Patronage Estimate for Downtown People Movers

Jeffrey M. Zupan, Regional Plan Association, New York, New York
Donald E. Ward, Urban Analysis Branch, Transportation Systems Center, U.S. Department of Transportation, Cambridge, Massachusetts
Granville E. Paules, Technology Transfer Division, Urban Mass Transportation Administration

To provide some guidance in the early planning and conceptual design of downtown people movers, a rough, aggregate approach was developed for determining the effects on ridership of major downtown people movers design and policy decisions. The approach is an abstract, parametric analysis that uses aggregate relations and simplified assumptions to show how ridership of downtown people movers is influenced by (a) alternative downtown people movers design configurations (i.e., such factors as number of stations and station spacing), (b) operating characteristics and policies (i.e., such factors as speeds, headway, and fare), and (c) the size, density, and distribution of activities in the central business district. Trips in five categories are examined separately for possible diversion to downtown people movers: regional trips to the central business district by automobile and transit and internal central business district trips by automobile, transit, and walking. The many combinations of site, system, and service variables tested allow general implications to be drawn from the numerical results. Among the most important are the following: (a) station spacings below or above the 366-488-m (1200-1600-ft) range begin to be less efficient; (b) systems that interface with regional transit at a central business district fringe station divert more transit passengers than does a central delivery arrangement, except in large, spread central business districts; (c) parking fees and capacities at downtown people movers stations are major factors in potential diversion of automobile users to downtown people movers; and (d) downtown people movers service policies have less effect on ridership than fares, except where downtown people movers are in competition with the local central business district bus.

Since no downtown people mover (DPM) systems have yet been built in this country, we have little experience to draw on in their plan, design, and implementation. Specifically, we have no basis for estimating their patronage. As part of its program for transportation planning support to urban areas, the Urban Mass Transportation Administration (UMTA) has developed several aids for planners of DPM systems, such as a DPM guideway-simulation model. Another of these is a report (1) that brings together the state of the art in planning data and methods for use in cities interested in DPM systems.

Before even the preliminary design of a DPM system is attempted for a specific downtown area, the planner must first determine whether or not a DPM is potentially suitable in the area. The planner must recognize the potential consequences of major design decisions about overall guideway length, number of stations, station spacing, and interfaces with the transit and highway systems. A chapter of the DPM planning methods report on aggregate analysis of system feasibility (1) presents a broad-brush parametric analysis by using aggregate relationships and simplified assumptions to examine the effects of alternative system configurations and service policies on potential DPM ridership. The planner can use the information in several ways: (a) a few basic pieces of data can be used to develop rough ridership estimates in a matter of minutes, by using the charts and tables; (b) more accurate patronage figures can be produced by using a worksheet technique, which is included to allow the use of more specific data; and (c) general implications and rules of thumb that can be used in initial considerations of policy and design can be derived from the results of the parametric analysis for several types of DPM use.

GENERAL APPROACH

The procedure used to estimate demand for the DPM system requires neither detailed data on zones or individual trip making nor site-specific data on trip making. It relies on travel demand and transportation system characteristics typical, on the average, of various-sized downtowns in North America.

The method first develops aggregate relationships between travel in the central business district (CBD) and CBD activities measured by employment and floor space. These relationships are used to estimate five categories of existing CBD trips, each of which has a potential for diversion to a DPM system:

Regional CBD trips (one end outside CBD, one end inside)
1. Transit
2. Automobile

Internal CBD trips (both ends inside CBD)

3. Walk
4. Transit
5. Automobile

An abstraction of the CBD is assumed in that it is characterized by only three parameters: employment (or floor space), area size, and density gradient, where the gradient reflects either a spread or concentrated pattern of activities about the central point. Similarly, DPM system configurations analyzed in the CBD are described primarily by the number and spacing of stations, which are located for maximum CBD coverage.

To estimate possible diversions to DPM for each of the five trips listed above, a de facto "maxizone" structure is used in which each zone, in general, corresponds to each DPM station. Trips are allocated to each zone by use of the activity density gradient. Then the average non-DPM trip between each pair of stations is compared in terms of costs and travel times with that trip if taken by DPM. A percentage of the trip interchange volume for that pair, which corresponds to those portions of the zones for which the DPM holds an advantage, is then allocated to DPM.

Several other assumptions are used to simplify the analysis. Of particular importance are the assumed values of time that are used to convert trip times and costs to equivalent units for comparison of the impedances, or disutilities, of alternative modes. These were taken from the literature rather than derived from equations or models estimated for this study. The set of values used is given in the table below.

	Walking Costs		Automobile User Costs	
Mode	($/min)	($/h)	($/min)	($/h)
Transfer or ascend escalator	0.05	3.00	0.08	4.80
Wait	0.03	1.80	0.05	3.00
Ride	0.02	1.20	0.03	1.80
Walk	0.05	3.00	0.08	4.80

Figure 1. Regional CBD trip ends.

