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CONTENTS

FOREWORD

The papers in this RECORD discuss a number of issues that are of interest to planners, administrators, and professionals in the field of public transportation. The topics include funding sources, determination of market sectors, operations, and levels of service.

A continuing concern at the national level is the real need and cost of urban public transportation services. The 1972 National Transportation Study was undertaken to assess the need and priorities for transportation funds in urban areas. Weiner describes how this study was undertaken and the type of information it collected. A general overview of the results is given. Hedges examines the urban transportation problem and argues for solutions of noncapital and low-capital alternatives that reduce the demand for vehicle trips and increase the effective capacity of existing transport systems. He also discusses some of the difficulties of such approaches and the activities of the U.S. Department of Transportation in this area. He concludes with a review of policy implications of the proposed shift in emphasis.

In recent years research has increasingly focused on understanding groups whose transport needs are unmet by existing systems. The term "latent demand" refers to the potential for necessary trip-making by an individual who has no access to an automobile or convenient access to public transportation. Anderson and Hoel present an analysis of latent demand at various levels of service of public transportation in rural and small towns. They used data from a household questionnaire of 4 representative cities in Minnesota.

Benson discusses surburban transportation planning. He identifies unique suburban approaches to transportation planning, including the irrelevancy of the existing transit patronage data, the availability of technologies suited for suburban areas, orientation of high-speed transit lanes to existing rights-of-way, and need for a marketing plan to stimulate ridership or new services. Wilson, Hultquist, Peterson, and Kendall discuss the marketing aspects of transit in more detail. They believe that the best promotion is an actual invitation to use the transit service. They report on a study in a small section of Cedar Rapids, Iowa, where promotional material and free bus trips were considered to generate an increase in noncaptive patronage.

Mix and Dickey report on a study of rural transportation problems and needs conducted in Virginia. Travel in most rural areas is now confined to the automobile. Because of financial or physical difficulties, certain groups have no access to a car and therefore must forego or depend on others for necessary travel. The authors analyze the transportation problem and suggest different ideas that might be used to implement public transit systems in rural areas. Included are the types of systems that might be used, organization, and funding.

Two papers treat the general subject of service standards for public transportation. Vuchic, Tennyson, and Underwood discuss application of guidelines that have been issued by the Pennsylvania Department of Transportation. This is a unique effort by a state to formalize evaluations of local transit operations. The state based distribution of funds among transit agencies on their compliance with the guidelines. Botzow describes a system of patron service variables that can be applied to all public transportation modes to determine which mode may be selected or upgraded on the basis of its ability to fulfill a desired level of service. The variables are those directly perceived by the user and include speed, delays, and comfort factors such as density, acceleration, jerk, temperature, and noise. The author suggests that an overall level-of-service factor be based 40 percent on speed and delay and 60 percent on quantifiable comfort factors.

NATIONAL REQUIREMENTS FOR URBAN PUBLIC TRANSPORTATION FUNDS

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The 1972 National Transportation Study was undertaken to assess the need and priorities for transportation capital funds for states and urban areas. This paper describes some of the results of that study with respect to urban public transportation. The results indicate that substantial funding is needed for urban public transportation in both the short and long term and that funding requirements vary widely between urban areas of different sizes and between urban areas of similar size. Capital funding requirements over time also vary. Major public transportation implementation programs peak in funding requirements midway in the programs. Operating costs as a proportion of total capital and operating costs are higher for existing public transportation systems than for new public transportation systems because existing systems are almost fully depreciated. Even with two-thirds federal funding for capital improvements, the state-local share of the 25-year cost to construct and operate urban public transportation systems is likely to be substantial.

•THE TRANSIT industry has been declining since the end of World War II. Figure 1 (1) shows the severe decline in annual revenue transit passengers and the sharp rise in fares since 1945. Transit fares have risen faster than the consumer index since 1965 (2).

The transit industry has been locked into a decline spiral that has been difficult to reverse. Decentralization of residences, jobs, and commercial activity has created a dispersed pattern of travel that is difficult to serve with public transportation, especially on a financially sound basis. In addition, rising incomes, major investments in highways, and poor transit service have led to significant increases in automobile ownership. Rising labor costs and operating costs have caused continuing increases in transit fares, which have further suppressed transit ridership. Figure 2 shows that, even if fares increase, costs increase faster than revenues.

However, patronage has declined less severely on rail rapid transit than on bus transit (Table 1), but deficits have been sizable (2). Rail transit systems accounted for 43 percent of the nationwide transit operating deficit in 1970 (3).

It is clear that the demand for and the environment within which urban transit operates have changed considerably within the last 20 years. However, it is not clear how the transit industry has perceived these changes and to what extent transit systems have been modified to adapt to these changes. There is little indication of changes in services, innovative approaches, marketing campaigns, or other efforts by transit operators in most urban areas to maintain and increase their share of the travel market. Further, most of the legal and institutional barriers to improving the efficiency and utility of public transportation still stand with little attempt to eliminate them.

The taxi industry has done much better. During the period from 1960 to 1970, annual revenue passengers dropped 20 percent on bus transit and 6 percent on rail transit but increased 31 percent in taxicabs (Table 1). In general, taxicabs operate under many of the same regulatory constraints as transit companies, have had increasing costs, and in some locations must carry a high-cost "medallion" burden as well. According to Wells et al. (4), the annual taxi revenue now exceeds the revenue of the total transit industry plus rail commutation even though taxis haul less than half

Figure 1. Average fare per revenue passenger from 1935 to 1970.

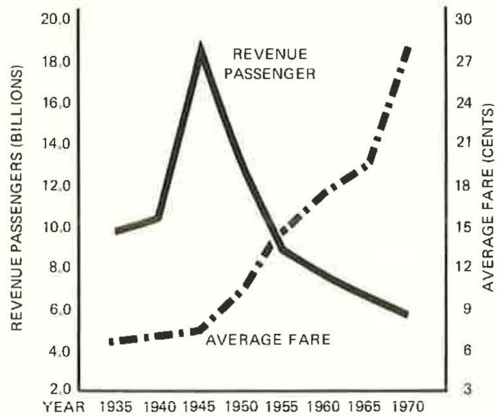

Figure 2. Transit revenues and expenses from 1961 to 1971.

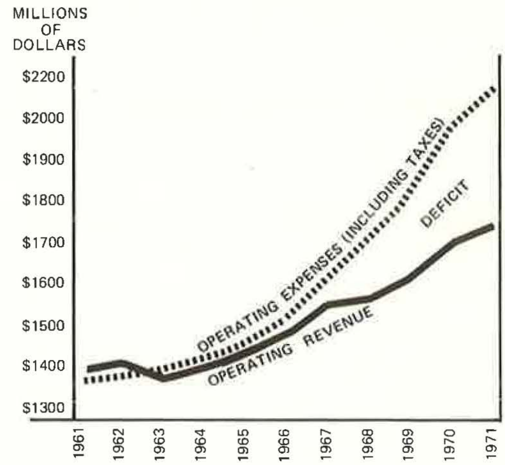

Table 1. Urban public transportation annual revenue passengers in 1960, 1965, and 1970.

Mode	Passengers (millions) 1960	1965	1970	Percentage of Change From 1960 to 1970
Surface rail	335	204	172	-43.7
Subway and elevated rail	1,670	1,678	1,574	-5.7
Total	2,005	1,882	1,746	-12.9
Commuter rail	248	233	247	-0.4
Trolley coach	447	186	128	-71.4
Motor bus	5,069	4,730	4,058	-19.9
Taxicab	1,820	1,960	2,378	30.7

Table 2. Urban public transportation operations in 1970.

Mode	Revenue Passengers (millions)		Passenger Revenue (millions of dollars)		Revenue-Miles (millions)	Vehicles (thousands)	Avg Employment[d] (thousands)
	Number	Percent	Amount	Percent			
Rail[a]	1,746	20.4	415	10.2	441	11	—[b]
Trolley coach	128	1.5	30	0.7	33	1	—[b]
Bus	4,058	47.4	1,194	29.4	1,409	50	—[b]
Subtotal	5,932	69.3	1,639	40.3	1,884	62	138
Commuter rail[c]	247	2.9	205	5.1	—[b]	—[b]	—[b]
Taxicab	2,378	27.8	2,221	54.6	3,417	170	111
Total	8,557	100.0	4,065	100.0	—[b]	—[b]	—[b]

[a]Includes elevated and subway rail rapid transit, grade-separated surface rail, and streetcar operations.
[b]Not available.
[c]Urban passenger rail service provided by railroad companies.
[d]Taxicab employment believed to be underestimated.

