This suggests that platform crowding due to incomplete stations may have been responsible for this incongruent perception rather than actual service availability.

A.2.3 Service Availability

MPM service availability is evaluated using two measures; headway or frequency of service per unit of time, and density of service per unit of population or geographic area. Headway measures both the scheduled and actual delivery of service per unit of time. Headway measures are presented for the entire MPM system and by link in order to portray the range of service density offered.

Systemwide, the Phase I MPM averaged 1,172 occupied dispatches per weekday between 8 A.M. and 5 P.M.; this is equivalent to a systemwide headway of 27.2 seconds.[13] (See Table A-11). MPM system headway per line averaged 1.4 minutes. By contrast, the prior U-bus service operated on actual system-wide headways of 1.6 minutes and, for the links or routes comparable with the MPM, 2.3 minutes. It should be noted that the bus service had actual headways 6 to 8 percent more frequent than scheduled.

Examining headways by link shows that the Beechurst-Engineering segment had markedly more frequent average headways than other links corresponding to its more frequent use; these headways were 16 percent lower than the other links.[14] Additionally, the MPM service on this link is markedly better than the prior bus service, approximately 275 percent more frequent than the pre-existing bus headways.

Actual MPM headways have been verified. A maximum dispatch rate between Engineering and Beechurst of 72 vehicles per hour or one vehicle every 50 seconds during peak demand was recorded. In addition, empirical verification of the system design specification of 15 second headways was recorded.

It is clear that the Phase I MPM system was able to meet its design specifications for headways and to offer significantly more service than the prior bus service. It appears that any difficulties in maintaining such frequent headways stemmed from the insufficient berthing capacity at the Engineering station and the occasionally inadequate number of operating vehicles to meet demand.

Availability can also be measured by analysis of density of service per unit of population or area. During the second operational year (October 1976 - October 1977), the Phase I MPM system served a 2.33 square mile area including shuttle bus feeder routes. Assuming an average vehicle availability of 17.5 for the second operational year, there were 7.5 vehicles per square mile. Using the ridership figures for the second operational year, the resultant demand was 560 person trips/square mile/hour per weekday.

The West Virginia University report (1978) indicates that the Phase I MPM has fairly well saturated its immediate service area. The Phase I service was available to 38 percent of the

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[13]This discussion is based on MPM operating data for April 4-8, 1977 reported by Elias Samy E. et. al. PRT Impact Study, Operational Phase.
[14]Note that these are calculated average weekday headway based on daily data.

TABLE A-11. HEADWAYS - PHASE I PRT VERSUS INTER-CAMPUS UNIVERSITY BUS[1]

–MODE

Link	Phase I MPM	Inter - Campus University Bus
Walnut-Beechurst	3.0 Minutes	N/A
Beechurst-Walnut	3.2 Minutes	N/A
Beechurst-Engineering	1.2 Minutes	4.7 Minutes (5.1)[2]
Engineering-Beechurst	1.3 Minutes	4.4 Minutes (5.0)
System	27 Seconds	1.6 Minutes (1.7)
		2.3 Minutes (2.5) *

1. Headways are calculated as follows: actual number of vehicles dispatched between 8 am and 5 pm weekdays divided per unit of time.

2. All numbers in parentheses are scheduled headways. Data is from April 4-8, 1977, reported by Elias, Samy E. G. et al, PRT Impact Study, Operational Phase.

* These refer to only bus routes equivalent to the Phase I MPM route structure.

urban area population and more than half of those served were riders, 59 percent (Elias, Samy E. G. et. al. The Phase I Impact on Morgantown Travel, Traffic, and Associated Activities, p. 32). This rate of the MPM utilization within the service area represents an increase over the prior bus utilization due to its more extensive and denser service.

Whatever availability measure used, it is apparent that the Phase I MPM was well integrated into its service area despite its limited and university oriented destination set. The Phase II expansion will result in a marked increase in availability due to the expanded geographic area and mix of destinations. It is likely therefore, that usage should have a correspondingly large jump.

A.2.4 Safety

Safety as a MPM service characteristic has two aspects which are discussed separately. They include the safety of the operating MPM system itself and the security of the MPM passenger from incidents of crime or violence.

The MPM system appears to have operated very safely. There was only one minor passenger injury during the first operational year, October 1975 to October 1976. West Virginia University, reporting on the operational history of the Phase I system for three academic years, stated that the "safety record of the system is unblemished with regard to accidents involving system patrons." (The Phase I MPM Impact on Morgantown Travel, Traffic, and Associated Activities, p. 44).

Finally, passenger security on the MPM also has been very good. Passenger security provisions may have contributed to this good record. The Phase I MPM was equipped with several overlapping surveillance measures designed to enhance security including continuous closed circuit television monitoring of stations and emergency telephones in stations and vehicles. Additionally, the MPM operator had, at all times, the capability of overriding destinations and rerouting distressed vehicles to a station or siding where a proper response was available.

In terms of incidents of crime or violence, no incidents of vandalism or assault were reported during the first operational year. West Virginia University stated that there were five incidents of "passenger misbehavior in the first two and one half years of operation" through spring 1978 (MPM Impact Study, The Phase I MPM Impact on Morgantown Travel, Traffic, and Associated Activities, p. 45). It should be noted that no occurrence of the type of victimization and crime predicted to accompany urban installations of the generic AGT systems was reported.

A.2.5 User Cost

In order to gauge the financial burden of MPM service to users, it is useful to analyze the user cost impact of the Phase I MPM in contrast with the prior bus system cost. Phase I MPM costs were most frequently borne as a fee payable by all full time students at semester registration. The fee was $15.00 for the spring semester of 1977. There was also a one time fare of 25¢ for all non-fee payers; however these other system users could voluntarily pay a fee to obtain a pass.

The Phase I MPM was open to the public. This contrasted with the prior bus service which was available to students upon payment of a fee and was free to faculty and staff upon presentation of a university identification.

The user cost per trip is calculated from the fee structure. Assuming a fifteen week semester, the fee payer's usage cost per weekday was 20¢ or 14¢ for the seven day week. By contrast, the U-bus user's fee was $4.25 per semester in spring 1975 which resulted in a comparable weekday user cost of 6¢ and 4¢ for the seven day week.[15] The 1977 fee increased weekday cost 233% and daily usage cost, 250%.

However, these increased user costs must be interpreted with qualifications. The increased cost was accompanied by significant improvements in service.

For example, MPM service frequency during peak and off-peak hours was much greater than was provided by the prior bus service. Only one bus provided service to the entire campus after 5 P.M. on weekdays; this bus made a circuitous campus-wide route. By contrast, the MPM offered service in the demand mode during off-peak hours. The significance of this service differential is shown in that 4 percent of the weekday bus ridership occurred after 5 P.M., whereas 8 percent of the MPM ridership was so distributed.