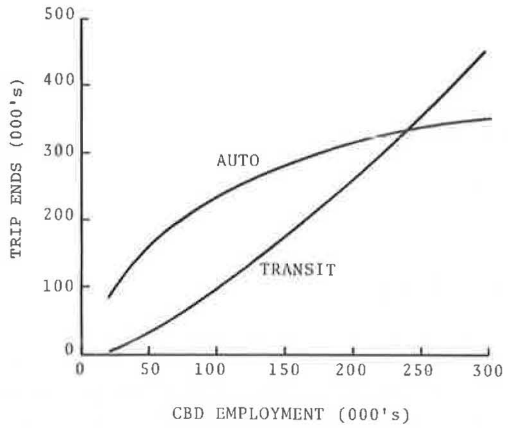
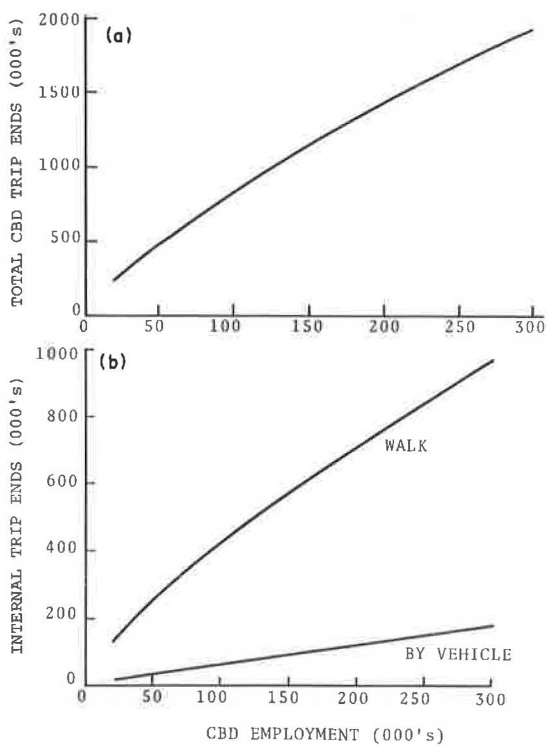


Figure 2. (a) CBD trip ends; (b) internal trip ends.



DPM daily ridership figures are calculated for different sized downtowns by parametrically varying the system configuration variables and three service variables—headway, vehicle speed, and fare. The estimates are unconstrained by any capacity considerations related to automobile parking or to the DPM system itself.

TRIP GENERATION ESTIMATES

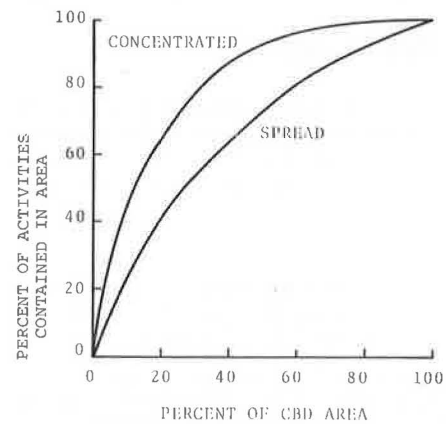
The trip generation estimation procedure was designed to yield trip volumes in the five trip categories listed above. The first step involved the estimation of regional CBD trips for automobile and transit, that is, trips that have one end external to the CBD and the other end inside the CBD. Several relations were developed by use of simple least squares regression techniques. These include (a) the use of CBD employment and floor space data, (b) the direct estimation of trip ends versus intermediate computations of transit mode shares, and (c) combinations of the data. Empirical data from about two dozen CBDs of widely varying characteristics were used to develop these relations. Estimates based on each yielded similar results; most correlation coefficients (r^2) were in the 0.80-0.90 range. Figure 1 shows the regional CBD trip ends by automobile and transit for a range of CBD employment up to 300 000. The share of transit trip ends increases rapidly for larger CBDs.

The second step was to estimate the total number of internal trip ends, that is, trips that both begin and end in the CBD. This was done by use of trip-end rates for three types of CBD floor space (office, retail, and other) to first estimate all trips that have at least one end in the CBD. Average values of total floor space, percentage of floor space by type, and trip-end rates were used and, where data indicated, varied with CBD size. Trip ends are summed and plotted in Figure 2a. Internal trip ends were then derived by subtracting the regional CBD trip ends from the total CBD trip ends.

The final step in the trip generation process was to split the internal trip ends into trip ends by walking only, automobile, and transit. An apportionment was made first between walking trips and vehicle-mode trips, again by use of trip rates for floor space by type. These trip ends are shown in Figure 2b. The vehicle-mode trips were then split into automobile and transit modes by use of average transit mode shares by size of CBD based on data from about 10 cities. Transit shares ranged from about 60 percent for CBDs of 300 000 employees to about 10 percent for the smallest CBDs considered.

In this part of the study some of the weaker techniques of modeling are employed (2), namely, the use of long chains of calculations and the use of differences between numbers of the same order of magnitude. Nevertheless, the results seem reasonable, internally consistent, and appropriate for the intended effort.