Table 3. 1970-1990 urban public transportation needs.

Type of Project	As of 1970 Amount	Percent	1970 to 1980 Amount	Percent	1980 to 1990 Amount	Percent	1970 to 1990 Amount	Percent
Bus	2,971	35	4,099	18	5,242	2	12,312	21
Rail	8,620	65	19,159	82	22,232	98	50,013	79
Total	11,591	100	23,258	100	27,476	100	62,325	100

Note: Amounts are in millions of dollars.

as many revenue passengers (Table 2). The transit decline may, therefore, be due in part to the character of its service.

1972 NATIONAL TRANSPORTATION STUDY

As part of the 1972 National Transportation Study, states and urbanized areas were requested to provide to the U.S. Department of Transportation information on their capital needs and separate statements of their program priorities under 3 federal program assumptions for urban public transportation (2, 5, 6, 7, 8). This comprehensive survey provides the first complete picture of the nation's needs for urban public transportation capital funds and the priorities for those funds. Further, these data on urban public transportation are placed in the context of the needs and priorities for capital funds for all transportation modes so that the relative needs of urban public transportation with respect to other modes can be assessed.

Data were requested for 3 time periods: as of 1970, 1970 to 1980, and 1980 to 1990. The capital improvement programs were requested for 2 time periods: 1974 to 1979 and 1980 to 1990.

PUBLIC TRANSPORTATION NEEDS

Table 3 gives a summary of the data on urban transportation needs provided by the states and urban areas as part of the 1972 National Transportation Study. The needs for capital funds for public transportation during the period from 1970 to 1990 for urban areas having populations of 50,000 and more are $62.3 billion, 79 percent of which is for rail rapid transit projects (2, 5, 6). These estimates are unconstrained by any budget limitations or federal program requirements. Fifty-six percent of the rail projects and 58 percent of the bus projects occur in the first 10 years.

The highway and public transportation needs are given by urban area population group in Table 4. There is a wide variation in the percentage of public transportation needs that are for rail rapid transit. Larger urban areas show greater needs for rail rapid transit both in absolute dollar terms and as a percentage of public transportation needs. Rail rapid transit needs as a percentage of public transportation needs range from 22 percent for the 50,000 to 100,000 population group to 87 percent for the more-than-2-million population group; the nationwide average is 79 percent.

Table 5 gives the transportation needs for the urban areas having a 1990 population of 1 million or more. Those urban areas have the greatest needs for public transportation—92 percent of the national public transportation needs of which 85 percent is for rail rapid transit. Of the 35 urban areas in the more-than-1-million population group, 26 indicated some rail rapid transit needs and 10 indicated that more than 90 percent of these public transportation needs are for rail rapid transit. The data in Table 5 show the wide variation in urban public transportation needs; the percentage of total needs for public transportation ranges from 1 to 69 percent, and the percentage of these public transportation needs for rail transit ranges from 0 to 95 percent.

Table 6 gives the needs per capita by population group. Highway needs per capita do not vary greatly by size of urbanized area, but urban public transportation needs per capita sharply increase as urban area size increases. The total highway and urban public transportation needs per capita do not reveal a pattern by size group except for those urbanized areas having a 1990 population of more than 2 million. The higher overall investment needs per capita of these are largely due to their higher public transportation needs per capita.

The implications of these results are that urban areas have different needs for public transportation capital funds, and flexibility may be required in the apportionment of those funds on a nationwide basis.

PUBLIC TRANSPORTATION PRIORITIES

As part of the 1972 National Transportation Study, states and urban areas were asked to delineate capital improvement programs under 3 federal funding alternatives (2, 5, 7, 8). Two of these are discussed below.

Table 4. 1970-1990 transportation needs by mode and urban area population size.

1990 Population Group	1970 Population (millions)	Highway Needs[a] Amount	Highway Needs[a] Percent	Public Transportation Needs Amount	Public Transportation Needs Percent	Public Transportation Needs Percent for Rail	Total Needs[a]
Less than 2 million							
1 to 2 million	18.4	24,439	82	5,395	18	55	29,834
500,000 to 1 million	13.3	15,899	86	2,598	14	33	18,497
250,000 to 500,000	10.5	16,402	94	1,043	6	18	17,445
100,000 to 250,000	10.3	15,357	96	708	4	21	16,065
50,000 to 100,000	6.5	8,624	94	522	6	22	9,146
Subtotal	59.0	80,721	89	10,266	11		90,987
More than 2 million	66.0	89,081	63	52,063	37	87	141,144
Total	125.0	169,802	73	62,329	27	79	232,131

Note: Amounts are in millions of 1969 dollars.

[a]Not including local roads or the cost of completing the Interstate System.

Table 5. 1970-1990 transportation needs by mode and urban area having 1990 population of more than 1 million.

Urban Area	1970 Population (millions)	Highway Expenditures[a] Amount	Highway Expenditures[a] Percent	Public Transportation Expenditures Amount	Public Transportation Expenditures Percent	Public Transportation Expenditures Percent for Rail	Total Expenditures
Atlanta	1.17	1,548	54	1,301	46	92	2,849
Dallas	1.34	4,414	84	825	16	81	5,239
Seattle	1.34	2,189	84	419	16	0	2,608
Miami	1.22	1,102	69	487	31	91	1,589
Milwaukee	1.25	927	86	148	14	0	1,075
Cincinnati	1.20	1,312	75	434	25	0	1,746
Kansas City	1.10	1,231	70	534	30	92	1,765
San Juan	0.82	1,241	59	853	41	66	2,094
Phoenix	0.86	1,154	93	83	7	0	1,237
New Orleans	0.96	824	83	169	17	79	993
Denver	1.05	902	99	12	1	0	914
San Antonio	0.77	610	92	56	8	0	666
Columbus	0.79	534	75	181	25	23	715
Indianapolis	0.82	381	84	70	16	0	451
Buffalo	1.09	1,142	81	270	19	79	1,412
Louisville	0.74	929	85	165	15	0	1,094
Memphis	0.69	410	24	147	26	69	557
Portland	0.75	1,964	93	155	7	01	2,119
Fort Worth	0.68	2,738	88	361	12	94	3,099
Fort Lauderdale	0.61	435	94	27	6	7	462
New York	17.36	20,354	61	13,037	39	93	33,391
Los Angeles	9.31	9,872	59	6,873	41	83	16,745
Chicago	7.10	8,369	78	2,410	22	74	10,779
Philadelphia	4.30	8,315	73	3,153	27	94	11,468
San Francisco	4.01	5,201	50	5,101	50	85	10,302
Detroit	3.97	7,827	73	2,827	27	46	10,654
Boston and Providence	4.23	6,874	80	1,710	20	79	8,584
Washington	2.48	4,125	53	3,718	47	96	7,843
Cleveland	2.15	2,632	69	1,183	31	84	3,815
St. Louis	1.88	2,492	62	1,497	38	94	3,989
Houston	1.68	3,692	80	910	20	75	4,602
Minneapolis and St. Paul	1.70	1,135	57	866	43	92	2,001
Baltimore	1.58	1,949	36	3,450	64	94	5,399
Pittsburgh	1.85	3,449	73	1,273	27	87	4,722
San Diego	1.20	1,245	31	2,753	69	97	3,998

Note: Amounts are in millions of 1969 dollars.

[a]Not including local roads or the cost of completing the Interstate System.

Table 6. 1970-1990 transportation needs per capita by mode and urban area population size.

1990 Population Group	Highway[a]	Transit	Total[a]
Less than 2 million			
1 to 2 million	1,328	293	1,621
500,000 to 1 million	1,195	195	1,390
250,000 to 500,000	1,562	99	1,561
100,000 to 250,000	1,491	69	1,560
50,000 to 100,000	1,327	80	1,407
Subtotal	1,368	174	1,542
More than 2 million	1,350	783	2,139
Total	1,358	499	1,857

Note: Amounts are in 1969 dollars and are based on 1970 population.

[a]Not including local roads, or the cost of completing the Interstate System.

Table 7. Expenditures for capital improvement programs from 1974 to 1990.