Travel time was another aspect of the improved service offered by the MPM. This was described in Section A.2.2. The MPM's improvement in travel time over the prior bus service was part of the improved service associated with the MPM.

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[15]Assuming an annual 8% inflation rate, $4.25 is equivalent to $4.96 in 1977, yielding per weekday and daily costs of 7¢ and 5¢. The 1977, MPM fee represents adjusted user cost increases of 186% and 280% respectively.

A.2.6 Service to Special Users

An important aspect of the evaluation of the Phase I MPM is how it meets the needs of mobility limited population sub-groups, in particular, the elderly and handicapped.

There is no apparent reason to assume that elderly status is incompatible with MPM usage assuming an able-bodied elderly population. However, the distinctly campus-oriented service provided by one Phase I MPM is much more likely to account for the low frequency of elderly usage. The youth bias among MPM users can be attributed to the university orientation of the Phase I MPM system. One might expect that the skewed age profile of the MPM user will alter when the Phase II opens, due to its service to the Medical Center, a major regional employer and treatment center.

The Phase I MPM was not designed to have, nor does it offer, service features encouraging use by the handicapped. However, certain features were included in the Phase I system specifically with the handicapped user in mind. The MPM vehicles were designed with entrances sufficiently wide for wheelchair access. Despite this, the Phase I system was not available to non-ambulatory passengers due to a decision to defer elevator installation in stations until the Phase II construction (Elias, Samy E.G. et. al, the Phase I MPM Impact on Morgantown Travel, Traffic, and Associated Activities, p. 45).

It should be noted that even the present limited availability of the Phase I MPM system to handicapped users represented an improved level of service over the prior bus service which had no special features for handicapped users.

Finally, the hilly terrain of Morgantown and the campus might discourage a handicapped student from attending this university. There are other state colleges in West Virginia which have less forbidding terrain and, according to local sources, are more attractive to handicapped students.

A.2.7 Perceived MPM Service

Having presented and analyzed objective measures of MPM service, it is also useful to evaluate how MPM service is perceived by people. It is important to understand also how the perceived service attributes are related to objective, measurable attributes; decisions on system use are made by individuals using their perceptions of service. Perceptions of MPM service in terms of its comfort, convenience or travel time, service availability or access, safety, and cost are discussed. In addition, available data on overall satisfaction are presented.

In general, people perceive the MPM vehicles as comfortable; specific areas of discomfort relate to the crowded platform area due to the incompleteness of the Phase I system and vehicle bumpiness. However, when MPM comfort is contrasted with the comfort provided by the auto and bus modal alternatives, the MPM takes second place; the auto is rated most comfortable and the bus least comfortable[16] It is also interesting to note that non-users of the MPM also perceive that the MPM provides a comfortable ride. Despite their lack of experience and exposure to negative publicity about the MPM; non-users share a similar perception of the MPM's comfort.

People report mixed perceptions of the MPM's convenience; convenience is most often used as a summary term conveying reliability, short travel time, and station location close to desired destinations. It appears that the MPM was most frequently negatively perceived due to its unreliability. Analysis of the data shows that 61 percent of the riders and 87 percent of the non-users rate the auto as more convenient than the MPM.

It should be noted that MPM usage was associated with people's perceptions of its convenience. The MPM users rated MPM higher on convenience than did the non-users. However, non-users with a higher income or who were younger were more critical of the MPM's convenience.

MPM service availability, was measured as perceived accessibility. Frequency of system usage does not differentiate between perceived accessibility. Most people reported that a one quarter mile distance to a station was the maximum acceptable walk.

People were asked their perception of the cost of MPM system usage and results were mixed. Generally, respondents thought the fare and fee structures were not excessive. However, examination of the data shows that riders and non-riders appear to perceive the MPM user cost quite differently. MPM riders rated the MPM as less expensive to use than the bus or auto. Non-riders rated the auto and the bus as cheaper to use; this difference was not due to student status or auto availability. One interpretation of this divergence is that users and non-users were rationalizing previous personal decisions regarding MPM usage on the basis of perceived cost.

The MPM is perceived as very safe. People use the MPM without fear of victimization or being injured by the system

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[16]Most data discussed in Section A.2.7 are from West Virginia University, MPM Impact Study, Operational Phase.

(West Virginia University, MPM Impact Study, Operational Phase I, Volume I, draft, p.46). Indeed, MPM riders perceive the MPM as safer than the auto or the bus mode.

Most of people perceive the MPM system as aesthetically pleasing. Relative to alternative modes, MPM riders selected the auto as most pleasant. The MPM takes second place and the bus last place. This suggests that the visual and personal experience of using the MPM is quite satisfactory.

APPENDIX B

MPM SYSTEM FINANCES

B.1 Capital Cost

The Morgantown project has had a history of increasing cost estimates and reductions in the scope of the system. This is in part due to the original estimates not having been based on detailed engineering design data, the unprecendented nature of the Morgantown system, the highly politicized atmosphere surrounding the project, and unforeseen implementation problems. Several studies have dealt with these cost estimates and overruns (see N.D. Lea Associates, Inc., and U.S. General Accounting Office Studies).

The original 1970 West Virginia University Board of Regents submission of a capital grant application was for 13.5 million dollars which represented the Federal share of the then estimated 18 million dollars needed to design, construct, and demonstrate a 6-station, 90 vehicle People Mover System in Morgantown. Since this cost estimate was made without the benefit of detailed engineering data, subsequent cost estimates were more realistic as more refined data were developed. The history of these estimates is documented in Table B-1 along with the changes in scope of the system. The final expenditure for a 3 station, 2.1 mile, 45 vehicle system was 57.9 million dollars (1976 dollars) with the expenditures taking place over a five year period, 1971 to 1975.

The actual capital cost of the Phase I MPM system can be separated into seven cost categories identified as follows:[17]

a. Vehicles - The rolling stock.

b. Guideways - The vehicle roadway including: site preparation, foundations, supporting structures, running and guidance surfaces, wayside switching equipment and special facilities for melting snow and ice.

c. Stations - Passenger loading platforms, shelters, access facilities such as ramps, stairways, escalators, elevators, graphics, fare collection equipment,

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[17]N.D. Lea and Associates, Inc., Summary of Capital and Operations and Maintenance Cost Experience of Automated Guidway Transit Systems - June 1978, p.3.