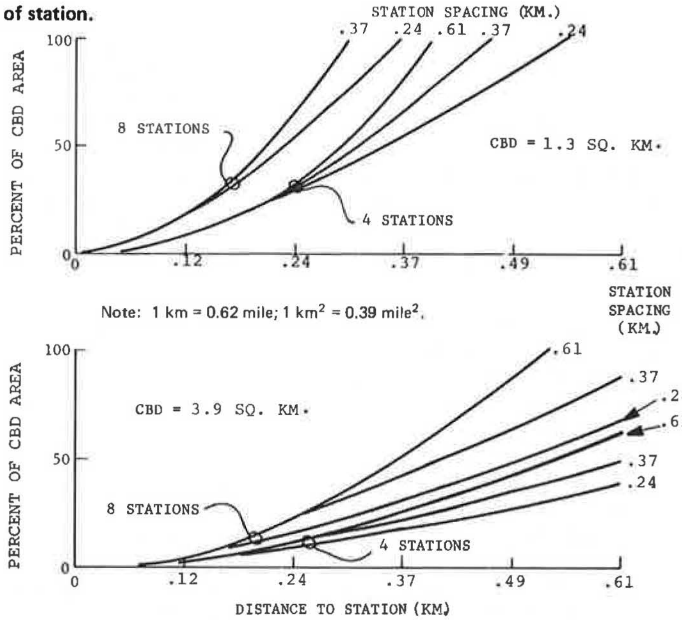
Figure 3. Activity estimation.



TRIP DISTRIBUTION PROCEDURE

The very simple procedure for allocation of trips to the DPM station maxizones is illustrated in Figures 3 and 4. Figure 3 describes, for two types of CBD density distributions, a cumulative distribution of activities for a given fraction of the CBD area. For example, the spread activity curves indicate that the densest 20 percent (in area) of the CBD contains 40 percent of the activities, and the next densest 20 percent contains about 20 percent of the activities in the CBD. The curves are based on small-area data from 10 cities where activities are measured variously by jobs, floor space, or trip destinations. These curves are used to estimate the

Figure 4. CBD area within given distance of station.



share of CBD activities in a maxizone by the area of the maxizone and its density ranking compared to the other maxizones.

Figure 4 shows sample curves that describe, for two CBD area sizes, two sizes of DPM systems, three station spacings, and the percentage of the CBD area within a given distance of a DPM station. The coverage curves were derived geometrically, assuming that the stations are located to provide maximum area coverage, i.e., minimum overlap. The full set of coverage curves (given in the DPM planning report), and to some extent the samples of Figure 4, indicate graphically how the coverage can be increased by either increases in the number of stations or increases in the station spacing (the latter of which increases the total guideway length). The larger the number of stations in a given CBD area, the smaller is the range of potentially cost-effective station spacings available to choose from. This is because systems that have many stations may not physically fit into a given area if the station spacings are large. On the other hand, many stations spaced close together will result in substantial overlap in coverage.

Allocation of trips to the station maxizones involves use of the two figures as follows. If a 4.35 km² (1.7 mile²) CBD has four stations at 366-m (1200-ft) spacing, each station, for simplicity, would have equal area coverage of about 12 percent of the CBD [within 610 m (2000 ft) of the station]. In the spread activity curve of Figure 4, the station located in the densest part of the CBD is assumed to have access from 26 percent of the CBD's activities, the station located in the next most dense maxizone, 21 percent (47-26), the third station 13 percent, and the last station 11 percent. The percentages of trips are assumed equivalent to the percentages of activities thus located.

ESTIMATES OF DIVERSION TO DPM

Estimates of trips diverted from other modes to the DPM system are calculated separately for each of the five trip categories. All estimates are first developed in terms of percentages and then applied to the aggregate trip volumes to yield DPM trips. The diversion calculation procedures are similar in that each requires a comparison of the non-DPM (automobile, transit, or walking) trip with that of a DPM trip for the same origin-destination pair.

Diversion of Regional Transit Trips

The knowledge of how trip ends are distributed about stations can be used to calculate the share of transit passengers likely to use the DPM if the destinations of the regional transit passengers are known. For example, the regional transit interface might be a central delivery point or it might be at one or more DPM stations at the fringe of the CBD. Also, walking is assumed to be the only alternative to DPM for the maxizone destinations, since any local CBD transit would be redesigned to avoid duplication with the DPM service.

The total DPM time and cost in dollars from a transit transfer station to a DPM destination station can be calculated by use of the values of time shown in the in-text table and a set of base DPM operating conditions and assumptions, such as headway (2 min), maximum vehicle speed [16 km/h (10 mph)], acceleration/deceleration [40 (km/h)/s (25 mph/s)], and no fare. This cost function does not include the access walk at the destination station.

The time cost for the walk-only trip can be calculated in a similar manner. Now the difference in the two cost functions represents the amount of walk at the destination DPM station of the DPM trip that would make the total costs of the DPM trip and walk-only trip equal. The data used to draw the curves of Figure 4 can be used to convert this break-even to the percentage of trip ends for which the DPM holds an advantage. If this procedure is performed for all relevant pairs of stations and all trips are added, the total number of transit diversions can be computed.

