Impact of People Movers on Travel: Morgantown—A Case Study

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Impact studies of the Morgantown People Mover (MPM) were conducted for two separate phases of construction. Estimates of MPM corridor travel by mode were made before and after opening of phase 1 in October 1975. Estimates of travel by mode, user group, and trip purpose were also made before and after the opening of the expanded system in August 1979. Highly similar impacts resulted both times. Several thousand person trips were diverted from the automobile to the MPM. Users, who are primarily but not exclusively students and faculty, expressed levels of satisfaction with the system nearly as high as users of private automobiles. Despite initial concern about safety before operation began, users now perceive MPM to be extremely safe.

In October 1975, the first phase of the Morgantown People Mover (MPM) system (referred to in the past as the Personal Rapid Transit System) was opened for passenger service. MPM is a revolutionary new mode of public transportation, built as a research development and demonstration project by the Urban Mass Transportation Administration (UMTA). Because this system was the first of its kind ever operated in a city, it provided a unique opportunity to study the interaction between a new mode and its service area.

Although the system installation at that time represented only the first phase of a much larger system, it was believed that some measurable impacts could still be derived from its first few years of operation that, it was hoped, could later be verified when compared with the impacts of the expanded system. That has definitely been achieved. As will be reported later in this paper, some of the most impressive impacts of the system, such as the measurable shift from automobile use to MPM use, appeared in both studies.

The MPM impact study was designed to record the effects of system operation on traffic and associated activity in the area adjacent to the MPM. The intent of the study was to provide information that should be useful to other cities contemplating public transit, particularly those planning for automated guideway transit (AGT) type installations.

Specifically, the major objectives of the study were to

1. Measure the service and accessibility of the system,
2. Determine the nature of system patronage, and
3. Measure the impact of MPM on the travel and traffic adjacent to the MPM corridor.

OVERVIEW OF TRANSPORTATION IN MORGANTOWN

Morgantown is a university city of about 30 000 population. West Virginia University (WVU) is the largest employer in the area, and some 19 000-20 000 students attend WVU in Morgantown. All of the WVU buildings were once located in a compact area contiguous with Morgantown's central business district (CBD). However, as WVU expanded, new buildings, which included classrooms, dormitory facilities, athletic facilities, and a medical center, were located several miles from the older buildings and became known as the Evansdale Campus. The original buildings near the CBD became known as the Main (or Downtown) Campus. In Figure 1, the Walnut Street station is located in the CBD and the Beechurst Avenue station serves the Main Campus. The Engineering, Towers, and Medical Center stations serve the Evansdale Campus.

The city has very few roads running in the north-south direction. The most heavily used of the north-south arteries is Beechurst Avenue, which is essentially a two-lane road, although its northern extension, Monongahela Boulevard, is four lanes wide. Most other north-south traffic is carried by the heavily used University Avenue, a two-lane road east of the Beechurst-Monongahela route at a slightly higher elevation. These routes are essentially the only routes between the Main Campus and the Evansdale Campus, and they must be used for all travel across Morgantown in a north-south direction.

The private automobile is the primary mode of transportation in Morgantown. Automobiles are used by students, faculty, and staff of WVU, as well as by the non-WVU-related residents of the area. However, parking is in short supply in the CBD and at most locations on the WVU campus; it is particularly limited at the Main Campus.

Prior to the advent of the MPM, most student trips within the WVU campuses were made by university bus. WVU operated a fleet of approximately 16 regularly scheduled buses, each bus having a seating capacity of 45-55. The university buses served all major activity centers on the Evansdale Campus and stopped at Campus Drive near the Main Campus. Passengers could get on or off university buses only at designated stops.

The City of Morgantown operates a very small transit system. In addition, bicycling is seldom used as a mode of transportation because of Morgantown's hilly terrain.

MPM SYSTEM CHARACTERISTICS

The MPM system is a computer-controlled (Figure 2), fully automated collection and distribution transportation system. Each vehicle (Figure 3) is air-conditioned and heated and is capable of carrying 8 seated and 12 standing passengers. The vehicles are electrically powered and receive power from a power rail (Figure 4) and operating instructions from an inductive loop embedded in the guideway.

