Bus Route-Level Demand Modeling

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The need for improved techniques in the area of bus route-level demand modeling is discussed, and a summary of the existing state-of-the-art methods used throughout the transit industry is provided. A working example of a modeling technique for local radial bus routes in Cleveland, Ohio, which was funded by the Office of Planning Assistance of the Urban Mass Transportation Administration, is presented.

For some time now, the Urban Mass Transportation Administration (UMTA) has equipped the transit planning community with an extensive set of computer programs designed to aid in the long-range planning of multimodal urban transportation systems. The bulk of the UMTA Urban Transportation Planning System (UTPS) deals with projecting the level of patronage that will be realized from alternative system considerations. Although UTPS has been invaluable in the design and study of fixed-guideway proposals throughout the country, it has not been used to any great extent in the design or planning of short-range bus route-level improvements. Consequently, individual transit properties have been left to fend for themselves in the development of in-house techniques to predict the impact on system ridership of new and/or extended bus routes as well as changes in the level of service provided on a given route.

Recognizing the need for improved techniques for projecting bus route-level ridership, the UMTA Office of Planning Assistance has recently initiated and funded a series of four short-range ridership projection study efforts by using data from the following cities:

City	System
Albuquerque, New Mexico	SUNTRAN
Cleveland, Ohio	Greater Cleveland Regional Transit Authority
Los Angeles, California	Southern California Rapid Transit District
Portland, Oregon	Tri-County Metropolitan Transportation District of Oregon

The need for simplified and accurate techniques for estimating bus route-level patronage is reflected in the changing priorities brought on, in part, by the funding philosophy dictated by the policies of the "New Federalism". With most major highway and transit facilities in place, interest has grown in management-oriented or transportation system management improvements, which are designed to improve the efficiency and increase the productivity of existing services. Therefore, it is imperative that any future bus-route expansions to the nation's transit systems must generate a sufficient level of ridership and/or farebox recovery so as not to further deplete already dwindling transit service resources. In other words, transit systems today do not have sufficient "risk" capital to operate new or extended routes where the incremental ridership gains fall far below passenger projections and minimal service performance standards.

SURVEY FINDINGS

As part of the study effort for Los Angeles, Multisystems, Inc., researched the state of the art in route-level demand modeling. In addition to an extensive literature search on the subject, 40 transit properties in the United States and Canada were surveyed to determine what, if any, in-house techniques were used to project ridership on route-level modifications. This survey indicated that the methods currently used to project route-level ridership changes fall into one of the following four categories:

1. Professional judgment, based on the judgment of one or more of the property's operations analysts;
2. Noncommittal survey techniques, where potential riders are asked directly if they would use a proposed service;
3. Cross-sectional data techniques, which examine the relation between transit use and a range of characteristics of the service and populations to be served; and
4. Time-series data techniques, which compare changes in ridership as service changes over time.

Despite the diversity of the different ridership projection techniques that fall into these four general categories, the survey results enable one to draw the following conclusions with respect to state-of-the-art techniques used throughout the industry:

1. The accuracy of existing techniques is open to question because very few empirical tests have been performed in which estimates of ridership made before implementation of a route or route modification were compared with the actual resultant ridership.
2. The application of the various techniques is done in an informal rather than a formal manner. Consequently, it is not known whether one analyst can replicate the predictions of another, given the same data base.
3. Inasmuch as the accuracy of the various techniques is not known and the processes are not formalized or well documented, there is little opportunity for transferability of techniques from one city or geographic area to another.

Thus, the survey illustrates a need for the development of short-range ridership projection techniques that meet the following criteria: (a) demonstrated accuracy, (b) formalized application and documentation, (c) low cost of application, (d) minimal technical sophistication, and (e) transferability among urbanized areas.

CLEVELAND EXPERIENCE

Although the Cleveland study effort is still not complete, it has become apparent that no single model can be used to accurately project ridership for all of the different types of service operated in the Cleveland area. Consequently, a series of models are being developed that are individually sensitive to the unique characteristics of the different types of service under consideration--e.g., local radial, crosstown, express radial, and rapid feeder.