Figure 5 shows sample curves of transit diversions as a function of station spacing for two sizes of CBDs, two sizes of DPM systems, two-CBD density distributions, and alternative assumptions about where the transit system interfaces with the DPM system. A number of observations are suggested by the full set of curves (presented in the DPM planning report).

Short station spacings may be very inefficient. Spacing of 244 m (800 ft) generally attracts less than half the number of passengers of 366-m (1200-ft) spacings but requires two-thirds of the route length. However, if station spacing is increased beyond 366 m, the diversion rate begins to show diminishing returns. For systems that have many stations or in CBDs of small land areas, the diminishing returns become evident at shorter station spacings.

Similar route lengths produce similar diversion rates. More stations for the same route length produce only marginally more diversion.

In many cases, an increase in the number of stations may be desirable. For example, for a CBD land area of 2.6 km^2 (1 mile^2), eight stations achieve more than double the diversions of four stations, at least at lower station spacings. At the higher spacings, doubling the number of stations from four to eight remains efficient if regional transit users are delivered to a central point, but for the fringe delivery, returns diminish.

Delivery of all transit passengers to the fringe for transfer to the DPM will always produce greater diversions to the DPM than will a central delivery arrangement. In reality, it is exceedingly difficult to intercept all transit passengers at DPM stations since they arrive from many directions. Further, interception is not particularly desirable since many transit passengers may be forced to travel in a less direct manner. Nevertheless, the number of transit passengers who transfer to the DPM will be largely determined by the manner in which the existing line-haul transit system is modified to create the necessity for that transfer.

Comparison of the central delivery system to the more realistic 50 percent fringe delivery arrangement suggests that the former will work better for spread CBD distributions and for the larger systems.

The sensitivity of transit diversions to vehicle speed, headway, and fare was calculated. Representative results are plotted in Figure 6 for a CBD of 2.6 km^2 (1 mile^2), 8 stations, and a spread CBD. The following observations can be drawn from the sensitivity results.

Under any conditions, increase in maximum DPM vehicle speeds from 16 to 32 km/h (10 to 20 mph) diverts very few additional passengers to the DPM. This occurs because maximum speeds affect only the in-vehicle portion of the total DPM trip, which is a small share of its price to the user. Furthermore, the higher maximum speeds are diminished by frequent stopping and starting of the system.

The impact of more frequent service also has a limited effect. Doubling of frequencies [i.e., reductions in headways by half from 2 min (base condition) to 1 min] decreases the waiting time for the DPM passenger by only 30 s, again only a small portion of the total price of the DPM trip. Reductions in service frequency by half (i.e., doubling of headways from 2 min to 4 min), also produce quite modest differences in the diversion rate.

The imposition of fares has a sizable effect on diversion to the DPM. The percentage of reductions in ridership if the $0.25 fare were imposed appears to be greater for the smaller systems. Since smaller systems are more likely to be planned for smaller CBDs, this tends to confirm the finding reported elsewhere that fare elasticities tend to be larger in smaller metropolitan areas. The magnitudes of differences between no-fare and fare systems also conforms to the evidence that ridership doubles for CBD systems when fares are eliminated.

Operating changes generally have more impact on the central delivery arrangement than on the fringe delivery arrangement. This apparently occurs because most transit users delivered to the fringe are sufficiently far away from their trip end locations to require another mode. Those delivered to the center will be more sensitive to the characteristics of the DPM because they have generally shorter walks to their final destinations.

Diversion of Regional Automobile Trips

The methodology for determination of diversion of regional automobile trips is similar to that used for regional transit diversion. Several other variables per-

Figure 5. Regional transit users diverted to DPM.