TABLE B-1. MPM SYSTEM COST EXPERIENCE[1]

Date of Estimate	8-15-70	4-1-71	4-29-71	9-27-71	10-15-71	2-11-72	1-1-75	1-1-75
Federal Share Excluding Support Costs (Millions)	13.5	37.1	23.4	40.6	27.4	36.9[a]	40.4[b]	59.9[c]
Estimator	University	JPL	JPL	Boeing	Boeing	Boeing	Boeing	Boeing
Stations	6	6	3	3	3	3	3	3
Guideway Miles	3.6	3.6	2.2	2.2	2.2	2.2	2.2	2.2
Number of Vehicles	90	100	15	15	10	5	5	45
Passenger/Vehicle	4-6	9	15	17	21	21	21	21

a) Original 1A contract estimate

b) Actual 1A costs

c) 1A and 1B estimate

[1] Table adapted from USGAO Staff Study, The Personal Rapid Transit System, Morgantown, West Virginia; April, 1975.

coordinated doors and other facilities related to the the movement of passengers into and out of vehicles.

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

e. Power and Utilities - Electric power transformers, feeders, switch gear, wayside power rails and normal housekeeping power equipment.

f. Maintenance and Support Facilities - Maintenance and repair shops, including such equipment as emergency vehicles.

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

The actual capital costs for each of these seven cost categories are listed in Table B-2.

The experimental nature of the Morgantown system and the accelerated schedule imposed on its implementation (so that the highly visible demonstration project would be in operation prior to the 1972 presidential election) increased its costs.. To account for these factors, a study by N.D. Lea and Associates, Inc. estimated the replacement cost for a duplicate installation. The capital cost expenditures by the seven cost categories detailed above were adjusted for costs associated with research and development. Costs due to design corrections and overdesigns resulting from the accelerated schedule were also deducted. For example, an estimate of the additional cost incurred from overdesigning the guideway structures to provide sufficient guideway strength to employ heavier vehicles than were eventually used was deducted from the guideway cost. Similarly, the accelerated schedule resulted in design changes due to an inadequate number of soil samples having been taken. These costs were appropriately deducted. The analysis estimated the unescalated replacement cost to be approximately 45.1 million dollars. Thus, about one-third of the actual cost can be attributed to research and development costs and schedule acceleration costs. The discussion to follow on the Phase I Morgantown MPM will use the replacement cost as the capital cost of the system.

While the Morgantown replacement capital costs are in general within the range experienced by other systems, they tend to be at the high end of the range. Table B-3 presents a summary of the capital costs of ten automated guideway systems. When

TABLE B-2. CAPITAL COST OF PHASE I MORGANTOWN MPM[1]

	ACTUAL COST	REPLACEMENT COST
	(all cost figures are in 1976 dollars)	
VEHICLES	8,970,000	7,074,000
GUIDEWAYS	19,100,000	14,546,000
STATIONS	2,550,000	1,982,000
CONTROL & COMMUNICATIONS	10,200,000	7,983,000
POWER & UTILITIES	2,710,000	2,066,000
MAINTENANCE & SUPPORT EQUIPMENT & FACILITIES	1,060,000	822,000
ENGINEERING & PROJECT MANAGEMENT	13,300,000	10,624,000
TOTAL	57,890,000	45,097,000

[1]Table adapted from N. D. Lea Associates AGT Summary Report

TABLE B-3. AGT CAPITAL COST SUMMARY[1]

	MORGANTOWN PHASE I	AIRTRANS	JETRAIL	CABINLIFT	TAMPA	SEA-TAC	HOUSTON	FAIRLANE	VEDWAY	KING'S DOMINION
VEHICLES										
NUMBER & CAPACITY	29 (21 PASS EA.)	31 (40 PASS. EA.)	10 (10 PASS. EA)	6 (12 PASS. EA.)	4 (1[illegible] PASS. EA.)	12 (102 PASS. EA.)	6 (36 PASS. EA.) (3 CAR TRAINS)	2 (24 PASS. EA.)	30 (20 PASS. EA.) (5 CAR TRAINS)	4 ([illegible] PASS. EA.) (8 CAR TRAINS)
ACQUISITION OR DUPLICATION COST & YEAR	7,074,000 71-75	8,890,000 72-74	300,000 1969	80,000 75-76	1,800,000 69-70	3,910,000 72&76	933,000 (1) 1972	600,000 1974	2,795,000 (1) 74-75	1,843,00 1974
ESTIMATED 1976 COST	8,970,000	12,200,000 (1)	468,000	80,000	2,703,000	4,950,000 (1)	1,310,000	732,000	2,190,000	1,250,000
PER VEHICLE	309,000 (1)	239,000	47,000	80,000	331,000	413,000	218,000	366,000	106,000	375,000
ESTIMATED 1976 COST PER VEHICLE PLACE	15,000	6,000	5,000	7,000	3,000	4,000	4,000	15,000	5,000	4,000
GUIDEWAYS										
LANE MILES	5.26	12.8	1.6	0.34	1.35	1.71	1.15	0.6	0.87	2.06
ACQUISTION OR DUPLICATION COST & YEAR	14,546,000 71-75	9,560,000 71-73	500,000 1969	556,000 75-76	1,921,000 69-70	7,385,000 (2) 70-71	1,443,000 1969	1,740,000 1974	1,654,000 (2) 1974	904,000 1974
ESTIMATED 1976 COST	19,100,000	12,900,000	935,000	556,000	3,450,000	12,400,000	2,700,000	2,080,000	1,970,000	1,080,000
PER LANE MILE	3,640,000	1,010,000	584,000	1,540,000	2,553,000	7,230,000	2,360,000	3,470,000	2,260,000	524,000
STATIONS										
NUMBER	3	28	3	2	8	6	8	2	1	1
ACQUISITION OR DUPLICATION COST & YEAR	1,982,000 72-74	5,156,000 (2) 72-73	300,000 1969	160,000 75-76	1,252,000 69-70	3,218,000 70	1,210,000 1969	350,000 1974	1,349,000 (3) 1974	151,000 1974
ESTIMATED 1976 COST	2,550,000	6,960,000	561,000	160,000	2,250	5,540,000	2,260,000	417,000	1,610,000	180,000
PER STATION	850,000	248,000	187,000	80,000	270,000	923,000	283,000	208,000	1,610,000	180,000
CONTROL & COMMUNICATIONS										
ACQUISITION OR DUPLICATION COST & YEAR	7,983,000 71-75	4,990,000 73-74	200,000 1969	18,000(1) 75-76	900,000 68-69	(3)	(2)	600,000 1974	2,824,000 74-75	28,000 1974
ESTIMATED 1976 COST	10,200,000	6,440,000	312,000	18,000	1,383,000			732,000	3,220,000	34,200
PER LANE MILE	1,930,000	505,000	195,000	50,000	1,020,000			1,220,000	3,700,000	16,600
POWER & UTILITIES										
ACQUISITION OR DUPLICATION COST & YEAR	2,066,000 71-74	3,958,000 1973	200,000 1969	78,000(1) 75-76	1,192,000 69-70	2,723,000 1972	(2)	790,000 1974	668,000 1974	270,000 1974
ESTIMATED 1976 COST	2,710,000	4,990,000	374,000	78,000	2,140,000	3,660,000		940,000	795,000	322,000
PER LANE MILE	515,000	390,000	234,000	217,000	1,590,000	2,140,000		1,570,000	914,000	156,000
MAINTENANCE & SUPPORT EQUIPMENT & FACILITIES										
ACQUISITION OR DUPLICATION COST & YEAR	622,000 72-74	2,930,000 73-74	100,000 1969	8,000 75-76	529,000 69-70	1,828,000 (4) 70-72	78,000 1969	100,000 1974	[illegible],000 (4) 1974	173,000
ESTIMATED 1976 COST	1,060,000	1,820,000	187,000	8,000	913,000	[illegible]	144,000	119,000	595,000	207,000
PER VEHICLE	23,500	74,900	18,700	8,000	133,000	240,000	24,300	59,500	19,900	34,500
ENGINEERING & PROJECT MGMT										
ACQUISITION OR DUPLICATION COST & YEAR	10,624,000 71-75	10,180,000 71-74	400,000 1969	INCLUDED IN ABOVE ITEMS	1,177,000 69-70	3,633,000 70-72	246,000 1969	930,000 1974	803,000 74-75	1,233,000 1974
ESTIMATED 1976 COST	13,300,000	13,300,000	620,000		1,470,000	5,180,000	394,000	1,090,000	819,000	1,420,000
% OF TOTAL	23%	22%	18%		10%	15%	6%	18%	7%	26%
TOTAL ACQUISITION OR DUPLICATION COST	45,097,000 (2)	45,672,000 (3)	2,000,000 (1)	900,000	8,771,000	22,705,000	3,190,000	5,120,000	10,616,000	4,602,000
TOTAL ESTIMATED 1976 COST	57,900,000	60,600,000	3,460,000 (2)	900,000 No Escalation	14,300,000	36,600,000	6,810,000	6,110,000	12,200,000	5,490,000
PER LANE MILE	11,000,000	4,730,000	2,160,000	2,500,000	10,600,000	20,300,000	5,920,000	10,200,000	14,000,000	2,670,000