		Alternative 2			Alternative 3		
Urban Area	Mode	Amount	Percentage of Total	Percentage of Public Transportation	Amount	Percentage of Total	Percentage of Public Transportation
All	Public transportation						
	Bus	7,965		30	8,650		28
	Rail	18,046		70	22,244		72
	Subtotal	26,011	20	100	30,894	23	100
	Highways	106,191	80		104,155	77	
	Total	132,202	100		135,049	100	
New York	Public transportation						
	Bus	634		12	703		10
	Rail	4,603		88	6,328		90
	Subtotal	5,237	35	100	7,031	47	100
	Highways	9,689	65		7,941	53	
	Total	14,926	100		14,972	100	
Chicago	Public transportation						
	Bus	472		32	474		32
	Rail	1,010		68	1,008		68
	Subtotal	1,482	25	100	1,482	23	100
	Highways	4,414	75		5,097	77	
	Total	5,896	100		6,579	100	
Los Angeles	Public transportation						
	Bus	673		49	659		50
	Rail	699		51	660		50
	Subtotal	1,372	14	100	1,319	16	100
	Highways	8,100	86		7,063	84	
	Total	9,472	100		8,382	100	

Note: Amounts are in millions of 1969 dollars.

1. Alternative 2—For fiscal years 1974 to 1978, and for fiscal years 1979 to 1990, all federally funded transportation programs are given that operate with existing legislative constraints, matching ratios, and funding levels. The matching ratio for all programs is 66⅔ federal and 33⅓ state or local or both.

2. Alternative 3—Funding levels are those authorized under existing legislation, with a matching ratio for all programs of 66⅔ federal and 33⅓ state or local or both and removal of legislated program constraints to permit transfer of funds among programs and into any transportation capital program. (Operating and maintenance costs are not included.)

Some of the information is given in Table 7. More total funds will be spent on highways and transit in urbanized areas under Alternative 3, the more flexible arrangement, than under Alternative 2. There are 2 reasons for this. The greater flexibility permitted some states to use more of the federal apportionments beneficially, and a slightly increased local matching percentage in some areas encouraged the states to spend more of their own funds to obtain all their federal apportionments.

A comparison of the 2 alternative capital improvement programs (Table 7) with the needs estimates (Tables 4 and 5) indicates that a lower amount of funds will be expended under the capital improvement programs than under the unconstrained needs estimates. The percentage that the capital improvement programs were of the needs was 50 percent for public transportation, 61 percent for highways, and 57 percent for total capital expenditures. For urban public transportation, a slightly lower proportion of funds will be expended on rail transit: 79 percent for the needs, 70 percent for Alternative 2, and 72 percent for Alternative 3.

Data in Table 7 also show how the increased flexibility was used by several of the largest urbanized areas. New York shifted large amounts into rail transit, in part, from highways. Chicago changed its public transportation expenditures very little. Los Angeles cut both programs, apparently choosing to spend its transportation dollars elsewhere in the state or for other forms of transportation.

These findings indicate that increased flexibility in the use of federal transportation funds will not cause major modal shifts on a national basis. However, the increased flexibility will be used by individual urban areas to better tailor transportation investments to local objectives.

TIME PHASING OF TRANSIT EXPENDITURES

In addition to the level of capital needs, time phasing of these needs must be investigated to understand the nationwide requirements for capital funds for urban public transportation. The phasing of public transportation expenditures over time requires that 2 issues be examined: (a) time phasing of an implementation program within individual urban areas and (b) time phasing of requirements on a national basis.

Figure 3 shows actual and planned annual expenditures of a major transit implementation program, which is typical of similar programs in other areas. Expenditures during the life of a major transit implementation program are not uniform, but tend to reach a peak in the middle years, which can sometimes represent 7 times the expenditures in the early or later years. This indicates that the demand for funds for individual urban areas will vary considerably over time.

Table 8 gives some additional information on major transit implementation programs in several urban areas. The data suggest that, if several urban areas carry out major implementation programs during the same time period, the annual requirements for public transportation capital funds on a national basis could and likely would vary considerably.

OPERATING COSTS OF NEW TRANSIT SYSTEMS

Table 8 also gives the total capital cost of new transit systems and the costs to operate those systems for a 25-year period (depreciation is excluded). The 25-year operating costs range from about 27 to 80 percent of the capital costs. The operating costs must be paid for by revenues and, where necessary, supplemented by state or local tax sources. If the federal contribution is ⅔ for capital costs and none for

Figure 3. Phasing of public transportation program in Atlanta.

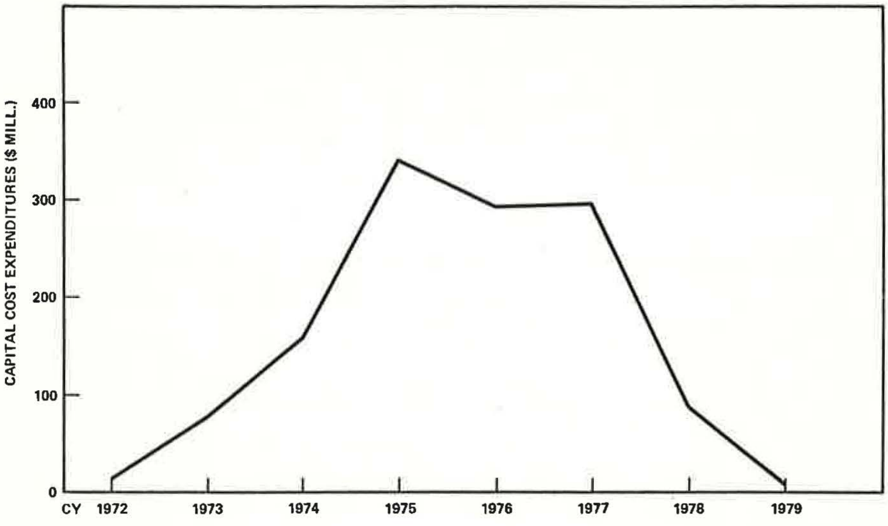

Table 8. Major transit implementation programs.

Urban Area	Start of Program	Year of Maximum Funding Requirements	Type of Transit Program	Total Capital Cost	Total Operating Cost for 25 Years[a]
San Francisco	1962	1967	Rail	1,527	575
Washington, D.C.	1968	1975	Rail	2,980	800
Miami	1972	1976	Rail	391	311
Atlanta	1972	1975	Rail	1,271	–
Baltimore	1973	1976	Rail	656	–
Buffalo	1971	1974	Rail	277	143
Dallas-Ft. Worth	1974	1976	Primarily rail	2,000	–
Puget Sound	1974	1980	Bus	97	–
Milwaukee	1974	1980	Bus	151	101

Note: Costs are in millions of dollars.
[a]Does not include depreciation.

operating costs, the local area must cover between 47 and 63 percent of the total capital and operating costs for 25 years of system operation.

OPERATING COSTS OF EXISTING TRANSIT SYSTEMS

The split between capital and operating costs of new systems is quite different from the split for existing systems. Existing systems are almost fully depreciated, and the variable portion of the operating costs (i.e., total operating costs less depreciation and amortization) dominates the capital input.

The variable cost of existing public transportation systems represents a major portion of their total operating cost. In 1970, the median cost of operating a bus transit system ranged from 63 to 85 cents per vehicle-mile; the higher costs were for the larger systems (4). Of this cost, approximately 93 percent was variable costs and 7 percent was depreciation and amortization (4). Since these figures are from data on current operations, the depreciation and amortization are probably understated.

The 1970 operating cost for existing urban rail systems ranged from 85 cents to $2.15 per vehicle-mile (4). The wide variation in rail operating costs is due to a number of factors including labor costs, operating conditions and efficiencies, demand conditions, and accounting procedures. Depreciation ranged from 3 to 17 percent of operating costs for those systems that keep a depreciation account. These depreciation accounts probably understate the annual amortization of capital because the majority of existing rail plants are old and fully depreciated in an accounting sense.

Clearly the variable cost of existing urban public transit operations represents the largest portion of operating costs. This is an important consideration in determining policies and programs for rail transit. The most recent rail system, the Lindenwold Line, achieved profitability after 4 years of operation (4). How other new systems will do financially remains to be seen.

CONCLUSIONS

Public transportation continues to decline in terms of revenue passengers while taxicabs attract increasing ridership. This may indicate that taxicabs are providing the type of service that is more attractive to the public.

The urban public transportation capital needs from 1970 to 1990 are substantial and highly variable among urban areas of different sizes and among large urban areas within the same size group. There are substantial capital needs for urban public transportation, particularly rail rapid transit.