Rather than discuss the development and calibration of the models at great length, it may be more useful to go through a sample validation of ridership on a local radial route to demonstrate the application of the model for this type of service.

Model Application

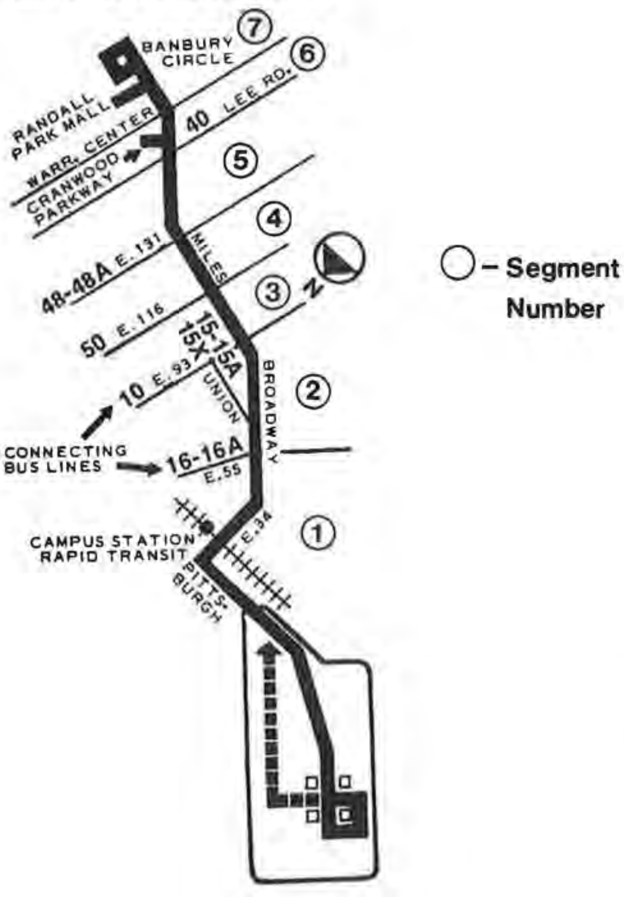
The data requirements for use of the model are as follows:

1. Map of route,
2. Socioeconomic data at traffic zone or census tract level,
3. U.S. Geological Survey (USGS) or land use maps,
4. Bus-route travel times,
5. Land use and/or employment data at traffic zone or census tract level, and
6. Schedules and ridership data for intersecting routes.

The steps in using the model are as follows:

1. Divide the route into segments,
2. Determine the market area for individual segments,
3. Determine the mean income for route-segment market areas,
4. Determine the home-based transit trip rate,
5. Calculate the home-based transit trips,
6. Calculate transfer trips, and
7. Distribute trips.

Figure 1. Route 19 bus-route segments.



The example used here is bus-route 19, Broadway-Miles, a radial route in Cleveland.

Step 1: Divide Route into Segments

In step 1, the route is divided into logical segments based on major intersections and transfer points. Segment divisions for Broadway are as follows (see Figure 1):

Segment	Boundaries
1	Public Square to East 55th Street
2	East 55th Street to East 93rd Street
3	East 93rd Street to East 116th Street
4	East 116th Street to East 131st Street
5	East 131st Street to Lee Road
6	Lee Road to Warrensville Center Road
7	Warrensville Center Road to Banbury Circle

It should be noted that intersections are assigned to the lower of the two adjacent segment numbers (i.e., passengers boarding at the Miles-East 131st Street intersection are included in segment 4).

Step 2: Determine Market Area for Individual Segments

In step 2, the market area for each route segment is determined. Northeast Ohio Areawide Coordinating Agency (NOACA) socioeconomic data or U.S. Census data at the block or tract level can be used. NOACA traffic-zone data are used in this example.