[1] From N.D. Lea Associates AGT Summary Report

examining this table one must be careful to bear in mind the differences among the systems; not only is a mix of manufacturers and system applications presented but the systems are of varying sizes; some have all tunnelled guideways while others have a mixture of elevated and at grade guideways. Additionally, system size, complexity, geographical location, topography and other site specific factors have considerable influence on capital costs and should be kept in mind.

The comparison of cost per vehicle presented in Table B-3 indicates that the Morgantown vehicle is the fourth least expensive. However, this comparison was based on the 45 vehicles that were delivered and not the active fleet of only 29 vehicles. Of the original 45 vehicles, 16 had been stripped for parts and were inoperative during Phase I. They are to be retrofitted in Phase II. Based on the active fleet of 29 vehicles, the cost per vehicle increases considerably. Vehicle cost can also be compared on a passenger space basis. On this basis, using 29 active vehicles, the Morgantown cost per passenger space is one of the two most expensive.

Except for SEA-TAC which is all tunnelled, Morgantown has the most expensive guideway. This is partly due to the fact that construction began on the guideway before the vehicle design was finalized, thus, it had to be overdesigned. This is also partly due to the guideway heating system which accounts for 20 percent of the guideway cost.

The Morgantown station cost is also one of the most expensive, although on a per berth basis, it is one of the least expensive of the ten systems in Table B-3.

Comparison of Morgantown to other systems in Table B-3 indicates that while Morgantown is one of the more expensive systems, its cost experience is generally within the range observed for other automated guideway systems.

B.2 Operating and Maintenance (O&M) Costs

As in any new system, Morgantown's annual operating and maintenance costs decreased as the system matured. Table B-4 presents the trend in Morgantown O&M costs. The first year O&M costs are unusually high due to the inclusion of all Boeing support cost during the initial operation. If research and development costs are omitted, the first year O&M cost becomes 3.36 dollars per vehicle mile.

Insight into labor cost component of the Morgantown can be gained by examining the personnel requirements for the system. Although the University provided some services to the MPM system

TABLE B-4. TRENDS IN MPM OPERATING COSTS[1]

	Oct-75 June-76	July-76 June-77	July-77 June-78
Total Annual O&M Cost	$3,166,066	$1,297,178	$1,257,397
Total Vehicle Miles	401,542	629,157	555,046
Average Cost Per Vehicle Mile	$7.88	$2.06	$2.26
Total Passenger Trips	607,452	1,857,949	2,007,292
Average Cost Per Passenger Trip	$5.21[a]	$ .70	$ .62
Average Cost Per Capacity Passenger-Trip	$ .59	$ .16	$ .18
Average Cost Per Capacity Passenger-Mile		$ .10	$ .11

a) Includes R&D Costs

1 From West Virginia University Phase I PRT Report

such as its security force and some general purchasing support, the job of operating and maintaining the Phase I MPM system was the function of the staff shown in Figure B-1. The operations staff had one additional position, System Programmer, that was not originally anticipated. The most significant increase, however, was in the maintenance staff. An additional 14 persons were added to the original estimate of 22 persons. The system programming staff also built up to a staff of 5 persons.