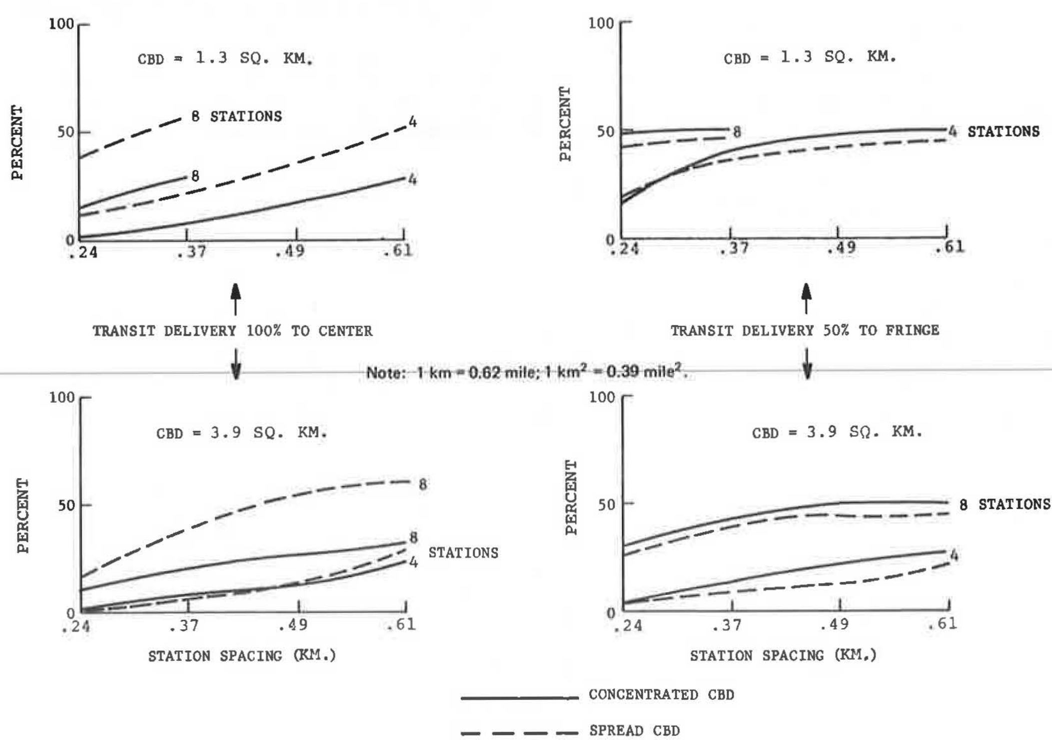
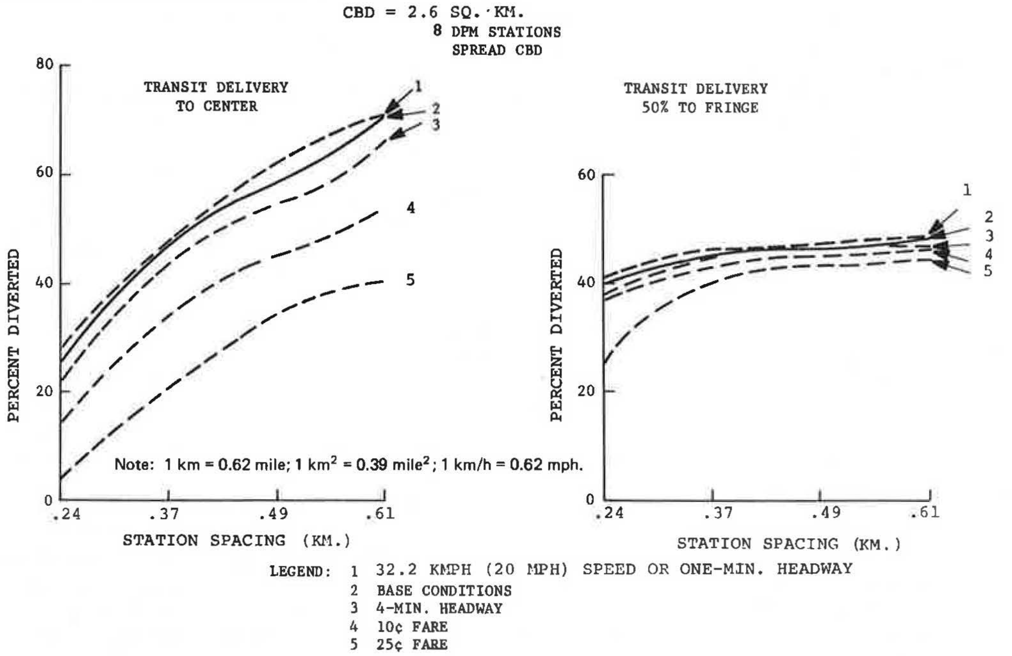


Figure 6. Transit diversion sensitivity to operating assumptions.



tinent to the automobile trip, such as CBD and DPM parking charges and automobile speeds in the CBD, are derived for the analysis on the basis of CBD size. Other assumptions relate to those automobile users whose parking is subsidized (assumed to be 20 percent of all automobile users), and how accessible the highway system is to DPM stations (assumed variable).

The complex interplay of the relationships that contribute to the diversion of automobile users suggests a number of observations relevant to the planning of a DPM system.

Each CBD configuration (jobs-area-distribution combination) appears to have a DPM configuration that can maximize diversion of automobile users to a DPM. This occurs because systems that are too small may not capture travel to a high proportion of CBD activities, and ambitious systems that have many stations and longer station spacings may lose riders who would have to spend excessive amounts of time on the system.

A CBD that covers a large area will require a larger system to reach the same diversion rates as a CBD of small area, but with the same overall amount of activities. For example, the 300 000-job, 8.9-km^2 (96-million ft^2) CBD could conceivably divert over 70 percent of automobile users to a four-station system if the CBD is contained in 1.3 km^2 (0.5 mile^2). However, if the area of the CBD is 3.9 km^2 (1.5 miles^2), eight or more stations that have longer spacings are required to achieve the same diversion rate.

A more concentrated CBD generally diverts more automobile users to the smaller DPM systems (4 stations). The reverse seems to be the case for larger systems (12 stations). This occurs because a small system can more efficiently service the fewer centers of activity in a concentrated CBD, but a spread CBD requires a more extensive system to service its more scattered locations.

High-activity CBDs can divert a substantial portion of all automobile users; low-activity CBDs can divert relatively few. This occurs largely because parking costs are usually sufficiently low in low-activity CBDs that there is little incentive to avoid them.