About half as much urban public transportation expenditures will be programmed under current federal funding levels as under the unconstrained needs estimates; rail transit systems will have a slightly lower proportion. This does not necessarily mean that the earmarked transit funds should double. Under a flexible federal funding policy, urban transportation funds for public transportation will slightly increase on a nationwide basis, directed for the most part for rail transit. A flexible federal funding policy will allow individual urban areas to better tailor their transportation programs to their individual needs.

The need for capital funding of major urban public transportation programs varies considerably during the implementation of the programs. If several urban areas implement programs during the same time period, the annual requirements for capital funds on a national basis for public transportation are likely to vary considerably over time.

The costs to operate new rapid transit systems are likely to be considerable, ranging from about 30 to 80 percent of the 25-year cost of construction and operations for a sample of urban areas. The proportion that operating costs are of the total cost of existing rail transit systems is considerably higher than for new rapid transit systems in that these existing systems are almost fully depreciated.

Even with two-thirds federal funds for capital improvements, the state and local share of the 25-year cost to construct and operate public transportation systems is likely to be substantial.

The 1974 National Transportation Study is collecting data on plans and programs for transportation by the states and urban areas. These plans and programs, in contrast to needs and priorities in the 1972 study, will likely produce a more accurate picture of the national requirements for urban public transportation funding.

ACKNOWLEDGMENT

The views expressed in this paper are solely those of the author and do not necessarily represent any policy or position of the U.S. Department of Transportation.

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LET'S ATTACK THE REAL URBAN TRANSPORTATION PROBLEM

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This paper examines different interpretations of the transportation problem and its solution and argues for an interpretation that takes as its point of departure the near term and the present supply of urban transportation resources and that gives greater weight to the economic forces influencing the behavior and performance of the urban transportation market. It suggests a range of noncapital and low-capital alternatives that reduce the demand for vehicle trips, increase the effective capacity of existing systems, or do both. Policy considerations and the advantages and obstacles of the low-cost approach are discussed, and policy implications are developed.

•THE DEMANDS for transportation services continue to strain the capacities of urban transportation systems, particularly during the peak hours. Transportation planning has consisted essentially of forecasting demands for 20- to 30-year periods, determining the capacities that would be needed to provide the desired levels of service, and designing systems accordingly. The planning approach, the institutions, and the financial assistance programs are geared to long-term, capital-intensive improvement programs that emphasize pure technologies, e.g., roads for private automobiles and rail transit systems operating on their own rights-of-way.

In the process of pursuing the Golden Age when a system scheduled for completion in the relatively distant future will provide optimum service, we tend to overlook the present and the immediate future. On the one hand, we overlook the capabilities of our present urban systems. As the result of previous investments, we have excess capacity in terms of both rights-of-way and vehicles during the off-peak, or 80 to 90 percent of the time. More surprising, we also have sufficient capacity during the peak periods to provide much higher levels of service if we would only use our transportation resources more efficiently (average automobile occupancy during the peak is 1.2 or less). On the other hand, we overlook the urban institutions (e.g., regulatory practices) and the characteristics of urban travel demand that contribute to poor performance (e.g., automobile travel tends to be highly concentrated in a relatively few corridors, especially during peak hours). An examination of the demand for and the supply of urban transportation services within the institutional setting reveals a continuum of alternatives to capital-intensive programs. They range from noncapital (e.g., charging economic prices for travel and parking in congested areas) to comparatively low-capital alternatives (e.g., separate rights-of-way for buses and possibly for car pools and consolidated pickup and delivery of small freight shipments) that could improve performance by reducing peak-hour demand or by increasing the people-carrying capacity of the system or by doing both. Not only would more efficient use be made of the existing system but also the suggested shift in emphasis would reduce damage to the environment, consume less energy, cause less disruption to urban form, expand the range of future options by preserving flexibility, and reduce future capital needs. In fact, unless existing systems are used efficiently, estimates cannot be made of the capacity needed for efficiency in the future and the levels of investment necessary to attain it.

OPPOSITE APPROACHES TO THE PROBLEM AND THE SOLUTION

Theory and Practice

Congestion has been considered the urban transportation problem in U.S. cities for more than 2 decades, particularly during the journey to work. To quote Meyer, Kain, and Wohl (1, p. 5):

> The focus is on the problem of moving passengers into and out of cities during the peak or rush hours, occurring morning and afternoons on weekdays. It is these movements that tax the capacity of existing urban transportation facilities and create the congestion and delays that most people associate with . . . the urban transportation problem.

In the same view, Netzer states (2, p. 138):

> The urban transportation problem, however, can be more narrowly defined. Public policy is concerned with travel at the times and along the routes that involve congestion and additional investment to improve service.

Creighton (3) is more comprehensive: "The urban transportation problem is the summation of things which people don't like about transportation." He places congestion at the top of the list, which includes noise, pollution, and accidents, and emphasizes "problem-reducing actions consisting of investments in new facilities . . . to provide new channels of movement."

In short, the problem is congestion, and the solution is additional capacity. [Some of the other difficulties associated with urban transportation are related to congestion. For a given number of vehicle-miles traveled, progress in reducing congestion will also reduce urban goods movement costs, environmental degradation, and fuel consumption and possibly improve the financial position of bus transit if improved service attracts more passengers. Pratsch gives an excellent discussion of the opportunities to significantly reduce peak-hour vehicle-miles of travel (VMT), congestion, air pollution, and energy consumption by comparatively modest increases in peak-hour automobile occupancy (4).]

Urban transportation planning in the United States has been oriented almost entirely toward long-range, capital-intensive programs to expand capacity, especially highway capacity. Based on 20- to 30-year forecasts of urban population, boundaries, and peak-hour travel volumes on the one hand and on the levels of transportation service specified to meet urban goals on the other hand, the estimation of future capacity and design requirements, present capacity and design deficiencies, engineering (construction) requirements to meet future demand, and "needs" or the dollar costs of improvements and additions to existing capacity was seen as a fairly straightforward process (5, 6, 7).

Results

The results of this approach to urban transportation planning are described in the 1972 National Transportation Report (8). Total federal expenditures on urban highway construction amounted to approximately $21 billion during the period from 1957 to 1970. The total street and highway mileage of municipalities was 560,000 miles in 1970, an increase of 30 percent from 1960. On the other hand, electric railway track mileage in 1970 was 2,100, a decrease of 32 percent since 1960, and round-trip motor bus route-miles were 112,700 or an increase of only 4 percent since 1960.

In contrast, the amounts obligated to make more efficient use of existing systems through fiscal year 1970 were $8 million under the Traffic Operations Program to Increase Capacity and Safety (TOPICS) funded by the Federal Highway Administration, while the amounts authorized for TOPICS were $200 million each year for 1970 and 1971 and $100 million each year for 1972 and 1973 (9). For the urban corridor demonstration projects, $2 million of obligations were shared evenly by FHWA and the Urban Mass Transportation Administration in 1970. Subsequently, an additional $12.2 million was obligated for the corridor program ($9.7 FHWA and $3.5 UMTA) and approximately $250 million for TOPICS during the fiscal years from 1971 to 1973. Adding the amounts authorized or obligated for bus purchases still leaves the federal contribution to efforts to make better use of existing facilities up through fiscal year 1973 at something less than $2 billion.

As a result of substantial investments in rights-of-way and vehicles in the past (especially since World War II), we now have an impressive collection of assets. Excluding all of our freight systems and our urban transit, commuter rail, and potential commuter rail systems and concentrating only on our passenger motor vehicle systems, we had in our urban areas in 1972 560,000 miles of right-of-way, of which approximately 48,000 miles are major arterials and approximately 9,000 miles of those are freeways or expressways (10); 70 million automobiles, or slightly more than three-fourths of a total of 90 million registered in the United States (8); 175,000 taxicabs (8); 50,000 transit buses and trolley coaches (8); and 39,000 intercity buses, of which a large proportion probably could be used to provide commuter service (11).

The new facilities—i.e., the highways—constructed in urban areas during the past 2 decades have increased the range of mobility for automobile owners and have made it possible for people to commute longer distances and to enjoy higher average speeds during the off-peak hours. And although average peak-hour speeds frequently have been higher, the peak-hour users generally have not enjoyed for long the levels of service for which the facilities were designed and which the commuters anticipated, e.g., level of service A or B and volume capacity ratios ≤ 0.7 or from 0.7 to 0.8 respectively (12). Partly because of their propensities to attract traffic from other routes and to generate additional vehicle trips, levels of service regarded as high, acceptable, or even tolerable (i.e., level of service D and a volume-capacity ratio ≥ 0.9) have been maintained by continually adding to capacity (or by increasing effective capacity via traffic engineering improvements).