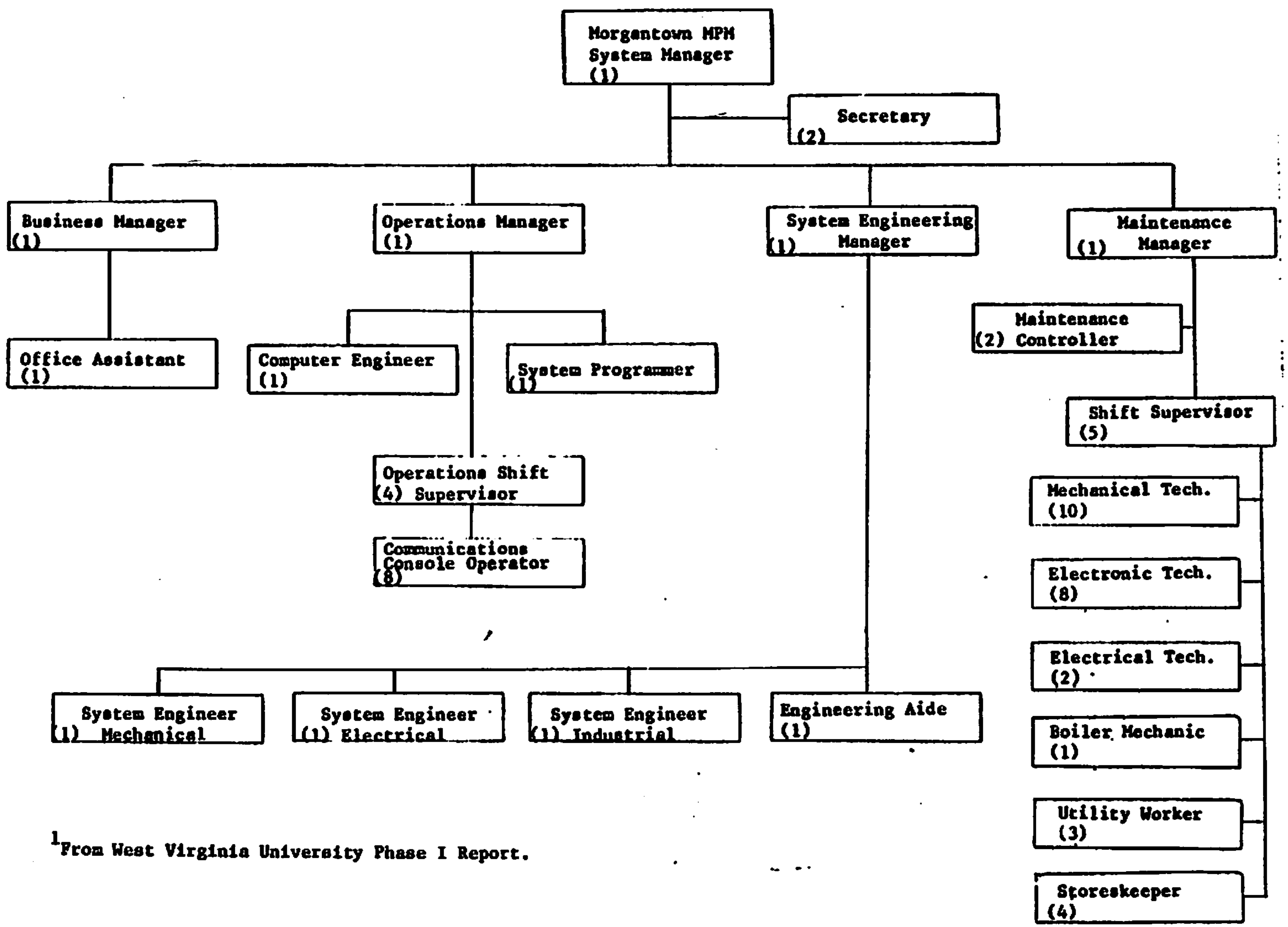
The additional maintenance personnel required were clearly the result of unscheduled maintenance to various components of the MPM vehicle. Table B-5 details the scheduled maintenance rate versus the actual maintenance rate for vehicle components that were most failure prone. As the maintenance personnel's familiarity with the vehicles increased, certain troublesome components were replaced on a scheduled basis to prevent anticipated failures.

B.3 Comparison with Other AGT Systems

On a monthly basis, Morgantown is the second most expensive system to operate of the ten automated systems compared in Table B-6. Morgantown's relatively high cost cannot be explained on the basis of more service being provided. Examining unit costs reveals that Morgantown is at the high end of the range, particularly for cost per vehicle mile and cost per passenger. A more meaningful comparison which accounts for the differences in vehicle size between systems would be to examine unit cost on a cost per capacity mile basis. It should be noted, though, that some AGT vehicles have no standees while others do not have any seats. Passenger comfort should be kept in mind in examining the comparison on a per capacity mile basis. Morgantown remains at the high end of the range on this basis.

The relatively high O&M cost of the Morgantown system can be attributed to several factors. The severe winter of 1977 resulted in costly guideway heating that is not expected to be duplicated in the future as better techniques for conserving energy have been learned by the operations staff. The fluctuations in the month to month O&M cost are also due to the varying cost of materials and services. These variations are due to the accounting procedures used where parts are charged as received rather than as used. Thus, the variation reflects the fluctuations in ordering and delivering parts rather than the use of parts and services.

The effectiveness of the Morgantown system can be compared with the effectiveness of other AGT systems within their respective operating/demand environment by examining the O&M cost per passenger and O&M cost per passenger mile. From Table B-7,



[1] From West Virginia University Phase I Report.

FIGURE B-1. MPM ORGANIZATIONAL CHART

TABLE B-5.

COMPARISON OF SCHEDULED AND UNSCHEDULED MAINTENANCE ACTION[1]

	SCHEDULED	UNSCHEDULED
VEHICLES	691	3,371
STATION CONTROL AND COMMUNICATION AND CENTRAL CONTROL AND COMMUNICATION SUB-SYSTEMS	50	1,165
SURVEILLANCE	101	59
COMPUTER	128	90
BOILER PLANT	4	30
SOFTWARE	0	127
SUPPORT EQUIPMENT	2	97
STRUCTURE AND POWER DISTRIBUTION	453	153
TOTAL	1,429	5,092

(data from 9-15-75 to 6-15-76)

[1]Table adapted from Boeing Operating Availability and Maintenance History Report.

TABLE B-6. AGT OPERATIONS AND MAINTENANCE COST AND PERFORMANCE SUMMARY[1]