The market area for the bus route is defined as the area within 0.25 mile of the route. The number of households within that area is determined by the following procedure:

1. Determine the traffic zones that are located within 0.25 mile of each route segment.
2. If some of the zone is within 0.25 mile of the route and some of the zone is not, determine the percentage of the zone that is within the market area.
3. If a zone is partly in one route segment and partly in another, determine the percentage of the zone that is in each segment.
4. Determine the percentage of the zone within each segment by multiplying the two percentages from steps 2 and 3. In other words, if 40 percent of traffic zone i is within the route market area (within 0.25 mile) and 50 percent of that portion of the zone is within the segment A market area, then the proportion of traffic zone i households in market area of segment A = (0.5) x (0.4) = 0.2, or 20 percent. Figure 2 shows this process.

Figure 2. Traffic-zone segmentation.

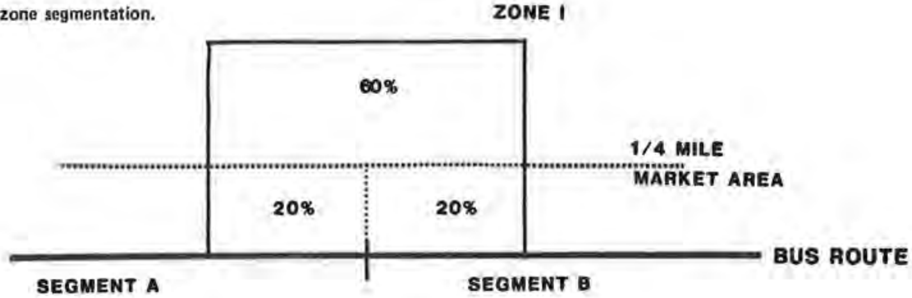


Figure 3. Partitioning of zonal land uses.

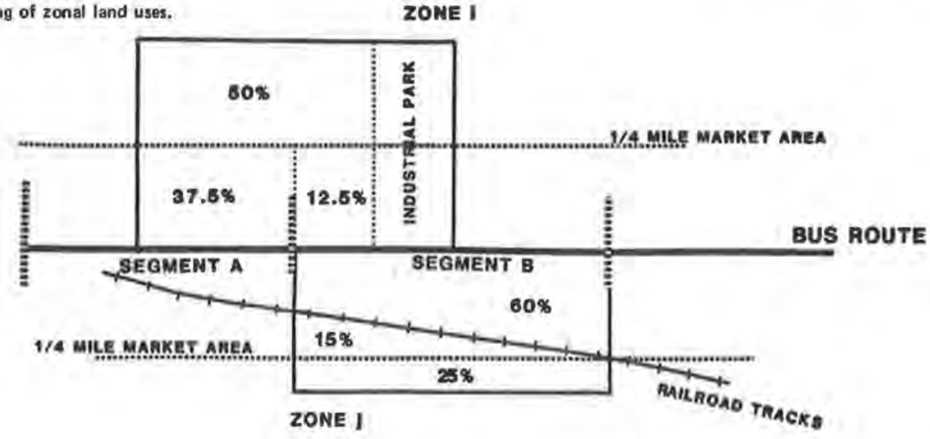


Table 1. Number of households in bus-route market areas.

Segment	Traffic Zone	No. of Households in Traffic Zone	Zone Households in Route-Segment Market Area (%)	No. of Households in Route-Segment Market Area[a]
7	655	509	100	509
6	656	511	75	383
	525	692	48	332
	661	1142	42	480
Total				1195
5	660	564	33	186
	524	106	0	0
	620	1010	40	404
	521	309	22	68
	629	661	85	562
Total				1220
4	628	0	0	0
	630	1072	100	1072
Total				1072
3	503	682	85	580
	502	1287	83	1068
Total				1648
2	501	425	85	361
	507	1656	50	828
	500	105	100	105
	499	877	75	658
	491	1483	40	593
	492	1138	50	569
	493	719	90	647
	508	960	15	144
	494	797	30	239
	490	74	100	+74
Total				4218

[a]Determined by multiplying columns 3 and 4.