However, the gains from the urban highway program and from private automobile travel have been purchased at high social costs with respect to displacement of families and businesses and disruption of personal ties, damage to the environment and consequently to health, and consumption of fossil fuels. Moreover, these social costs have resulted in constraints to the highway solution. The constraints now exist in a number of forms, but especially in legislation passed within the last 10 years to mitigate the displacement and environmental impacts of transportation, in highly organized citizens' revolts against urban freeways, and in the evolving measures to conserve energy. We can safely assume that over the long run these constraints will become stiffer and that new constraints will be added.

Capital and Noncapital Approaches in the 1972 National Transportation Study

Two different approaches to improving transportation performance were highlighted in the 1970-1990 National Transportation (or Needs) Study, particularly in the treatment of urban transportation. The purpose of the study was to obtain estimates of 1980 and 1990 total capital needs (to include replacement as well as additional capacity) based on local goals, desired levels of service, and federal guidelines and to obtain proposed capital improvement program (CIP) priorities based on project costs and different levels of federal funding. The methodology employed in the study was based on the techniques used to estimate highway capacity needs (6). When the guidelines were prepared to assist the cities and states to respond to requests for urban public transportation information (13), it became apparent that

1. Given the desired levels of service, the cost estimates would be quite sensitive to the values assumed for key parameters such as average automobile occupancy, modal split, and the ratio of peak to off-peak travel; and
2. These parameter values would depend on a number of public policy and administrative decisions in each city with respect to the regulation of public transportation, to transit vis-a-vis automobile levels of service, to transportation pricing and financing, to parking policy and parking rates, to scheduling of work hours, and to many other local decisions relating to environmental quality, land uses, and urban form.

Consequently, the guidelines (13) requested the cities to consider to what extent their 1980 to 1990 goals and desired transportation service levels could be achieved—and their capital needs reduced—by a number of noncapital and low-capital alternatives. Noncapital alternatives were assumed to require no net investment to implement, for example, changes in transit regulations, staggering of work hours, changes in parking rates, and certain other pricing changes. Low-capital alternatives were assumed to require some capital costs but no additional rights-of-way, for example, traffic engineering changes, modification of streets and highways to give priority or exclusive use to buses, and the purchase of additional vehicles.

The information provided by the cities and states is found in the 1972 National Transportation Report (8). For urban areas of 50,000 population and more, the total unconstrained urban transportation capital needs reported for the period from 1970 to 1990 are $232 billion, of which 73 percent are highway needs (Table 1). For CIP alternative 3, the total urban transportation public capital expenditures proposed (Table 2) were slightly more than half the amount of the unconstrained needs. (Under alternative 3, the states and cities were requested to indicate their proposed CIPs for the period 1974-1990 under the high federal funding level of $140 billion, i.e., a federal matching ratio of 66⅔ percent for all eligible capital expenditures, no support for operating costs, and complete flexibility to allocate transportation funds between rural and urban areas, among local programs, and between modes. Alternative 2 provided the same level of funding as alternative 3, but allowed no flexibility to reallocate funds among programs. Alternative 1 also permitted no flexibility and provided $70 billion federal support.) However, for both the needs estimates and CIP alternative 3, the highway-transit mix is relatively constant; approximately three-fourths of the expenditures are proposed for highways. Similarly, the proportions of public transit funds to be devoted to rail transit—79 percent and 72 percent respectively—are roughly the same. The data given in the tables reveal the greater capital intensity of passenger travel in larger cities. Expenditures per capita are an increasing function of city size, and the percentage of rail to total transit needs and expenditures is higher in larger cities—especially those in the 1-million-and-more group.

To induce the urban planning groups to give serious consideration to the use of noncapital and low-capital alternatives and to get a better picture of the extent to which planners use (or even consider) nonbuilding solutions to urban transportation problems, a request was made that urban planning groups complete a table indicating whether they employed, attempted, or even contemplated the use of noncapital means to improve transportation performance (Fig. 1). A summary of the results is given in Table 3. The findings of the survey support the contention of this paper, i.e., that we have only scratched the surface in our attempts to employ nonconstruction alternatives—particularly economic incentives—to improve transportation. It is significant, however, that the most extensive use of noncapital alternatives to date has been in the most densely populated areas, where environmental and congestion problems are the worst and the costs of CIPs are the highest (1, 14).

The Problem Reconsidered

Given our previous investments in urban transportation resources, the existing stocks of assets, the number and the range of noncapital and low-capital options open to us, and our failure to exploit these options except in a relatively small proportion of our cities and on an individual and ad hoc basis, we can clearly obtain substantial improvements in transportation performance without massive CIPs, particularly without doubling urban highway mileage by 1990 to 647,000 miles at a cost of $170 billion (1969 prices) to satisfy 1990 needs (8, 10).

To repeat, the conventional approach has not solved the problem. The reason it has failed is that the problem it is attacking—congestion—is but a symptom of our failure to attack the more basic problem—poor use of urban transportation resources. In other words, the problem involves not capacity but economics. The best example of this is the way we treat highway resources. When a capital improvement program is completed, the product—the highway—is not used very productively, for there is excess capacity during the peak hours as well as during the off-peak hours. As a case in point, the Washington, D.C., Metropolitan Council of Governments recently estimated that during the morning peak period every weekday the number of empty seats in passenger cars entering the District of Columbia exceeded the number of transit riders entering the city. There are other shortcomings to the emphasis on new facilities:

Table 1. 1970-1990 transportation needs by mode and per capita by urban area population size.

1990 Population Group	1970 Population (millions)	Highway Needs[a] Amount (millions)	Highway Needs[a] Percent	Public Transportation Needs Amount (millions)	Public Transportation Needs Percent	Public Transportation Needs Percent for Rail	Total Needs (millions)	Needs per Capita[b] Highway[a]	Needs per Capita[b] Transit	Needs per Capita[b] Total
Less than 2 million										
1 to 2 million	18.4	24,439	82	5,395	18	55	29,834	1,328	293	1,621
500,000 to 1 million	13.3	15,899	86	2,598	14	33	18,497	1,195	195	1,390
250,000 to 500,000	10.5	16,402	94	1,043	6	18	17,445	1,562	99	1,561
100,000 to 250,000	10.3	15,357	96	708	4	21	16,065	1,491	69	1,560
50,000 to 100,000	6.5	8,624	94	522	6	22	9,146	1,327	80	1,407
Subtotal	59.0	80,721	89	10,266	11		90,987	1,368	174	1,542
More than 2 million	66.0	89,081	63	52,063	37	87	141,144	1,350	789	2,139
Total	125.0	169,802	73	62,329	27	79	232,131	1,358	499	1,857

Note: Amounts are in 1969 dollars.

[a]Not including local roads or the cost of completing the Interstate System.

[b]Based on 1970 population.

Table 2. 1970-1990 transportation expenditures under capital improvement alternative 3 by mode and per capita by urban area population size.

1990 Population Group	1970 Population (millions)	Highway Expenditures[a] Amount (millions)	Highway Expenditures[a] Percent	Public Transportation Expenditures Amount (millions)	Public Transportation Expenditures Percent	Public Transportation Expenditures Percent for Rail	Total Expenditures (millions)	Expenditures per Capita[b] Highway[a]	Expenditures per Capita[b] Transit	Expenditures per Capita[b] Total
Less than 2 million										
1 to 2 million	18.4	16,895	82	3,673	18	41	20,568	918	200	1,118
500,000 to 1 million	13.3	10,841	86	1,701	14	53	12,542	815	128	943
250,000 to 500,000	10.5	9,682	93	677	7	26	10,359	922	64	986
100,000 to 250,000	10.3	8,136	94	502	6	22	8,638	790	49	839
50,000 to 100,000	6.5	4,774	93	344	7	22	5,118	734	53	787
Subtotal	59.0	50,328	88	6,897	12		57,225	853	117	970
More than 2 million	66.0	45,907	66	23,997	34	81	69,904	696	364	1,060
Total	125.0	96,235	76	30,894	24	72	127,129	770	247	1,017

Note: Amounts are in 1969 dollars.

[a]Not including local roads or the cost of completing the Interstate System.

[b]Based on 1970 population.

Figure 1. Form for providing information on noncapital alternatives.