The vehicles run on headways of 15 s at a maximum speed of 30 mph. The right-of-way for the vehicles is an exclusive guideway (Figure 5). The guideway is constructed at three grades: at grade, above grade, and a very short section in a cut-and-cover tunnel.

To summarize, the major innovations of the MPM and those that distinguish it from earlier operational transit systems include the following:

1. Central computer-control function,
2. Demand-activated service,
3. Small personalized vehicles,
4. On-board switching,
5. Short headways,
6. Off-line stations, and
7. Nonstop trips from origin to destination.

MORGANTOWN MPM SYSTEM

The MPM system was constructed in two phases. Phase

Figure 1. System configuration, Morgantown.

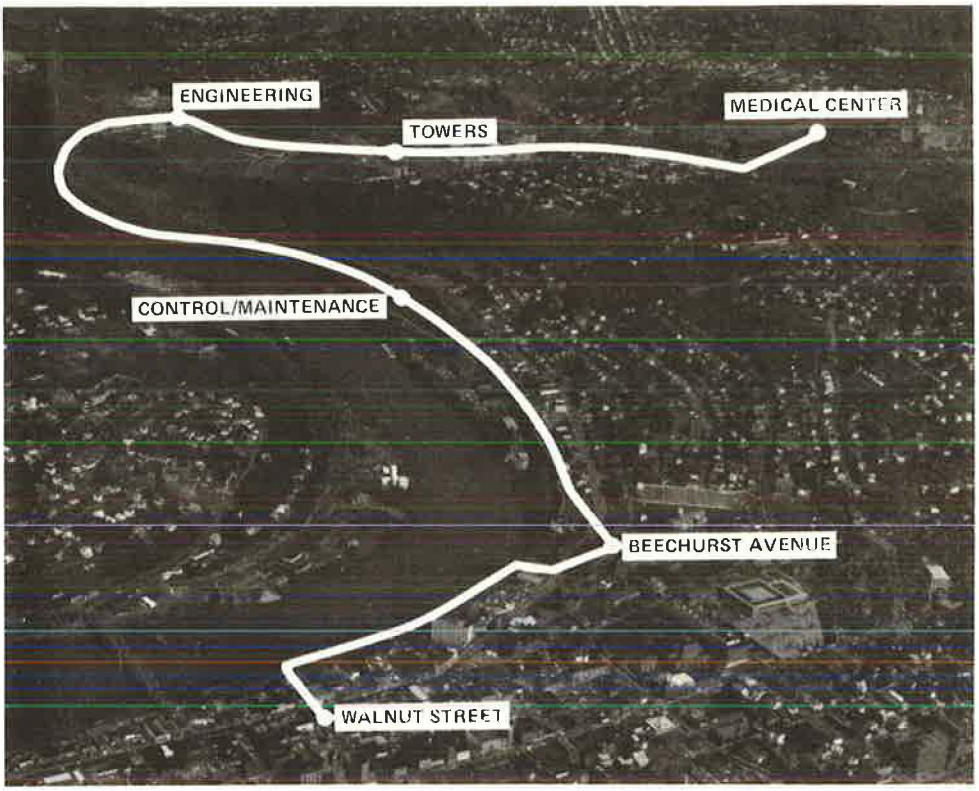
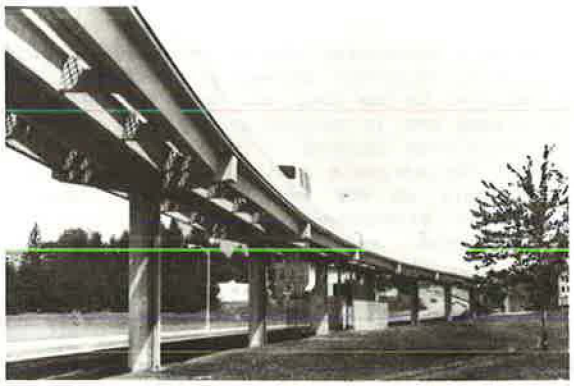


Figure 2. Control center.

Figure 3. Vehicle.

Figure 4. Power collector, pneumatic tire, and lateral wheels.

Figure 5. Guideway.



1 of the MPM system was completed in October 1975 and phase 2 in October 1979.