The most dramatic differences in diversion rates for automobile users occur as a result of the placement of sufficient parking areas at fringe DPM stations. Four well-placed stations around the fringe of the CBD that have good highway access may produce diversions several times as great as will one such station.

Sensitivities of automobile diversions to varying operating assumptions were tested. General observations from sensitivity testing showed that very high-activity CBDs show only minor changes in diversion rates for variations of operating conditions. This occurs because most automobile users found use of the DPM system overwhelmingly advantageous and the changes postulated made little difference. For very low-activity CBDs, the diversion rates also change very little. This is so because these automobile users found use of the DPM system overwhelmingly disadvantageous and the postulated changes made little difference.

CBDs in the middle range of activity show greater variation in diversion rates. This occurs because the choice of using the DPM is often not that clear-cut and small differences can tip the potential rider's decision in one direction or another.

As with transit users, automobile users will be most influenced by changes in fare; a $0.10 change in fare has considerably more impact than doubling speeds or doubling or halving headways.

Diversion of Walking Trips

The same procedure was used to determine diversions of walking trips to DPM as was used for regional trips. A major consideration in the walking trip analysis is the variation of trip lengths with CBD size: the larger the CBD, the greater proportion of long walking trips. The walking trip-diversion analysis yields the following suggestions.

A DPM seldom attracts more than one-third of all walking trips. This occurs because a large share of such trips are for very short distances when the savings in time and convenience of using the DPM cannot be realized.

CBDs that have more activities will attract a larger share of walking trips to a DPM. This occurs because walking trip lengths are generally longer in such CBDs, so the choice of a DPM is relatively more attractive. CBDs where activities are concentrated will attract a larger share of walkers to the DPM than will spread CBDs. This occurs because a concentrated CBD is more likely to have a larger share of its trip ends located near a DPM station, which results in short walking links to the station. The concentrated CBDs, in general, have diversion rates that are at least one-third higher.

CBDs small in area divert walkers at a greater rate than CBDs of larger size but with the same amount of activity. This finding is intuitively logical because a larger share of trip ends is likely to be within a short walk of a DPM station if the CBD is small in area. Diversion rates generally increase at least in direct proportion to the increase in the number of DPM stations.

As the spacing between stations increases, diversion rates for a fixed number of stations increase, up to a point. In most cases, maximum diversion appears to take place at a station spacing of about 487 m (1600 ft). This occurs because at very short station spacings the DPM will be unable to reach a large share of activities, and at very long station spacings potential users will find the access walk to or from the DPM station excessive.

A sensitivity analysis of operating characteristics on walking trip-diversion rates produced the following observations. Variation of service characteristics of speed and headways within the range tested do not alter the diversion rates dramatically. They do, however, result in modest but significant shifts in relative terms. The increase of speed to 32 km/h (20 mph) adds 1 or 2 percentage points to the diversion. In effect this would increase ridership among walkers up to at least 20 percent. The reduction of headways to 1 min has slightly less impact, but an increase in headways to 4 min lowers the diversion rates in more or less an equal but opposite direction. The imposition of a fare causes a dramatic drop in the diversion rates. A $0.10 fare tends to lower the diversion rates up to half; a $0.25 fare lowers the rate by two-thirds or more in every case.

Diversion From Local Transit

To determine the extent to which the DPM can divert trips from the local bus system, we assumed that the DPM system replaces bus routes that run on the same street, and that, at least in the central portion of the CBD, the existing bus routes operate in a tight grid pattern, run on every street, and stop every 122 m (400 ft).

General conclusions of the local transit diversion analysis were similar to those of walking trips:

1. CBDs of greater activity divert a larger share of trips,
2. CBDs of larger land area divert a smaller share of trips,
3. Concentrated CBDs divert a larger share of trips than do spread CBDs,
4. DPMs attract trips in direct proportion to the number of stations, and
5. Diversion rates increase when spacing between stations is longer but returns are greatly diminished.

Of more interest is that the diversion of internal transit trips to a DPM is very sensitive to the operating policies assumed. This is because the competition in this case, the local bus, has similar, directly comparable features. Small changes can easily tip the scales toward one mode or the other. That was not the case for diversion of regional automobile trips, where the cost of parking in the central CBD and the availability of fringe parking near a DPM station weighed more heavily than DPM system's operating characteristics. And this was not the case for walking trips, where trip length largely determined diversion rates.

Eight combinations of operating variations, which represent different advantages of the DPM over local bus service, were tested. It was determined that the DPM will attract no internal transit trips when the only advantage is headway or when speeds are only 32 km/h (20 mph). In fact, the headway advantage and a high-speed system together will not attract passengers under most circumstances. A fare differential is required to attract local bus trips and to attract more and more passengers as the system becomes larger. Furthermore, with a fare differential, the other DPM advantages begin to have an impact; the fare advantage combined with either higher speed or closer headways increases the DPM diversion rates by almost two times. The combination of all three advantages produces a still more potent impact and diversion rates of about three times are achieved.