NAME OF URBANIZED AREA ________ STATE ________ CARD 2 4 STATE 8 AREA 8 8

ALTERNATIVE	CARD NO.	CONSIDERED IN PAST?[1]	ATTEMPTED IN PAST?[1]	PRESENTLY PRACTICED?[1]	PLANNED FOR FUTURE?[1]	IF PLANNED FOR FUTURE GIVE DATE
1. STAGGERING OF WORK HOURS	1	12	13	14	15	19 16 17
2. MEASURES TO ENCOURAGE CAR POOLING		18	19	20	21	19 22 23
3. BANNING PRIVATE AUTOMOBILES FROM THE CBD		24	25	26	27	19 28 29
4. RAISING TOLLS ON TOLL BRIDGES AND TUNNELS DURING PEAK HOURS		30	31	32	33	19 34 35
5. LOWERING TOLLS ON TOLL BRIDGES AND TUNNELS DURING OFF-PEAK HOURS		36	37	38	39	19 40 41
6. INCREASING CBD DAYTIME PARKING RATES		42	43	44	45	19 46 47
7. RAISING TRANSIT FARES DURING PEAK HOURS		48	49	50	51	19 52 53
8. LOWERING TRANSIT FARES DURING OFF-PEAK HOURS		54	55	56	57	19 58 59
9. UNRESTRICTED ENTRY OF TAXICABS		60	61	62	63	19 64 65
10. UNRESTRICTED ENTRY OF JITNEYS		66	67	68	69	19 70 71
11. RESERVED LANES FOR BUSES		72	73	74	75	19 76 77
12. RESTRICTIONS ON CURBSIDE LOADING AND UNLOADING IN CONGESTED AREAS	2	12	13	14	15	19 16 17
13. EVENING DELIVERY BY TRUCKS IN DOWNTOWN AREAS		18	19	20	21	19 22 23
14. OTHER (DESCRIBE)						

[1]CODE ANSWERS: YES = 1, NO = 2

Table 3. Percentage of urban areas by 1990 population size practicing noncapital alternatives.

Alternative	Entire Country	>2 Million	1 to 2 Million	500,000 to 1 Million	250,000 to 500,000	100,000 to 250,000	50,000 to 100,000
Staggering of work hours	25.7	35.7	53.3	48.3	21.6	22.6	18.8
Measures to encourage car pooling	6.8	14.3	13.3	6.9	2.7	6.0	6.8
Banning private automobiles from the CBD	0.7	0.0	0.0	0.0	2.7	1.2	0.0
Raising tolls on toll bridges and tunnels during peak hours	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lowering tolls on toll bridges and tunnels during off-peak hours	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Increasing CBD daytime parking rates	19.6	28.6	33.3	24.1	16.2	21.4	15.4
Raising transit fares during peak hours	0.3	7.1	0.0	0.0	0.0	0.0	0.0
Lowering transit fares during off-peak hours	3.7	42.9	6.7	0.0	2.7	3.6	0.0
Unrestricted entry at taxicabs	21.6	50.0	26.7	20.7	18.9	17.9	21.4
Unrestricted entry of jitneys	9.8	7.1	20.0	13.8	2.7	10.7	9.4
Reserved lanes for buses	7.8	50.0	20.0	13.8	8.1	4.8	1.7
Restrictions on curbside loading and unloading in congested areas	51.0	85.7	73.3	58.6	48.6	56.0	39.3
Evening delivery by trucks in downtown areas	9.1	21.4	20.0	10.3	10.8	6.0	7.7

1. Long lead times between initial planning and final completion;
2. Right-of-way and construction costs, which were conservatively estimated in 1968 to average $1.3 million per lane-mile for urban freeways (15);
3. High accident rates of motor vehicle travel (highway fatalities constitute 90 percent of total transportation fatalities) (8);
4. High energy costs required for the construction of highways as well as for motor vehicle travel (roughly 45 percent of total vehicle-miles traveled are in urbanized areas, where congestion and delays waste fossil fuels) (8);
5. Propensity of new facilities to generate additional trips (and to encourage traffic-generating land uses); and
6. High environmental costs associated with highway construction and with motor vehicle travel.

With regard to environmental costs, air quality has declined to dangerous levels in many areas, and motor vehicles now account for roughly one-third of the total nitrogen oxides, one-half of the hydrocarbons, and two-thirds of the carbon monoxide. These pollutants are emitted mostly on 10 to 15 percent of our land area (8). Traffic noise is now viewed as the most annoying kind of unwanted sound, and it exceeds that from any other source throughout the greater part of urban areas. Forty-five decibels are sufficient to interfere with conversation, but traffic-produced median levels of 73 decibels at night were found in cities tested by the Environmental Protection Agency (16). Large amounts of urban land are devoted to the movement and parking of vehicles. The acquisition prices of rights-of-way have increased sharply in recent years, and the opportunity costs in the form of open space and parkland sacrificed have been sufficiently high to arouse considerable opposition and organized resistance.

The Solution Reconsidered

Apparently a major shift in transportation policy and methodology is to attempt to significantly improve levels of service by better management of transportation systems. Until quite recently, this approach has received very little attention in government (especially at the federal level). The philosophy of transportation agencies, their organization (especially state and local highway departments), their financial assistance programs (both absolute amounts of funds and matching shares), and the planning process (methodologies, technical manuals, training programs) all have minimized or ignored the potential for improving transport services by making more efficient use of previous investments. The urban planning literature also reflects the capital bias. For example, Creighton emphasizes that he is not concerned with improvements in management, administration, regulation, and education, although he acknowledges (2, pp. 14-16), "These are probably the most important kinds of actions which can be taken because they are related most directly to the social, economic and governmental nature of the problems."

As suggested earlier, the means to achieve increased efficiency are many and varied. The key is to treat as variables what we have regarded previously as givens, parameters, or constraints—i.e., average automobile occupancy, work hours, modal split, transit levels of service, economic regulations, prices, and even modes or variations of existing modes (for example, the jitney and subscription bus service). Although these are commonly viewed as "institutions," which change over the long run (if at all), such changes are virtually the only means of achieving very much in the way of better service in the short run when the scale of the physical plant—the rights-of-way—is fixed. Moreover, we are in a period of changing institutions, partly as a result of the 1975 air quality standards set by the Environmental Protection Agency and the energy situation.

Before we examine some suggested low-cost improvements, we should consider some factors that contribute to congestion during the journey to work. Congestion occurs because the demand for transportation services is highly concentrated in terms of time periods, routes, and directions. In developing alternatives to reduce congestion, we must identify the journey-to-work characteristics that produce this concentration.

1. Hours of employment coincide for most people (e.g., 9 to 5). The result is that the vast majority of work trips occur during 1 or 2 hours in the morning and again in the afternoon.
2. Places of residence and employment typically are separated, leading to commuting to work.
3. The automobile is used for most work trips, more than 82 percent nationally (8).
4. Individuals tend to drive to work by themselves. Automobile occupancies average 1.2 to 1.5 per car, depending on the city. More than half of the automobiles carry only 1 person (8).
5. Most workers commute along a relatively small number of corridors to their places of employment.
6. Automobiles as well as all motor vehicles impose external costs on others, chiefly, air pollution, noise, and higher time and operating costs.
7. Most motorists underestimate or are not conscious of their commuting costs (including depreciation) or costs that are external to them.
8. Public transportation (and car pools as well) is unavailable, inconvenient, or considered demeaning by many people.

Paradoxically, some urban travel characteristics that contribute to congestion can be used to alleviate it, e.g., low average automobile occupancy and travel peaking. The following section describes a number of techniques that may be used to restructure the demand-supply relations that create congestion and to improve transportation performance.

TAXONOMY OF NONCAPITAL AND LOW-CAPITAL ALTERNATIVES

Noncapital and low-capital alternatives may be grouped into 2 broad categories: demand-oriented programs that take the capacity of a system as given and seek to reduce the number of vehicle trips (or at least peak-period vehicle trips) and capacity or supply-oriented programs that seek to increase the people-moving capabilities of a system.

Demand-Oriented Alternatives

1. Pricing—Increasing the price of peak-hour travel will reduce the demand for peak-hour trips. There are strong economic grounds for raising the price of peak-hour travel to levels commensurate with marginal social costs (principally the additional travel time costs created by congestion, but also the related operating, risk, air

pollution, and noise costs) by means of self-canceling tickets, toll changes on existing toll facilities, and higher parking charges (20, 21, 22, 23).

2. Spreading Travel Peaks—If the total number of passenger and vehicle trips per day is accepted as given, peak volumes can be reduced by measures to reduce certain nonwork trips (e.g., afternoon baseball games), by staggering of work hours, and by gliding time. As the 4-day work week gains acceptance, 4 days of work can be spread over 5 or 6 days (24, 25, 26).