5. Use USGS maps to make sure that the percentage of residences in the route-segment market area is accurate. Empty land, industrial land, or major barriers such as highways or railroad tracks might require a revision of the percentage derived in step 4. This type of problem is illustrated in Figure 3. In zone i, 25 percent of the land area consists of industrial land use. Therefore, the division of residential land between the two segments must be modified. Fifty percent of the residential area is within the market area but, due to the location of the industrial park, 75 percent of that 50 percent is in segment A and 25 percent is in segment B. The calculation is therefore as follows: Segment A = (0.75) (0.50) = 0.375, or 37.5 percent of households in zone i; segment B = (0.25) (0.50) = 0.125, or 12.5 percent of households in zone i. In the case of zone j, 75 percent of the residential land in the zone is within the market area for segment B. However, 20 percent of that 75 percent is located beyond a railroad embankment and is inaccessible to the route. The percentage of zone j actually accessible to the route is (0.80) (0.75) = 0.60, or 60 percent of zone j is in the bus-route market area.

6. Residential market areas are calculated for all route segments outside the central business district (CBD). The CBD is always designated as route segment 1, and residential market areas are not calculated for the CBD area. This is because the CBD has little residential land use and also has its own circulation system, the loop bus. Thus, for route 19, the number of households in the bus-route market area for bus-route segments 2 through 7 is as given in Table 1.

Step 3: Determine Average Income for Route Segments

The income of residents in the bus-route market area will affect the rate of transit tripmaking. By using NOACA data on average income at the traffic-zone level for 1980, the average income for each route segment can be determined.

1. Find average income from the NOACA tables for each traffic zone. For bus-route segment 6, the figures would be as follows:

Traffic Zone	Mean Income ($)
656	14 010
525	14 314
661	14 607

2. Calculate a weighted average for the segment based on the number of households in each traffic zone, as given below for segment 6:

Traffic Zone	No. of Households in Bus-Route Market Area
656	383
525	332
661	480

The formula used is [(income x number of households for zone 1) + (income x number of households for zone 2) + ... + (income x number of households for zone N)] ÷ total number of households (zones 1-N); or, for route 19, segment 6,

[(383 x 14 010) + (332 x 14 314) + (480 x 14 607)]/ (383 + 332 + 480) = 14 334

Step 4: Determine Home-Based Transit Trip Rate

The number of home-based transit trips for each segment of the route is based on the average income of the segment and the frequency of service provided. The home-based transit trip rate is determined as follows:

1. Determine the income category of each segment based on the following breakdown:

Level	Amount ($)
Low	<10 000
Middle	10 000 to 14 000
High	>14 000

For route 19, average income and income level by segment are as follows:

Segment	Avg Income ($)	Level
7	11 414	Middle
6	14 334	High
5	10 945	Middle
4	10 164	Middle
3	10 126	Middle
2	9 085	Low

2. Determine the combined peak and off-peak service frequency for each route segment by using the following formula: combined frequency - (0.67 x peak frequency) + (0.33 x off-peak frequency). For segments 2-4, the average peak headway is 13 min and the average off-peak headway is 14 min. Segments 5-7 have less frequent service in the peak period (22 min) but run at 14-min headways in the off-peak. This unusual service pattern on segments 5-7 exists because the route serves a major suburban mall. For segments 1-4, the combined frequency is 13.3 = (0.67 x 13) + (0.33 x 14); for segments 5-7, the combined frequency is 19.4 = (0.67 x 22) + (0.33 x 14).

3. Equations are used to generate a home-based trip rate for each route segment. Based on the income category of the segment, the following equations are used for radial routes (in the final model, graphs will be available to determine the home-based trip rate):

Income Level	Equation
Low	0.78 - (0.221 x natural log combined frequency)
Middle	0.65 - (0.0232 x combined frequency)
High	0.015 - (0.0013 x combined frequency)

The rates for each segment are calculated in Table 2.

Table 2. Home-based trip rate by route segment.