The synergistic effect that the relative headway and speed improvements can have when combined with the fare differential requires some explanation. Without the fare difference, the other advantages can barely, if at all, overcome the negative impact of the pedestrian change in grades of an elevated DPM. Consequently, the break-even walking distances around the DPM stations are minuscule, and few trips are captured. When the fare differential is $0.25 and the break-even walking distances are longer and cover a wider area, any further improvement (headways or speeds) expands the covered area as the square of distance and the diversion rate is consequently increased.

Diversion of Internal Automobile Trips

The diversion to DPM of internal automobile users is determined by assuming that this group is composed of three types of trip makers:

1. The regional automobile user who diverts to a DPM at the fringe and then behaves like a transit user for the internal trip;
2. The nondiverted regional automobile user who pays for parking but who values comfort and convenience highly; and
3. The regional automobile user who is assumed to be nondivertible because parking costs are reimbursed or because the use of automobile for multistop shopping or business provides an overwhelming convenience over every form of public transit.

The first group is handled in the same manner as local transit users. The second group's diversion is determined by the usual trip time and cost comparison method, which yields the break-even walk distances for DPM use. The third (nondivertible) group is simply assumed to represent 20 percent of the total.

The implications of the local automobile diversion analysis are similar to those of other trip-making categories. An important point is that the vast majority of diverted automobile trips comprise those who left their automobiles at the fringe and become captive transit riders for their internal trips. This diversion, then, depends on constraints of fringe parking location and capacity.

Induced DPM Demand

Up to this point, the only DPM demand explicitly considered is that generated by existing land use and diverted to the DPM. New development activity at particular sites would, of course, generate potential DPM trips that should be considered in forecasts. These induced trips will occur if the DPM enables a trip to be made that was very difficult via existing modes, such as trips that require either excessive time unavailable to the potential trip maker (lunch hour shopping trips) or high costs and great inconvenience. Most of these trips will probably be internal CBD trips; regional CBD trips are less spontaneous because of their greater length. Also, since the DPM represents a small portion of a longer trip, regional CBD trips are less likely to be induced by a new DPM that serves a small segment of the total trip.

IMPLICATIONS FOR PLANNING

DPM ridership potential will be greatest in CBDs that have the greatest activities for three reasons:

1. In larger CBDs, a greater share of those traveling to the CBD are already transit users and divertible to the DPM;
2. The contrast in the cost of parking in the CBD core and the cost of parking at the DPM fringe stations will be greater in the larger CBDs, thus providing more incentive to divert to the DPM; and
3. The number of walking trips is significantly greater in larger CBDs and the lengths of those trips are longer there.

Thus, the DPM would provide greater benefits for a larger number of walkers in larger CBDs. The full potential of the DPM in any CBD, whatever the size, depends on a number of factors. To divert regional transit passengers, the transit system must be arranged to feed the DPM at the fringe of the CBD. For existing transit systems that are fixed, the interface between their CBD stations and the DPM are also critical. Diversion of substantial numbers of regional automobile users depends on the provision of sufficiently large parking areas at fringe DPM stations, which are located strategically near the highway network. Finally, the operating characteristics and policy of both the DPM and existing internal transit systems, usually bus, is critical. Ridership will be especially sensitive to the DPM fare. If the fare is set low, many passengers will be attracted, particularly if fare levels are kept higher on the preexisting transit mode. Considerably less important in attracting more DPM riders are very high DPM speeds or very low DPM headways. This finding suggests that the DPM need not be highly sophisticated technologically to be a constructive addition to the urban scene.

ACKNOWLEDGMENT

The study from which the material in this paper was taken was sponsored by the Urban Mass Transportation Administration under grant funding to the Regional Plan Association from the Office of Policy Research and under project funding to the Transportation Systems Center from the Office of Planning Methods and Support. The conclusions discussed in this paper are our own and, of course, do not necessarily represent the views of the U.S. Department of Transportation.

REFERENCES

1. Planning for Downtown People Movers. Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, Draft Rept., Feb. 1979.
2. W. Alonso. The Quality of Data and the Choice and Design of Predictive Models. HRB, Special Rept. 97, 1968, pp. 178-192.

Discussion

Steven E. Shladover, Systems Control, Inc., Palo Alto, California

The paper represents an important attempt to quantify the potential ridership of a DPM system that must compete with other modes. However, the authors appear to have made some implicit geometric assumptions that are so strong as to make their results difficult to believe. Moreover, some of these results are presented in a form that is likely to lead the reader to draw unwarranted conclusions.

The authors' description of a DPM system includes the number of stations and the station spacing as the principal independent variables. The DPM system's area of coverage (fraction of CBD within a specified allowable walk-access distance) was derived by assuming that the stations are located so as to provide maximum area coverage and no overlap. However, neither the geometry of the station service areas, the relative locations of the stations, nor the guideway alignments were specified. This is a serious oversimplification, particularly when the DPM system is designed to contain more than a very few stations. In order to produce realistic estimates of passenger travel and wait times (number of intermediate station stops), explicit assumptions must be made about guideway alignment, network topology, and service policies. The authors' implicit assumptions unfairly penalize systems that have a larger number of stations, which could be expected to offer more sophisticated service policies on more highly connected networks (such as skip-stop or alternate routes). The conclusion that increasing the number of stations reduces the DPM modal split without qualifying that observation by the simplifying assumptions they have made is thus misleading.