Phase 1 consisted of a three-station system connected by 5.4 miles of equivalent single-lane guideway and served by 45 vehicles. Phase 2 represented the completion of the system. In phase 2, two new stations (see Figure 6) were built, the guideway extended to 8.7 miles, and 26 new vehicles were added to the system. These vehicles operate at a maximum speed of 30 mph and a minimum headway of 15 s.

SYSTEM OPERATIONAL DESCRIPTION

The MPM system is operated in either a schedule or demand mode. During those periods when passenger demand is highly predictable, the system is operated in the schedule mode. Vehicles are dispatched between origin-destination pairs on a preset schedule. When passenger demand is less predictable, the system is operated in the demand mode. Vehicles are then dispatched only in response to a passenger request.

Passenger actions on entering the system are always the same, regardless of the mode in which the system is operating. Normally, a passenger would arrive on the concourse level of the origin station where static and dynamic displays provide direction (Figure 7) to the platform that services his or her destination, proceed to the platform level, insert a coded card (fare cards are included in student fees but can also be purchased locally) or exact change in a fare gate (Figure 8), and press a button that selects the destination. A gate display illuminates, which informs the passenger to proceed to the vehicle loading area. A vehicle destination display above the loading gate provides vehicle boarding instructions. If assistance is needed for any reason, a dedicated telephone link to the central operator is available near each entry gate area. The passenger is kept informed of changes in the system operating status via the station public address system.

The passenger boards a vehicle when it arrives at the loading gate, and the display indicates that the vehicle is assigned to his or her destination. The door closes and the vehicle automatically proceeds to the destination. At the destination station the vehicle stops at an unloading gate, the door opens, and the passenger leaves the station through an exit gate.

Elevator service is provided from station concourse levels to each platform to permit use of the system by the handicapped and the elderly. The system operates between the hours of 6:30 a.m. and 12:00 midnight on Monday through Thursday, 6:30 and 1:00 a.m. on Friday, 9:30 and 1:00 a.m. on Saturday, and 9:30 a.m. and 12:00 midnight on Sunday.

MPM OPERATIONAL HISTORY

It seems appropriate at this time to take a few moments and summarize the operational history of the system over the past six years. Very briefly, the system, as expected, has matured and has showed a steady increase in dependability and ridership and a reduction in cost per passenger mile. The table below summarizes the operating statistics for 1980-1981:

Item	Quantity
Total labor, fuel, parts, and unclassified (benefits, insurance, etc.) ($)	2 160 537
No. of operating days per year	338
Avg system cost per day ($)	6392
No. of miles driven per year	1 168 723
Avg system cost per vehicle mile ($)	1.848
Total passengers per year	3 087 314
Avg cost per passenger trip ($)	0.699
Avg cost per passenger mile ($)	0.384

Overall system dependability has continued to improve. Table 1 summarizes its performance since the first month of operation. Note that during the last 12 months, the system's dependability averaged 97.7 percent. Dependability is the product of system availability (downtime divided by operating time), trip reliability (probability of completing the trip successfully once one is on the vehicle),

Figure 6. Medical Center station.

Figure 7. Destination displays.

Figure 8. Automated fare gate.

Table 1. System dependability.

Phase	Year	Month	System Dependability (%)	Phase	Year	Month	System Dependability (%)
Phase 1	1975	October	84.33	Expanded system	1979	July	79.6
		November	81.59			August	85.7
		December	74.37			September	90.6
	1976	January	64.36			October	90.9
		February	69.14			November	93.9
		March	86.44			December	93.7
		April	92.90		1980	January	92.2
		May	94.48			February	95.0
		June	92.80			March	91.8
		July	93.19			April	91.2
		August	91.27			May	96.4
		September	92.67			June	97.6
		October	91.16			July	97.5
		November	92.45			August	94.9
		December	90.53			September	96.5
	1977	January	82.93			October	96.6
		February	95.19			November	96.1
		March	93.88			December	96.8
		April	96.53		1981	January	98.3
		May	98.56			February	96.1
		June	98.98			March	98.4
		July	99.01			April	97.9
		August	97.85			May	99.0
		September	96.88			June	99.0
		October	96.30			July	98.1
		November	97.47			August	99.5
		December	97.11				
	1978	January	93.37				
		February	91.04				
		March	94.20				
		April	96.85				
		May	97.74				
		June	98.63				

Notes: System dependability = system reliability times system availability times vehicle availability.
System average between August 1980 and August 1981 was 97.1 percent.

and vehicle availability (number of vehicles available divided by number of vehicles required).