Segment	Income Level	Combined Service Frequency	Calculation
2	Low	13.3	0.78 - (0.221 ln 13.3) = 0.78 - (0.221 x 2.588) = 0.238
3	Middle	13.3	0.65 - (0.0232 x 13.3) = 0.341
4	Middle	13.3	0.65 - (0.0232 x 13.3) = 0.341
5	Middle	19.4	0.65 - (0.0232 x 19.4) = 0.20
6	High	19.4	0.105 - (0.0013 x 19.4) = 0.08
7	Middle	19.4	0.65 - (0.0232 x 19.4) = 0.20

Step 5: Determine Number of Home-Based Trips

For each segment, the trip rate is multiplied by the number of households in the market to obtain the number of home-based trips in each segment:

Segment	Trip Rate	No. of Households	No. of Home-Based Trips
2	0.238	4218	1004
3	0.341	1648	562
4	0.341	1072	366
5	0.200	1220	244
6	0.080	1195	96
7	0.200	509	102

Step 6: Determine Number of Transfer Trips

In step 6, the number of passengers transferring onto the route in each segment is determined. It is assumed that passengers will transfer from crosstown routes to radial routes only, not from a radial to a radial. The number of passengers transferring is a function of (a) the total number of passengers on the crosstown bus at the transfer point and (b) the combined frequencies of the two routes. When a transfer point is located at the intersection of two route segments, the transferring passengers are loaded onto the segment closest to the CBD.

To demonstrate this technique, the transfers from routes 16-16A to route 19 (boarding in segment 1) are calculated:

1. Calculate the number of passengers on the crosstown route at the transfer point:

Route	No. of Passengers
16 Northbound	370
16-16A Southbound	680
16A Northbound	192
Total	1242

2. The combined service frequency for route 19, segment 1, was previously determined to be 13.3. The combined frequency for routes 16-16A can be determined from Greater Cleveland Regional Transit Authority (GCRTA) schedules. At Broadway the peak headway is 12 min and the off-peak headway is 15 min. The combined frequency is therefore (0.67 x 12) + (0.33 x 15) = 13.

The sum of the combined frequencies is 26.3, and is used in the following equation to determine the transfer rate.

Table 3. Transfer rate by route transfer points.

Segment	Crossing Route	Crossing-Route Frequency	Combined Frequency	No. of Passengers on Bus	Transfer Rate	No. of Transferring Passengers
2	10	18	31.3	635	0.070	45
3	50	18	31.3	335	0.070	24
4	48-48A	13.67	27.0	1548	0.089	137
5	40	16.3	32.6	267	0.065	17
6	41	25.0	41.3	466	0.036	17

Transfer rate = 0.498 - (0.1242 x natural log combined frequencies) = 0.498 - (0.1242 x ln 26.3)

or 0.092 = 0.498 - (0.1242 x 3.27). By taking the transfer rate (0.092) and multiplying by the number of passengers on the bus (1242), the number of transferring passengers is obtained: 0.092 x 1242 = 114. Thus, 114 passengers will transfer from route 16-16A and board the Broadway bus. Table 3 gives the number of transfers for each of the transfer points along route 19.

3. Transferring passengers are added to home-based boardings for each segment to obtain total one-way boardings:

Segment	Home-Based Boardings	Transfers	Total One-Way Boardings
1	0	114	114
2	1004	45	1049
3	562	24	586
4	366	137	503
5	244	17	261
6	96	17	113
7	102	0	102
Total			2728

Step 7: Distribute Trips to Other Segments

The next step is to determine where the boarding passengers are going. This will eventually make it possible to obtain total two-way boardings by route segment. The distribution is a function of the distance between segments and the level of employment in each route-segment market area.

1. For radial routes, the number of trips bound for the CBD is a function of travel time from the CBD. For each segment, the following equation is used:

Percentage of trips to CBD = 72.7 - (0.718 x travel time to CBD)

For segment 2, the travel time from the center of the segment to downtown is estimated at 16 min. The calculation therefore is 72.7 - (0.718 x 16), or 61.2 percent = 72.7 - (0.718 x 16). Thus, 61.2 percent of the passengers boarding in zone 2 will alight in zone 1 (the CBD). The other 38.8 percent will alight in one of the other zones. The CBD-bound trips for all zones are given in Table 4.