	MORGANTOWN (1) Oct 76-Sep 77	AIRTRANS Apr 76-Mar 77	JETRAIL (1)	CABINLIFT (1)	TAMPA	SEA-TAC	HOUSTON	FAIRLANE Mar 76-Feb 77	MIDWAY	KING'S DOMINION
OPERATIONAL STATISTICS										
Vehicle Miles Traveled	379,471	3,745,439	338,650 (1)	10,700	403,000	410,600	122,000	60,262	712,000	25,333
Vehicle Capacity	21	40	10	12	100	102	36 (1)	24	20 (1)	96 (1)
Passengers Carried	1,908,932	5,126,463	1,600,000 (1)	(2)	14,500,000	10,100,000	1,300,000	2,434,000	4,640,000	872,900
Passenger Miles	3,092,000	N/A	N/A	(2)	2,470,000	3,611,000	325,000	1,148,000	4,050,000	1,001,000
Passengers per Vehicle Mile	3.3	1.7	4.7	N/A	35.8	24.6	10.6	39.7	6.5	34.5
O&M COSTS										
Labor			322,250				114,940 (2)			
Operations	149,245	343,745		1,133	20,000	150,000			144,000 (2)	23,100
Maintenance	352,418	1,306,474		1,616	27,000	310,000	31,800	300,000	89,000	62,400
Utilities										
Electricity	98,629	227,004	13,250	1,049	36,500	8,200	24,600	55,000 (1)	44,000	17,000
Other Energy	100,835 (2)									
Materials & Services	525,133						114,829 (3)			
Contract Services		327,589 (2)		2,240	364,980	195,000				
Spare Parts & Materials		672,913	106,500			79,400		40,000	39,000	4,000
G&A	139,630	(3)	N/A	N/A	10,000	8,000	42,761	N/A	33,000	
TOTAL O&M COST	1,365,890	2,967,765	442,000 (2)	6,038	478,480	751,200	328,930	395,000	349,000	156,500
MONTHLY	113,824	246,743	36,833	503	39,873	62,600	27,410	32,917	29,083	13,041
UNIT O&M COSTS										
Cost/Vehicle Mile	$2.36 (3)	$0.79 (4)	$1.31 (4)	$0.56	$1.18	$1.83	$2.70*	$6.55	$0.49*	$6.18*
Cost/Capacity Mile	10.7¢	2.0	13.1¢	4.7¢	1.2¢	1.8¢	7.5¢	27.3¢	2.5¢	6.4¢
Cost/Passenger	71.6¢	48.3¢	27.6¢	N/A	3.3¢	7.4¢	25.3¢	16.2¢	7.5¢	17.9¢
Cost/Passenger Mile	44.2¢	N/A	N/A	N/A	19.4¢	21.0¢	$1.01	34.4¢	8.6¢	8.7¢

*Costs are per Train Mile

[1] From N.D. Lea Associates AGT Summary Report

TABLE B-7. COMPARISON OF AGT UNIT O&M COSTS[1]

AGT System	Cost Per Veh. Mile	Cost Per Cap. Mile	Cost Per Veh. Hr.	Cost Per Cap. Hr.	Cost Per Passenger	Cost Per Pass. Mile
Morgantown Phase I (10-76 to 9-77)	$2.36	11.2¢	$38.94	185¢	71.64	44.2¢
Wedway	0.49	2.5	2.55	12.8	7.5	8.6
Tampa	1.18	1.2	10.38	10.4	3.3	19.4
Sea-Tac	1.83	1.8	16.84	16.8	7.4	21.0
Houston	2.70	7.5	10.00	27.8	25.3	101.0
King's Dominion	6.18	6.4	40.17	41.8	17.9	8.7
Fairlane	6.55	27.3	64.19	267	16.2	34.4

[1]Table adopted from AGT Systems Costs vs. Conventional Transit Costs memo from Leonard Bronitsky to David Rubin, March 28, 1978.

Morgantown exhibits the highest cost per passenger and the second highest cost per passenger mile. The Morgantown system's effectiveness, however, is expected to improve as the system matures. As the system reaches maturity, not only is the O&M cost expected to decrease, but system ridership is also expected to increase. The third year of operation is consistent with this hypothesis since the average cost per passenger decreased from 70 cents to 62 cents. Full maturity, however, is not expected to be reached until after Phase II has opened and reached stability.

B.4 Comparison with Pre-MPM University Bus System (U-Bus)

Another perspective on the O&M cost of the Morgantown Phase I MPM system can be obtained by comparing its O&M cost with that of the University bus system prior to Phase I operations. A comparative analysis of the two systems' O&M cost, however, is difficult because of the major differences in the two systems' operating characteristics.

The level of service provided by the two systems was clearly different. Significant differences exist in the areas served by the two systems. The Phase I MPM system did not extend to the Medical Center, although shuttle bus service was provided. On the other hand, the University bus system never really provided service to the Morgantown CBD. The Phase I MPM system, however, had a station located in the Morgantown CBD.

By operating within an exclusive right of way, the MPM system was able to avoid delays due to auto traffic congestion that hinders bus travel. Additionally, the MPM system offered non-stop travel between origin station and destination station. Also, the MPM system offered demand-responsive service in the off-peak when the bus system had long headways. Thus, riders did not have to adjust their schedule to match that of the transportation system. The MPM system adjusted to the riders' schedules.

Another concern when comparing the MPM and bus systems is the time frame of the comparison. The life expectancy of the MPM guideway is thirty-five to fifty years. Consequently, future cost as well as current costs should be of concern. A comparison of the two systems should recognize the ease of changing the system configuration with buses. Forecasting future operating costs is difficult at best; some components may inflate more than others, which would result in one alternative being less costly in the long run despite current experience suggesting the opposite.

A further consideration is the difference in the quantity of service provided by the two systems. For the period prior to MPM service from July 1974 to June 1975, the University bus system logged a total of 148,444 vehicle miles. In contrast, the MPM system logged 594,000 vehicle miles from June 1976 to May 1977. Assuming that a bus has a capacity of 70 passengers and the MPM vehicle has a capacity of 21 passengers, the University bus system offered 10,391,080 place miles per year as contrasted to the 12,474,000 place miles for the MPM system.

Since the bus feeder routes were an integral part of the overall Phase I transit system, the O&M cost that was associated with these routes is an additional factor that needs to be considered. To simply add this amount to the Phase I MPM's O&M cost makes the comparison of Pre-MPM and Phase I MPM O&M costs equivocal. It neglects the phasing of the construction of the MPM system which upon the completion of the total system in Phase II would reduce the need for feeder routes, and thus provide more efficient overall transit service than was demonstrated by Phase I. Similar problems exist with the simple addition of ridership from the feeder routes to MPM ridership in comparing the effectiveness of the two systems. MPM riders who transferred from the feeder routes would be counted twice under this procedure. In view of the above incomparabilities, the comparisons to follow are in general between MPM O&M cost and Pre-MPM University bus O&M cost.

Further, economies of scale are possible with the MPM operation. Figure B-2 illustrates theoretical bus and MPM cost curves. Note that bus costs per seat-mile remain relatively constant over the quantity of seat-miles provided. The MPM curve, however, displays definite economies of scale, the cost per seat-mile decreases with the number of seat-miles provided. It has yet to be determined whether the MPM cost curve goes below that of the bus before the capacity of the system is reached (as in CASE I) or whether despite the economies of scale, MPM costs are never lower than bus costs.

One perspective on the breakeven comparison of bus and MPM costs can be obtained by comparing the cost per platform hour of the two sytems. A platform hour is defined as an hour spent in operating activity. This would include running time and layover time and would not include collateral times, such as overtime, spread time, meal time, etc. Based on current operating experience and the current service offered in Morgantown, C*, the critical value of platform hours has been computed, Table B-8. Actual bus costs lower than C* imply that the bus system is less expensive to operate, actual bus costs above C* imply that MPM is less expensive to operate.