DATA-COLLECTION PROCEDURES

Impact studies were conducted for the phase 1 system, which began operation in 1975, and also for the expanded system, which began operation in 1979. However, the data-collection procedures were different in each study. For the 1976 study, impact data were collected primarily by means of a telephone household survey among randomly selected households in Morgantown. The survey asked detailed information about the previous day's tripmaking throughout Morgantown. The data were expanded on a zonal basis to provide information on modal use. MPM users were also given a very short questionnaire on entering the system. On departing the system the questionnaire was collected. A small sample of the people who completed the form were then contacted by telephone for additional information. Unfortunately, problems were encountered in the telephone survey due to difficulty obtaining the head of the household and the length of the survey form. For these reasons, a different approach was taken in 1979 and 1980.

In the expanded system survey, which was conducted in early April 1979 and late March 1980, emphasis was placed on surveying individual corridor trips rather than households. A questionnaire was developed that sought information on trip origin and destination, purpose, satisfaction with various aspects of the trip, and the tripmaker's household characteristics. (Questionnaires are available from the researchers on request.) The questionnaire was handed out to a sample of automobile drivers at all intersections from which trips entered the MPM corridor, and it was also handed out to a sample of university bus system users (1979) and MPM users (1980) at system entry points. The questionnaires were completed at home and mailed back.

Traffic ground counts and observed vehicle occupancy were used to estimate total corridor person trips. The returned automobile-intercept survey forms were then expanded to equal total estimated corridor person trips. Great care was taken to expand the survey data separately for each intersection approach where survey forms were distributed. A similar procedure was followed for expanding survey forms distributed on the bus and MPM. On-off counts were obtained and used as estimated control totals for expansion. Altogether, 4126 usable questionnaires were returned in 1979 and 5195 in 1980, which represented roughly 7 and 8 percent of total corridor person trips, respectively. This represented a return rate of about 30 percent almost uniformly across modes.

The City of Morgantown and surrounding areas in Monongalia County were disaggregated into 54 zones along boundaries consistent with 1970 census enumeration districts. Origins and destinations of trips were coded to these zones. Those zones within easy walking distance (about 10 min) from MPM stations were designated as the primary market area (PMA). These 24 zones included all of the WVU campus and dormitory zones, the CBD of Morgantown, and adjacent residential areas, which housed a high proportion of WVU students and employees. The PMA contained the MPM corridor except for one section near the middle, which was located more than a 10-min walk from any station.

MAJOR FINDINGS

One of the most striking findings was the change in perception of system safety following the opening of

Table 2. Modal split of person trips in MPM corridor.

Item	Preoperational Survey, 1979				Operational Survey, 1980			
	Total Trips[a]	Percentage of Trips		Maximum Error of Estimates[b]	Total Trips	Percentage of Trips		Maximum Error of Estimates[b]
		Via Automobile	Via University Bus			Via Automobile	Via University Bus	
Trips with ends both in PMA	23 086	57.6	41.6	2.0	23 670	49.9	49.1	1.9
Trips with one end in PMA	24 885	96.2	3.0	0.7	29 735	93.2	5.6	0.8
Trips with either end in PMA	9 354	99.9	0.1	0.2	10 949	99.4	0.2	0.3
Total corridor trips	57 325	81.3	18.0	1.0	64 354	78.3	20.7	0.9

[a]Includes city bus. [b]Estimates are for 90 percent confidence interval.

Table 3. Comparison of system impacts: 1976 phase 1 versus 1980 expanded system.

Mode	1976	1980	Mode	1976	1980
Automobile			Total trips[a]		
Preoperational	10 369	13 308	Preoperational	17 893	23 086
Operational	8584	11 809	Operational	17 316	23 670
Change (%)	-17.2	-11.3	Change (%)	-3	+2.3
Transit[a]			Transit share (%)		
Preoperational[b]	7524	9594	Preoperational	42	42
Operational[c]	8732	11 627	Operational	50	50
Change (%)	+16.1	+21.2	Change	+19	+19

Note: Statistics are for person trips with both ends in the PMA.
[a]Excludes city bus. [b]Includes university bus. [c]Includes MPM.

phase 1. Prior to opening, people thought that the MPM would be less safe than the automobile and bus. But following a year of operation, MPM was perceived to be more safe than the automobile or bus. These perceptions still exist and have been reinforced by the safety record of MPM. To date (August 1981), after serving almost 11 million passengers and operating 4.3 million vehicle miles, there has not been a single system-induced injury or death.