A highly aggregate analysis, such as that presented by the authors, produces some very strange implicit assumptions about service area geometry and network topology, especially if all stations are assumed to be located on a single closed loop or extended shuttle. Indeed, it appears (based on the final paragraph of the section entitled Trip Distribution Procedure) that the authors have implicitly assumed their station maxizones to be annular. This would produce some rather odd walk-access trips. The minimum-walking-distance station service areas, in a CBD having a rectilinear street grid, should be diamond-shaped, as I have demonstrated (3), which incorporates an explicit geometric representation of a DPM-like network.

The results and conclusions presented in the paper did not clearly distinguish among the effects produced by changes in the different independent variables. Particular problems were in distinguishing among the effects attributable to station spacing, number of stations, and area coverage. The authors drew very different conclusions about the effect of the number of stations on diversions of walking trips and transit trips without explaining the source of the difference. In the discussion of walk-trip diversion, the authors note that diversion rates increase (up to a point) as the spacing between stations increases, for a fixed number of stations. The increase they observe could be just as easily (and probably more justifiably) attributed to the increased length of the system, which will provide walking accessibility to more of the CBD. Had the guideway length been held constant, and the spacings and number of stations varied, the effect of station spacing on trip diversions would have appeared to be reversed.

The same problem of choosing which parameters to hold constant is the source of the intuitively unappealing trend of increasing diversions with increased station spacings shown in Figure 5. A reader could easily conclude from that figure that the best way to increase DPM ridership is to locate stations as far apart as possible, since the increasing ridership trend on that figure is the strongest of any presented in the paper. This, of course, disregards travelers' willingness to walk and walk-refusal distances. Would it not be less potentially misleading to present that figure with guideway length as the independent variable, or to replot the results for constant guideway length, with station spacings and number of stations varying?

There is a very real need for the development of planning tools that can be used to design DPM systems. The demand-related aspect of the work reported in the paper appears to be a worthy contribution toward filling this need, but the supply modeling seems to have suffered from some overly generalized geometric assumptions. Combination of the demand analysis reported here with a more geometrically specific supply analysis such as I suggested in another article (3) would produce a significantly more powerful DPM design tool. The results derived by use of such a DPM design tool need to be presented so that the significance of the respective independent and dependent variables is made unmistakably clear to avoid possible misinterpretations.

REFERENCE

3. S. E. Shladover. Activity Center Circulation: The Competition Between Automated Guideway Transit and Pedestrianization. Transportation Research, Vol. 11, No. 4, Aug. 1977, pp. 265-278.

Authors' Closure

The discussion is useful on two grounds: It ventilates some of the problems associated with the complexity of DPM system design and it provides the opportunity for us to clarify the possible misconceptions arising from the paper and omissions therein.

Let us handle the omissions and misconceptions first. Our analysis assumes that (a) the station coverage areas are diamond-shaped, not annular, which is indeed a necessary assumption for a grid street pattern; (b) stations are spaced equally, for to do otherwise would be unnecessarily complex and unmanageable; (c) guideways are aligned either as a loop or a shuttle; (d) stations are located to maximize coverage, which could, nevertheless, lead to overlap, particularly if there are a large number of stations, spaced close together; and (e) service is provided without skip stops, alternate routes, or other sophisticated arrangements, a reasonable assumption for the first wave of DPMs.

The explanation for the very different patterns of DPM diversions among walking trips and line-haul transit trips with respect to station spacing, number of stations, and coverage, lies in the fact that the walking trips diverted to the DPM involve two new walk links, access and egress, but the transit trips diverted involve only one. This occurs because the transit station and DPM station are located at the same point.

The discussant is quite right that the use of the system length as a variable in the graphics would add another valuable dimension to the paper. Indeed, longer system length would provide added DPM accessibility for walk trips, albeit with the danger of diminishing effectiveness. Unfortunately, in the interest of brevity, only a sampling of the derived relationships are shown.

The full report, which this paper summarizes, provides an estimate of DPM demand for 504 explicit combinations of DPM and CBD characteristics, including system length, for each of five categories of demand. From these, serious evaluation of alternative DPM configurations can take place. In addition, six DPM service alternatives, two line-haul transit arrangements, and a spectrum of highway configurations are treated in the analysis. We hope that a reading of the full report will remove any unintended misinterpretations that emanated from the necessarily telescoped version presented here.

Publication of this paper sponsored by Committee on Transportation Systems Design.

Development of Efficient Central Management Strategies for Advanced Group Rapid Transit Systems

Waheed Siddiqee and Peter J. Wong, Transportation and Industrial Systems Center, SRI International, Menlo Park, California
Norman R. Nielsen, Information Science Laboratory, SRI International, Menlo Park, California

This paper presents a summary of a computer-aided method for developing efficient central management system strategies for advanced group rapid transit systems by use of medium-sized, automatically controlled vehicles that travel on dedicated guideways. Some efficient central man-