Table 4. CBD-bound trips.

Segment	Total One-Way Boardings	Travel Time to CBD (min)	Passengers to CBD		No. of Passengers to Other Segments
			Percent	No.	
1	144	14	90	62.6	54
2	1049	16	642	61.2	407
3	586	22	333	56.9	253
4	503	26	272	54.0	231
5	261	30	134	51.2	127
6	113	35	54	47.6	59
7	102	42	43	42.5	59
Total	2758		1568	56.8	1190

2. Each alighting will become a boarding later in the day. In other words, it is assumed that a person who travels to the CBD from segment 2 will make a return trip later in the day, boarding in the CBD and alighting in segment 2.

3. To determine the distribution of the non-CBD trips, the level of employment in each route-segment market area must be determined. The procedure used is similar to that used in step 2 to estimate the route-segment residential market area. The NOACA data base included a breakdown of commercial, industrial, and retail land use acreage for each traffic zone. NOACA also has data on employment densities for each zone and for different land uses.

Traffic-zone and USGS maps were used to determine the acreage within the 0.25-mile bus-route market area. With the data available, it was not possible to separate retail and commercial land uses. Therefore, two categories, industrial and retail-commercial, were used. USGS maps were used to locate industrial areas. Employment densities for the zone were then multiplied by land use acreage to determine the number of employees in the segment market area. An example for segment 3 of route 19 is given in Table 5.

In some cases, more specific information can be obtained. If a traffic zone includes only a major shopping mall, for example, specific employment data may be available from the mall. Where specific land uses can be identified, NOACA data on land-use-specific employment densities can be used. Strip commercial development, for example, is estimated to have 25-30 employees/acre, a measure that can be used instead of zone-specific densities. For route 19, estimates of employment for each route segment are given in Table 6.

4. The travel time between each segment on the route can easily be determined from the GCRTA schedules. For each segment, determine the travel time to all other segments except the CBD (segment 1). For segment 2, these times to other segments are as follows:

Segment	Time (min)
3	6
4	10
5	14
6	19
7	26

Travel within a segment is generally not estimated unless the segment is unusually large (>10-min travel time from end to end) because walking is competitive with transit for short trips.

5. For each segment, divide employment in all

Table 5. Land use acreage and employment density for segment 3.

Traffic Zone	No. of Acres		Acres in Market Area				Total Acres	Traffic-Zone Employees per Acre	Employees in Segment Market Area
			Industrial		Retail-Commercial				
	Industrial	Retail-Commercial	No.	Percent	No.	Percent			
503	9.5	9.9	9.5	100	9.9	100	19.4	23.6	458
502	43.2	13.8	21.6	50	6.9	50	28.5	26.1	744
Total									1202

other segments by travel time to those segments. For segment 2, the results are as follows:

Segment	No. of Employees	Travel Time (min)	Employment/ Travel Time
3	1202	6	200.3
4	1358	10	135.8
5	1531	14	109.4
6	2011	19	105.8
7	5482	26	210.9
Total			762.2

6. The non-CBD trips are then distributed by dividing the employment travel time for each segment by the sum of employment/travel time for all segments. This fraction is multiplied by the number of non-CBD trips for each zone. From segment 2, there are 407 non-CBD trips, which are divided as in Table 7. As the table indicates, 107 passengers boarding in segment 2 will go to zone 3, 72 will go to zone 4, and so on. These will become reverse trips later in the day. The 107 passengers going from segment 2 to segment 3 will reverse the trip, boarding in segment 3 and alighting in segment 2 later in the day.

7. The trip distribution table for non-CBD trips along route 19 can be structured as in Table 8.

8. The trip distribution table is completed by adding CBD trips and reverse trips. Reverse trips are calculated by adding paired cells. For example, segment 3 to segment 2 has 135 trips and segment 2 to segment 3 has 107. Reversing the trips would result in addition of these two numbers so that both cells have 242 (see Table 9).