3. Group Riding—If the number of peak person trips is accepted as given, increasing average vehicle occupancy by car pooling and bus pooling would reduce the number of motor vehicle trips (19, 27).

4. Improving Urban Public Transportation—An unknown but potentially large proportion of automobile commuters can be attracted to public transportation by improved service. For example, express bus service can reduce line-haul times; subscription service, changes in schedules and routes, and more imaginative use of taxis, jitneys, and demand-responsive vehicles can facilitate collection and distribution; better coordination and integration can facilitate transfers between modes and service areas of different transit companies; dismanteling of most of the economic regulations can increase innovation, reward private initiative and risk, and ease the restrictions that limit the number of taxicabs and prohibit jitney operations; and service improvements combined with more aggressive marketing can improve the public image (19, 28, 29).

5. Restructuring Commuter Rail—Satisfactory commuter service and some reduction in automobile commuting can be achieved in corridors in many U.S. metropolitan areas by the initiation of commuter rail service on existing track, use of idle rolling stock, and provision of parking lots (30, 31, 32).

6. Improving Urban Goods Movement—In some cases the interference between freight and passenger movements can be decreased (and freight costs lowered) by a reduction in the number of urban truck trips. Ways to reduce truck trips include consolidating terminals and coordinating pickup and delivery, rescheduling the times that freight is picked up and delivered, restricting curbside loading and unloading, and using special routes or lanes for trucks (33, 34, 35).

7. Facilitating Bicycle Travel—Use of the bicycle for the journey to work can be encouraged by the provision of bicycle lanes on streets, secure storage areas for bicycles at transit stations and places of employment, and buses and rail cars that accommodate bicycles (36).

Capacity-Oriented Alternatives

8. Improving Traffic Operations—The effective vehicle capacity can be increased by traffic engineering, e.g., reversible lanes and coordinated and computerized signals, and traffic regulation, e.g., banning of curbside parking during peak hours (37).

9. Using Larger Public Transportation Vehicles—The passenger capacity of streets and highways can be further augmented by the use of larger vehicles. For example, articulated and double-decked buses have long been in service in Germany and the United Kingdom respectively (38).

10. Giving Priority to High-Capacity Vehicles—Giving priority to high-capacity vehicles (i.e., buses, or possibly buses and car pools) can provide high-speed passenger capacity (i.e., 50,000 to 60,000 seated passengers per hour per lane) sufficient to serve the demand in almost any radial corridor in any U.S. city (19, 39).

POLICY CONSIDERATIONS IN CHOOSING AMONG ALTERNATIVES

Because so little attention has been devoted to low-capital improvements to transportation, the state of the art of planning and the understanding of policy considerations are primitive. This section will discuss factors that should be considered in developing noncapital and low-capital improvement programs. These considerations are also applicable to more capital-oriented programs.

Energy and Environmental Implications

During the period from 1965 to 1970, motor VMT and their expenditures increased at the annual average rate of 4.2 percent; at that rate, they would double every 17 years (8). Gasoline consumption has grown at a rate of 5 to 6 percent, or a doubling every 12 to 14 years (40). The 1972 National Transportation Report forecast a rate of growth of VMT of 3.8 percent for the 1970 to 1980 period, or a doubling every 20 years. Rates of growth of this magnitude are not compatible with the world's dwindling supplies of fossil fuels and the present national policies to conserve energy.

Alternatives 1, 3, 4, 5, 6, 7, and 10 would have the effect of reducing VMT; alternative 1 would offer the most potent tool. Alternatives 2 and 8 would tend to increase average speeds and thus, other things being equal, would generate additional vehicle trips. Because reducing VMT is fundamental to transportation environmental and energy goals, the emphasis should be placed on noncapital alternatives that would reduce or at least not increase VMT.

Complementarity and Substitutability

Not nearly enough is known about the interrelations among the alternatives recommended in this paper. No city has attempted some of the alternatives (e.g., pricing and the 4-day work week), much less all of them collectively. Nevertheless, 2 types of relations are evident.

There are strong complementarities or synergistic effects among the alternatives. On the demand side, measures to correct the price-cost distortion among modes (i.e., higher prices for automobile driving and parking, especially the journey to work) would encourage peak spreading through encouraging nonwork trip-makers to travel during off-peak hours and by providing greater incentive to stagger work hours. Those measures would also encourage car pooling and would divert more riders to public transportation. The demand for public transportation would also be increased by changes in the regulatory environment, by better marketing, and by measures to improve transit speed, whether by service improvements (e.g., express bus operations) or by improvements on the supply side (e.g., reserved lanes for buses and car pools) or both. Reducing interference between passenger and freight vehicles could improve the travel times of both and would reduce freight delivery costs.

There is also substitutability among some of the alternatives, and trade-offs would be required if those alternatives are implemented simultaneously. Programs to stagger work hours may complicate efforts to increase vehicle occupancy. On the other hand, gliding time facilitates car pooling and reduces the 15- and 30-minute transit peak demands by permitting employees to rearrange working hours. Transit improvement programs may divert commuters from car pools and other transit modes as well as commuters who drive alone. The effects of these and other conflicts can be mitigated by increasing the size of the area and the number of people affected to expand the range of choice (e.g., southwest Washington, D.C.) and by careful planning. Or, one alternative (e.g., group riding) may preclude the need for others. Greater reliance on economic incentives and the market would assist individuals in making the proper trade-offs (e.g., between car pools and buses). Obviously, the alternatives selected and their manner of implementation would vary among and within cities.

Cost Comparisons

Because of their disparate nature (e.g., staggered hours vis-a-vis commuter rail), alternatives cannot be compared on a passenger or seat-mile basis. Studies recently completed for the U.S. Department of Transportation provide rough comparisons. Table 4 (19) gives operating costs of the various highway alternatives, and Figure 2 (18) shows passenger trip-miles per vehicle-hour related to costs. Table 5 gives costs of commuter rail (43) and implementation costs associated with reserving a freeway lane for buses and for constructing an exclusive bus lane (18). Revising transit regulations, changing work schedules, and certain improvements to facilitate bicycle travel are even cheaper to initiate and administer.

Table 4. Travel time savings and cost characteristics of busways in 7 urban areas.

Site	Busway Length (miles)	Time Saving: Bus Over Automobile: Amount (min)	Time Saving: Bus Over Automobile: Percent	Time Saving: Bus Over Former Bus: Amount (min)	Time Saving: Bus Over Former Bus: Percent	Costs (dollars): Implementation	Costs (dollars): Operating (attributable to exclusive lane)
Freeway							
New Jersey I-495	2.5	na[a]	na	10	na	750,000[c]	171,000/year
Long Island Expressway	2	15	85	na	na	50,000 (est.)	500/day (est.)
Boston Southeast Expressway	8.4	7.5	42	14	58	50,000 (est.)	500/day (est.)
Specially constructed							
Washington, D.C., Shirley Highway a.m.	9	13	33	na	na	620,000/mile	Insignificant from prior costs
p.m.	9	20	54	na	na		
Arterial							
Louisville Third Street[b]	2	Slower	Slower	5.5 to 12[d]	13 to 28[d]	30,000 (est.)	Insignificant from prior costs
Indianapolis College Avenue	na	na	na	na	na	Very low	Insignificant from prior costs
San Juan Fernandez Juncos and Ponce de Leon	10.4	na	na	30	38	100,000 plus staff time	Insignificant from prior costs

[a]Not available.
[b]Increases in speeds were noted for all eastbound traffic whether traveling the bus lane or not.
[c]Not representative because of post-setting equipment.
[d]For total bus route; data are not available for the portion of the trip on the exclusive bus lane.

Figure 2. Relation of passenger trip-miles per vehicle-hour and costs.