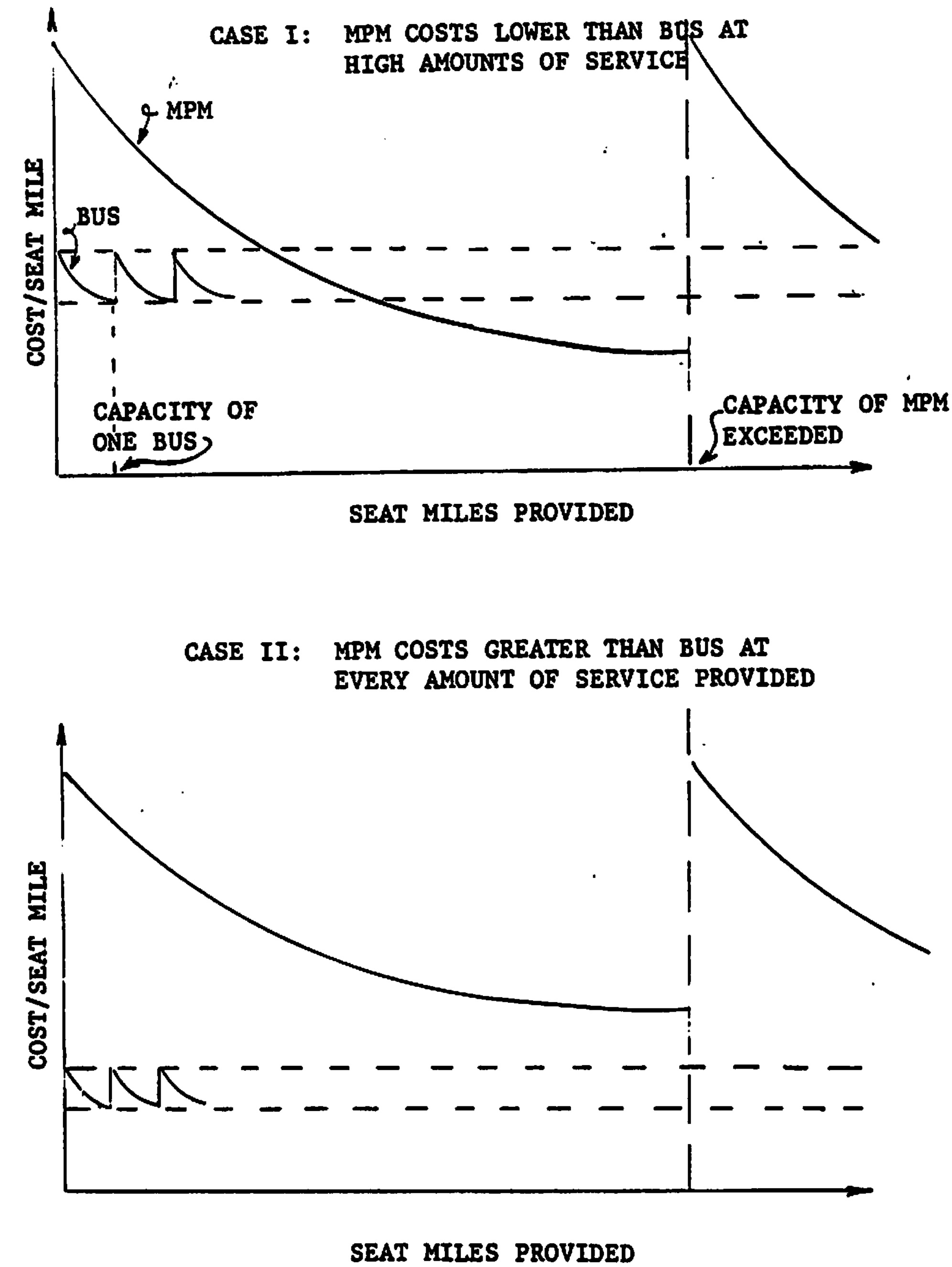


FIGURE B-2. THEORETICAL SHORT-RUN COST CURVES

TABLE B-8. COMPUTATION OF BUS BREAKEVEN COSTS

Cost per day for MPM	$4029[1]
Platform bus hours needed per day	118[2]
Critical value of bus hour	$34.14

[1] $\frac{\text{Total Operating Cost for 9 mos.}}{\text{Total Revenue days (table 4)}} = \frac{\$983,193}{244} = \$4029$

[2] Table 4.4, p. 39, Pre-PRT Report

The C* computed for the Phase I MPM was $34.14 per platform bus hour. The current cost of the bus system in Morgantown (which does not have union drivers) is about $8 to $9. Thus the MPM, at the moment, is more expensive to operate.

Nevertheless, some comparisons between the two systems are useful. These are depicted in Table B-9. The O&M cost per platform hour is substantially lower for the University bus system. As previously noted, this is partially the result of University bus drivers having been non-unionized. The bus drivers were simply University workers who could be easily assigned to other duties. Similarly, the cost on a per vehicle mile, per capacity mile, and per passenger are all significantly lower for the University bus system. In examining the components of the O&M costs for each system, it is interesting to note that the labor proportion of O&M cost for the MPM system, 42 percent, was lower than the University bus system's labor proportion, 49 percent. One of the primary objectives of the MPM system was to reduce the typically high labor cost associated with providing transit service. Since the University bus system's labor cost

TABLE B-9. COMPARISON OF BUS & MPM O&M COSTS

ANNUAL OPERATING EXPENSES	PRT (6-1-76 to 5-31-77)	U-BUS (7-74 to 6-75)
Labor	542,754	59,890
Unclassified (Benefits, Insurance, etc.)	86,841	41,856
Fuel, Parts, etc.	667,583	19,900
Leased Contract		109,200
TOTAL	1,297,178	230,846
OPERATING STATISTICS		
Operating Days	329	246
Average System Cost per Day	3,943	938
Total Vehicle Miles	594,000	145,444
Average Cost Per Vehicle Mile	2.19	1.59

was much lower than an urban transit operation's labor cost, it appears that this objective was met.

B.5 Comparison with Conventional Transit Systems

The Morgantown system can also be compared with various conventional transit systems, both bus and rail (Table B-10). The different service characteristics of conventional bus and rail as contrasted with the Phase I MPM system increases the difficulty with which the comparisons between these system can be made on a unit cost basis. Morgantown is similar to conventional rail transit system in its operation on an exclusive right of way and passenger boarding and alighting in stations. Morgantown, however, had inter-stops distances and average operating speeds that are characteristic of conventional bus systems. Differences in vehicle designs between these systems makes the comparison of cost on a per vehicle mile basis less meaningful. It is more meaningful to make the comparisons on a per capacity mile basis. On this basis, Morgantown is much costlier than either conventional bus or rail. It is noted that the Morgantown MPM's service is significantly better than these bus and rail systems as well.