Table 6. Employment by route segment.

Segment	No. of Acres: Industrial	Retail-Commercial	Total	Employees per Acre	No. of Employees
7	23	403	426	12.9	5284
6	183	91	274	7.3	2011
5	55	45	100	15.3	1531
4	7	59	66	20.6	1358
3	31	17	48	25.0	1202
2	117	154	271	21.7	5880

Results

As Table 9 indicates, the model predicted total daily passenger boardings of 5500. This is compared in the table below with an actual 1980 boarding count of 5777 for a margin of error of -5 percent:

Segment	Boardings Estimated by Model	Ridership Count	Error (%)
1 (CBD)	1712	2084	-18
2	1346	1124	+19
3	749	649	+15
4	649	838	-23
5	400	457	-12
6	274	156	+76
7	370	469	-21
Total	5500	5777	-5

Similar validation efforts for other routes in the Cleveland area have produced projections in the range of +2 to +8 percent of actual observed ridership.

At the moment, reliable models have been developed for local radial and crosstown service and are in the process of being validated through the use of historical ridership data. Work is still progressing on models for express radial service and rapid feeder service. The calibration of those two models should be completed shortly so that their validation can begin and a final report on the entire range of models developed as a result of this study effort can be published in the very near future.

FUTURE DIRECTIONS

Admittedly, the four ridership projection model study efforts mentioned earlier were designed to suit local conditions and needs and to be compatible with local data bases. This is not to say that the models in their present form cannot be used in areas other than that for which they were initially designed. This is to say that the transferability of any or all of the models is not known and can only be ascertained through further study.

To that end, it would appear reasonable that some effort over and above normal technical report dis-

Table 7. Non-CBD trip distribution for segment 2.

Segment	Employment/ Travel Time		Sum of Employment/ Travel Time				Non-CBD Trips		Trip Distribution
3	200.3	÷	762.2	=	0.263	x	407	=	107
4	135.8	÷	762.2	=	0.178	x	407	=	72
5	109.4	÷	762.2	=	0.144	x	407	=	58
6	105.8	÷	762.2	=	0.139	x	407	=	56
7	210.9	÷	762.2	=	0.277	x	407	=	114
Total									407

Table 8. Non-CBD trip distribution for all segments.

Origin Segment	No. of Trips to Segment: 2	3	4	5	6	7	Variance
1	30	6	4	3	3	8	-54
2	-	107	72	58	56	114	-407
3	135	-	38	24	20	36	-253
4	82	33	-	43	28	45	-231
5	32	10	21	-	30	34	-127
6	11	3	5	11	-	31	-59
7	17	4	6	10	22	-	-59
Total	307	163	146	149	159	268	

Table 9. Distribution of reverse trips for all segments.

Origin Segment	No. of Trips to Segment: 1	2	3	4	5	6	7	Total
1[a]	180	672	339	276	137	57	51	1712
2	672	-	242	154	80	67	131	1346
3	339	242	-	71	34	23	40	749
4	276	154	71	-	64	33	51	649
5	137	80	34	64	-	41	44	400
6	57	67	23	33	41	-	53	274
7	51	131	40	51	44	53	-	370
Total								5500

[a]CBD.

tribution is warranted to disseminate the findings of these study efforts to the transit community. Just as UMTA has offered training sessions for existing and potential users of the UTPS software packages, a similar effort could be undertaken by either the Transportation Research Board, UMTA, or the American Public Transit Association for the short-range demand estimation planners.