The most important traffic impact was a marked shift in ridership from automobile to MPM among trips within easy walking distance of MPM stations. This occurred simultaneously with a large increase in overall automobile travel in the corridor. The total number of person trips in the corridor increased by nearly 7000/day between 1979 and 1980. Of this increase, the majority (nearly 6500) represented automobile trips that had at least one end outside the PMA and thus were not potential MPM trips. The net increase among trips that had both ends in the PMA was very small (only about 500) but was accompanied by a large shift from automobile to MPM. In fact, MPM carried about 2000 more PMA person trips per day than had the university bus system, whereas the highway system in the corridor carried approximately 1500 fewer PMA automobile person trips following the opening of the expanded system. Thus, there was a clear shift from automobile to MPM among trips with both ends in the PMA, as seen against the background of a large overall increase of 12.3 percent in total corridor person trips (Table 2).

A second major finding was that the impact of the MPM was nearly the same following both the opening of the phase 1 system and the opening of the expanded system, especially among tripmaking within the PMA. Both times, the share of PMA trips made by transit (university bus versus MPM) increased from 42 to 50 percent following the opening of the system. This reflected a decrease in automobile person trips of 17.2 percent in 1976 versus 11.3 percent in 1980, and an increase in transit person trips of 16.1 percent in 1976 versus 21.2 percent in 1980. Neither time did total trips within the PMA change by more than 600 (Table 3). Thus, based on the data, the system appeared to be influencing similar changes in travel behavior at two points in time separated by four years.

It was expected that WVU students and employees would be the groups experiencing most of the impacts due to the configuration of the guideway and the fact that the only parking readily available at four of the five stations was restricted to individuals with WVU parking stickers. The impact studies verified this and indicated that impacts occurred primarily among school and non-home-based trips. Among home-based school trips that had both ends in the PMA, transit use rose from 64.8 to 73.2 percent following the opening of the expanded system, and non-home-based school trip transit use rose from 62.5 to 79.8 percent. Transit use for non-home-based work trips rose from 11.1 to 18.3 percent, and for non-home-based other trips it rose from 13.2 to 22.1 percent. Among other trip purposes there was no noticeable shift in modal use (Table 4).

The impact study also verified that the strongest impact had occurred among students who did not live in dormitories but in private housing. These were the students most likely to own automobiles and use them for school-related trips. Transit use in this group increased from 38.8 to 52.7 percent for trips made within the PMA, and automobile use dropped by a corresponding percentage (Table 4). Dormitory students, who were less likely to own automobiles, registered a smaller change from 78.9 to 87.7 percent transit use. Transit use by WVU employees changed from only 7.7 to 18.1 percent for trips entirely within the PMA. Similarly, other Morgantown residents not affiliated with WVU made only 7.1 percent of their within-PMA trips on MPM (the university bus system had not been available to them). The data suggest that WVU employees and townspeople are reluctant to abandon the convenience of their automobiles in return for a combined walking and MPM trip.

An examination of user satisfactions indicated that more automobile users were satisfied with their mode of travel than were transit users, both before and after opening the MPM. However, an interesting finding was that satisfaction with each mode increased after the expanded MPM was opened (Table 5). The MPM scored high levels of satisfaction (better than 75 percent of users expressing satisfaction) with respect to overall trip duration, overall ease of making the trip, cost of trip, and overall satisfaction. It scored nearly as well as the automobile mode in these areas. But in terms of satisfaction with waiting time, walking time, and vehicle occupancy it scored lower. In fact, 9 percent fewer MPM users were satisfied with waiting time than university bus system users. This may be related to the fact that bus system users could always sit inside the buses while waiting for their

Table 4. Impact by trip purpose and user status: trips with both ends in PMA.