Since costs of conventional transit systems are closely related to labor cost and thus vehicle hours of service, the comparison of Phase I MPM cost on a vehicle hour basis is useful. From Table B-10, the MPM system's vehicle hour cost is at the top end of the range of conventional bus systems, but in the middle of the range of conventional rail system. Accounting for vehicle design differences by comparing on a capacity hour basis places the MPM system at the extreme high end of both conventional bus and rail.

B.6 Revenue Approximations

The MPM system has two sources of revenue: a $15 per semester pass (1976-1977 academic year) required for all full-time students at West Virginia University and a 25¢ fare for riders without the pass.

The total estimated revenue for the 1976-1977 academic year is broken down in Table B-11. The student fee is by far the most significant contribution to revenue.

Estimating yearly operating costs at $1.3 million (based on data in Table B-9), yields a recovery rate (revenue/expense) of 0.48.

TABLE B-10. COMPARISON OF MPM & CONVENTIONAL TRANSIT UNIT O&M COSTS

	$/Unit	¢/cap	$/veh hr.	¢/cap hr.*	Conventional Systems[1]	$/Unit	¢/cap mi.*	$/veh hr.	¢/cap hr.*
Long Beach	1.04	1.3	12.59	15.7	Toronto	1.01	0.4	20.2	7.3
Nashville	1.07	1.3	13.92	17.4	Cleveland	1.34	1.3	32.84	32.8
Dallas	1.09	1.4	14.86	18.6	Chicago	1.95	1.1	--	--
40-city average	1.54	1.9	17.91	22.3	NYCTA	2.27	1.1	41.86	20.9
Chicago	2.26	2.8	20.05	25.1	PATCO	3.15	2.0	116.64	77.8
NYCTA	3.11	3.9	26.43	33.0	PATH	3.27	2.3	74.37	51.3
Manhattan/ Bronx	3.54	4.4	19.62	24.5					
Morgantown	2.36	11.2	38.94	185					

*Capacities of conventional systems are based on a comfort standard of 2.5 squ. ft./standee.
Source: 1. APTA 1975 Operating Expense Report.

TABLE B-11. ESTIMATED REVENUE 1977-1978

1.	Fee	
	16,567 full time students in 1977-1978 $15@	$248,505/semester
2.	Fare Box	497,010/year
	Academic Year average weekday ridership, 16,415	
	16,415 x 5 days x 12% x 25¢ x 40 weeks (weekends not included)	$98,490
	Summer average weekday ridership 3,225 3225 x 5 days x 50% x 25¢ x 12 weeks	$24,188
3.	Total	$619,688

BIBLIOGRAPHY

Barton-Aschman Associates, Inc., Evaluation of Alternatives, Morgantown PRT System. Draft Final Report prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, August 1976.

Benjamin, Jack R. and C. Allin Cornell, Probability, Statistics, and Decision for Civil Engineers (New York, McGraw-Hill, Inc., 1970).

Boeing Aerospace Co., General Specification for Performance/Design and Qualification for the Morgantown Operational Personal Rapid Transit System. SS191-90000-3C, November 6, 1973.

Boeing Aerospace Co., Morgantown Personal Rapid Transit System. Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, November 1975.

Boeing Aerospace Co., MPRT O&M Phase Operating Availability and Maintenance History. D 191-62000-1, prepared by A. L. Stone, January 1977.

Bronitsky, Leonard, "AGT System Costs vs Conventional Transit Costs," TSC Memorandum to Chief, Urban and Regional Research Division, March 28, 1978.

Charles River Associates, Disaggregate Travel Demand Models, prepared for National Cooperative Highway Research Program, Transportation Research Board, February 1976.

Chung, Cady C., The MITRE Corporation/METREK Division, Preliminary Data Base for Existing Automated Guideway Transit Systems. Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, July 1977.

Daily Atheneum, "PRT Guide to Riding the Personal Rapid Transit System", West Virginia University, October 3, 1975.

Elias, Samy E.G., et.al., PRT Impact Study, Operational Phase Volume I - Travel Analysis. Final Report Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration.

Elias, Samy E.G., et. al., PRT Impact Study, Operational Phase, Volume II - Data Collection Procedures and Coding Manual. Final Report Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration.

Elias, Samy E.G., et. al., PRT Impact Study, the Phase I PRT Impact on Morgantown Travel, Traffic, and Associated Activities. Final Report Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration.

Elias, Samy E.G. et.al., PRT Impact Study, The Phase I PRT Impact on Morgantown Land Use. Draft Final Report Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, undated.

Elias, Samy E.G. et. al., PRT Impact Study, Pre-PRT Phase, Volume I - Travel Analysis. Final Report prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, March 1976.

Elias, Samy E.G. et. al., PRT Impact Study, Pre-PRT Phase, Volume II - Data Collection Procedure and Coding Manual. Final Report prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, March 1976.

Engineering News Record, "Bart Scores Low on Report Card, Could Up Grades over Long Term," November 3, 1977.

Multisystems, Inc., Morgantown Personal Rapid Transit System, Phase II Impact Evaluation Plan. Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, December 1978.

National Oceanic and Atmospheric Administration, Environmental Data Service, Climatological Data, West Virginia, Volume 83, # 10 through Volume 86, # 1, October 1975 through January 1978.

N.D. Lea and Associates, Inc., Summary of Capital and Operations and Maintenance Cost Experience of Automated Guideway Transit Systems. Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, June 1978.

Nussbaum, E. and B. Zumwalt, The MITRE Corporation, Environmental Impact Issues for Automated Guideway Transit Systems. Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, August 1976.

Procaccia, Ronit, The Morgantown PRT File. Unpublished task report KHL-TSC-78-1557 ADP Job Order D8416A, Kentron International, Inc. September 1978.

State Road Commission of West Virginia, Morgantown TOPICS. September 1969.

Stearns, Mary D. and K.H. Schaeffer, Impact Evaluation of the Morgantown PRT 1975-1976 Ridership: Interim Analysis. Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, June 1977.

U.S. General Accounting Office, The Personal Rapid Transit System, Morgantown, West Virginia. Staff Study, April 1975.

Watt, C. W., Morgantown People Mover (MPM) Operating, Dependability, and Maintenance History - October 1976 through June 1978. Prepared for U.S. Department of Transportation, Urban Mass Transportation Administration, July 1979.

West Virginia University, "A Feasibility Study of an Integrated City and University Transportation System," Final Report August 1970.

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