Transit Fare Development Procedures and Policies

EDWARD M. ABRAMS

Transit properties throughout the country will be facing difficult policy decisions in the next several years, principally due to the phasing out of federal Section 5 funds (Urban Mass Transportation Act of 1964, as amended). Furthermore, local communities have shown a strong resistance for further increases in their tax assessments. Although in the past transit was heavily subsidized by public funds, these shifts are causing more of the financial burden of transit to be placed on user charges. Fares, however, are a sensitive and visible element of transit services. The transit rider is constantly reminded of the cost of the journey each time he or she boards a bus. These riders will be hard pressed to accept the reasons for the shift in the financial burden for transit. Therefore, a fare-pricing policy must be cognizant of this attitude and attempt to mitigate it through innovative approaches and marketing programs. In the past, transit properties generally increased their fares by a uniform increase throughout the fare structure. Little attention was paid to each element of the structure in terms of effect on ridership and revenue. However, recent research has found that fare-change impacts are not uniform throughout the various submarkets within a transit property. Therefore, transit properties are faced with initiating a high level of fare increase more frequently and without a complete understanding of how the various submarkets will be affected. This paper presents an approach for addressing this problem by delineating a comprehensive development process for making transit fare changes. The process has at its foundation the development of policy guidelines to identify what is expected from the fare change. Two major analysis procedures are defined. First, a technique is presented whereby individual submarket elements of the fare structure can be changed and their ridership and revenue impact readily determined. Second, the development process relies on a building-block approach, whereby changes to each unit of the structure are tested with respect to ridership and revenue impacts and then combined into overall fare-structure alternatives. The procedures contained in this paper were developed as part of a study sponsored by the Pennsylvania Department of Transportation to offer guidance to small and medium-sized transit properties in making service and fare-structure changes.

This paper contains a suggested approach for making fare-structure changes in order to deal with the different ways each submarket of a system is affected by the change. It relies on the process developed as part of the Transit System Performance Evaluation and Service Change Manual for the Pennsylvania Department of Transportation (PennDOT) (1). The process of fare-change development suggested here contains seven major steps, as listed below:

1. Define evaluation procedures,
2. Develop analytical tools,
3. Describe fare actions,
4. Determine ridership and revenue impacts,
5. Develop alternative fare structures,
6. Evaluate alternative structures, and
7. Select and implement preferred alternative.

The procedures suggested for each, as well as how each works together to form a total fare-structure development program, are described in detail below.

DEFINE EVALUATION PROCEDURES

In planning for fare-structure changes, the first and perhaps most important step is to determine what are the objectives to be accomplished by the changes. Is it to increase revenue by a certain percentage? Is it to simplify the structure? These and other questions must be answered to guide the transit fare-development process.

The process for answering these questions could involve the delineation of criteria that have significance levels assigned to each. Such criteria may involve local priorities with respect to six factors associated with transit fares, such as the following:

1. Fiscal integrity: With cutbacks in federal operating support and with the general concern to minimize local financial support, fiscal integrity is probably the most important priority. It describes the financial objectives to be achieved by the fare changes that may be measured by the amount or percentage of a revenue increase, or the percentage of expenses recovered by the farebox.
2. Fare-structure simplification: A major advantage of transit is its low cost. In order to market this advantage, the fare structure should not be overly confusing to hinder its use.
3. Fare promotion programs: Other things being equal, the fare structure that can attract the most transit trips is preferred. Fare promotion programs, at relatively little revenue loss, can be designed to draw attention to new or improved services and also try to establish a transit riding habit.
4. Passenger equity: Although transit fare equity is hard to define, it generally can be considered in three categories: riding distance, quality of service, and patron's ability to pay. A zone structure is usually established to equalize the patron fare based on distance traveled. Premium services, which offer the patron a higher standard of dependability, speed, comfort, or convenience, may command a higher price. Finally, the relative importance of the fare to different user groups should be considered before setting the same price for everyone.
5. Ease of administration: A fare structure must lend itself to easy (low administrative cost) collection of, and accounting for, route revenues. Security of revenues is also a consideration.
6. Effect on energy and the environment: Transit can play a major role in energy conservation and in improving the environment. Therefore, the fare structure may be a key element to influence a modal shift from private automobile to transit.

What is probably most obvious from these six criteria is that they do not work together; that is, a change to enhance satisfaction of one criterion may affect another criterion detrimentally. Thus, there are trade-offs to be made, so that a balance may be struck between the different criteria. These trade-offs can be made by assigning significance levels to