Item	Preoperational Survey, 1979				Operational Survey, 1980			
	Total Trips	Percentage of Trips		Maximum Error of Estimates[a]	Total Trips	Percentage of Trips		Maximum Error of Estimates[a]
		Via Automobile	Via University Bus			Via Automobile	Via University Bus	
Home-based work trips	2098	85.9	11.4	4.7	2665	84.0	13.5	4.1
Home-based school trips	8596	34.8	64.8	3.2	9015	26.4	73.2	2.7
Home-based other trips	3818	83.2	16.0	3.7	2812	81.8	16.9	4.2
Non-home-based work trips	1961	88.2	11.1	4.5	2055	78.9	18.3	5.2
Non-home-based school trips	4220	37.2	62.5	4.6	3878	20.2	79.8	3.7
Non-home-based other trips	2325	85.2	13.2	4.3	2851	76.6	22.1	4.6
WVU faculty and staff	3843	89.9	7.7	3.0	3989	80.2	18.1	3.6
WVU dormitory students	7204	21.1	78.9	3.0	6388	12.3	87.7	2.4
WVU nondormitory students	8377	60.7	38.8	3.3	9051	46.8	52.7	3.0
Other Morgantown residents	2734	98.6	-	-	3293	89.5	7.1	3.0
Nonresidents, non-WVU	929	59.8	39.8	9.8	949	67.2	31.8	8.8

[a]Estimates are for 90 percent confidence interval.

Table 5. Traveler satisfaction with trips made in corridor.

Item	Automobile				Transit			
	1979		1980		1979[a]		1980[b]	
	Percent	Maximum Error of Estimates	Percent	Maximum Error of Estimates	Percent	Maximum Error of Estimates	Percent	Maximum Error of Estimates
Trips under 10-min perceived travel time within PMA	42	2	49	2	25	2	17	1
Travelers satisfied with overall trip duration	73	2	80	1	66	2	75	1
Travelers satisfied with ease of making trips	73	2	82	1	68	2	78	1
Travelers satisfied with waiting time	83	1	88	1	67	2	58	2
Travelers satisfied with walking distance	83	1	90	1	62	2	65	2
Travelers satisfied with vehicle occupancy	82	1	80	1	58	2	67	2
Travelers satisfied with cost of trip	NA		53	2	NA		83	1
Travelers expressing overall satisfaction with trip	NA		84	1	NA		76	1

Notes: NA = not applicable.
Estimates are for 90 percent confidence interval.
[a]Data for university bus.
[b]Data for MPM.

trips to begin, whereas MPM users have to stand outside on the station platforms while waiting. In all other areas the MPM scored better than the university bus, with generally about 9 percent more MPM users expressing satisfaction. The MPM scored better than the automobile in only one area--satisfaction with trip cost. More than 30 percent more MPM users were satisfied with trip cost than automobile users.

Questions were asked regarding perceived trip duration. The automobile was regarded as superior to MPM, as evidenced by nearly 50 percent of the automobile users expressing the belief that total trip duration was less than 10 min. Only 17 percent of the MPM users perceived that trip duration was less than 10 min, an even smaller percentage than university bus system users. This was probably related to decreased satisfaction with waiting time for MPM. Despite this, more MPM users were satisfied with overall trip duration than university bus system users. This apparently contradictory result may indicate a bias on the part of MPM users to react more favorably to the overall characteristics of the trip because of a favorable overall satisfaction with the mode. Clearly, overall satisfaction with the MPM was high (76 percent of the users) and within 8 percentage points of the automobile. Thus, despite MPM shortcomings in regard to waiting time, walking distance, and vehicle occupancy, the percentage of users who expressed overall satisfaction was high.

CONCLUSIONS

The MPM appears to have achieved a shift in modal split from automobile to MPM for those trips that both begin and end near the system's stations. Impact was strongest for WVU students who do not live in dormitories. Although waiting time for vehicles appears to be a source of dissatisfaction for users, the general reaction is more favorable than it was for the bus system and almost as high as for the automobile mode. System dependability has improved with operational experience and is currently about 97 percent. Despite high initial capital costs, the system has relatively low labor requirements, which should help to keep operating costs from escalating as rapidly as those for conventional driver-operated systems. This fact alone should help to sustain a continuing interest in such systems for urban transportation.

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