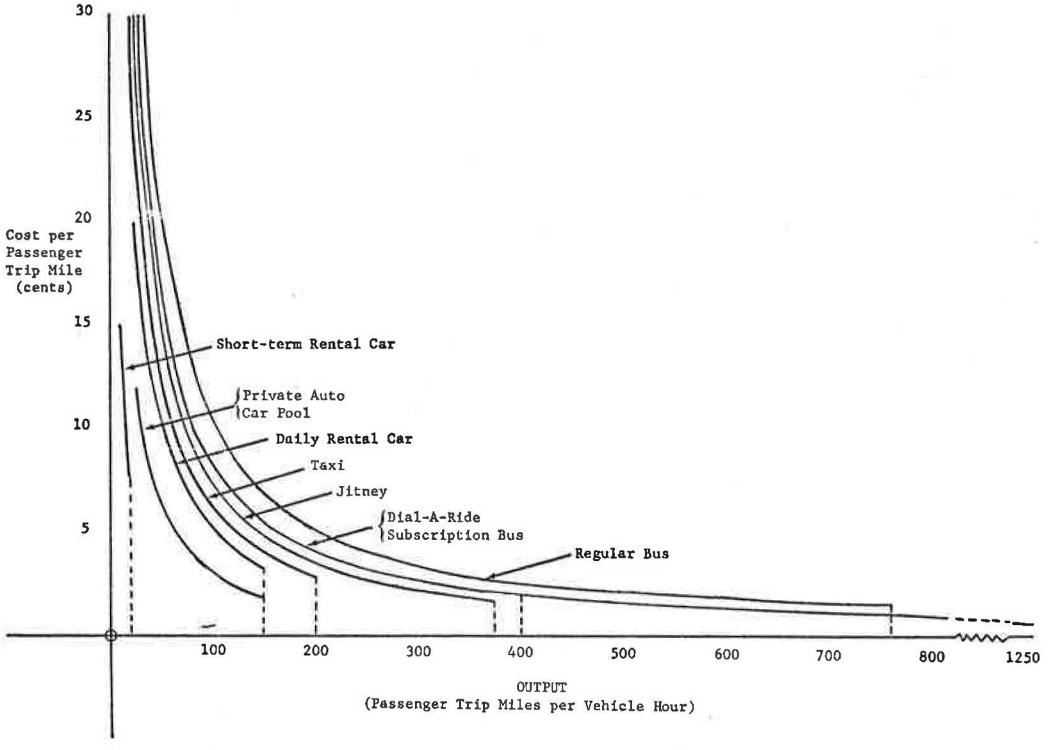

Table 5. Costs of highway alternatives and commuter rail.

Alternative	Operating Cost per Seat-Mile, Including Depreciation (cents): Range	Avg
Automobile	12 to 18	14.2
Car pool	2 to 3	2.4
Bus pool	1 to 4	1.8
Bus transit	1.5 to 4	1.8
Commuter rail	3 to 40[a]	5.3

[a]Per passenger-mile.

Demand and Equilibrium

Implementation of some of those alternatives will set in motion market forces that, after a period of adjustment, will reduce somewhat the improvements in congestion and travel time. Thus, staggering work hours, car pooling, and increasing public transportation use will reduce peak automobile volumes and increase average speeds. The reduction in travel time will mean that the average cost or price of peak-hour automobile travel will be lower, and at the new reduced price some trips that previously had been taken during the off-peak will be attracted to the peak. Similarly, some commuters who previously had used public transportation or car pools will choose to drive their cars because the price is now below the threshold necessary to induce them to make such a change. The volumes that occur at the new equilibria will depend on the elasticities of demand, the alternatives used, and the effectiveness of implementation. To prevent such erosion of the gains from these alternatives, some means must be found to ration the available capacity, particularly during the peak hours. One means is restrictions of various types, including cutbacks in the supply of fuel available. Economic means (for example, peak-hour tolls and higher commuter parking rates) have the advantage of being less arbitrary, of allowing greater choice, and of permitting people to express their preferences on the basis of willingness to pay. The chief problem is to gain public acceptance (the equity issue can be resolved by providing alternatives so that no one is penalized).

Over time, the demand for transportation services changes in response to changes in income, population density and distribution, and tastes. The levels of service will depend on the patterns of demand in terms of mode, time of day, route, direction of travel, and the degree of capacity utilization in terms of these factors. Based on historical experience, the number of automobile trips will probably have to be restrained at least during peak hours if high service levels are to be maintained without investment in additional capacity. As noted earlier, if the emphasis is on the movement of persons rather than vehicles, capacity will be sufficient in all but perhaps the most heavily traveled corridors to provide high-quality passenger transport. What the emphasis should be, of course, is a policy issue, which will include environmental, energy, demand, supply, and cost considerations.

ADVANTAGES AND OBSTACLES

Advantages

The strongest argument for the approach suggested here is that it explicitly addresses the congestion problem, the question of economic efficiency, and other interpretations of "the urban transportation problem." The author is convinced this is the only approach that offers at this point any real hope because it employs a more diverse and sharper set of tools than other approaches he has seen and deals explicitly with the underlying market forces. Other advantages are discussed below.

Potential for Service Improvements—Dramatic changes in peak travel times can be achieved if these alternatives (or even a subset of them) are employed simultaneously on an areawide basis, particularly if they are accompanied by some form of congestion pricing and higher commuter parking charges.

Range of Choice—These alternatives would provide urban travelers with a greater range of choice in terms of price and service characteristics, particularly commuters who now have (or who perceive that they have) no other choice than to drive alone. Some of the alternatives, for example, relaxing constraints on taxi and jitney operations, would improve mobility for inner-city residents and in addition provide employment opportunities for drivers.

Transit Subsidies—Implementing para-transit alternatives (e.g., replacing low-patronage bus routes with shared-taxi and jitney services and diverting some bus travelers to lower cost subscription services and thereby reducing bus peak demands) might reduce or eliminate the need for subsidies on some routes.

Medium- and Small-Sized Communities—Given the funds available for subsidies under the present transit programs and those likely under future transit programs, many communities are not large enough to generate the demand necessary to sustain a conventional bus transit system. For such communities the choice appears to be public transportation in the form of para-transit (and possibly commuter rail for new towns) or no public transportation.

Cost—The costs of the alternatives are quite low except for improvements involving actual construction of reserved lanes, and even those costs are modest on a passenger or seat-mile basis relative to automobile-highway and rail transit alternatives.

Time—Not including planning time, the time to implement the improvements described here is a matter of months, sometimes weeks, in contrast to a minimum of several years for capital programs (or sometimes not at all, as in the case of the San Francisco Embarcadero Freeway).

Energy and Environment—Although the proposals advanced here are oriented primarily toward improving efficiency and reducing congestion, they are the same proposals advanced to improve environmental quality and conserve energy, particularly the proposals that reduce VMT. Moreover, these alternatives are much less damaging to the environment than capital-intensive programs.

Flexibility—Because of the pace of change in urban values and goals and developments in transportation technology, flexibility is a quality that will become increasingly important. By their very nature, capital improvement programs tend to be irreversible. In contrast, noncapital and low-capital alternatives increase the range of future options.

Future Capital Programs—Low-capital alternatives could reduce substantially the amounts of capital needed in the future to improve transportation service. Moreover, this approach would provide some of the information we now lack for long-range planning. How much are people willing to pay for (i.e., how much do they value) different types of transportation service? After an "optimum" solution is achieved in the short run, how much (and what kind of) investment is needed to achieve a long-run optimum?

Obstacles

The obstacles to low-capital improvements are primarily institutional, or at least progress is retarded by institutional rigidities.

Construction Orientation—Our construction orientation is not surprising, given our heritage: a subcontinent where until the 1940s the transportation problem was seen as one of providing links between cities or between farm and market. Now that we have extensive urban highway systems in various stages of completion, we have difficulty conceiving of the problem as being something other than capacity and the solution as being something other than a choice among capital-intensive, "pure" technologies, i.e., highway (automobile) or transit (rail). This bias is reflected in the professional literature, in textbooks, in college and university curricula, in short courses conducted by professional organizations, and in governmental studies and programs.

Aid Programs—Existing aid programs, particularly federal, are capital oriented. With the exception of TOPICS (which will not receive separate funding after 1975), no ongoing federal program finances technical studies or capital grants or operating programs oriented toward noncapital improvements.

Organizational-Jurisdictional—At the metropolitan level, normally no metropolitan-wide central agency has authority for all aspects of transportation planning, financing, administration, and regulation. Mayors do not have the power to bring all the actors together, and full cooperation is usually impossible to attain. At the U.S. Department of Transportation, responsibility for ground transportation is split between FHWA and UMTA. Low-capital projects frequently need funds from both administrations, but each has its own goals, priorities, procedures, and time schedules, making an integrated program difficult. To date, there have been little concentrated effort and no central focus for noncapital and low-capital programs.

Lack of Information—Most planners are not aware of the full range of alternatives available to them. If they are, they lack sufficient information to evaluate some of them, for example, economic incentives.

Lack of Methodologies—We have numerous manuals on trip generation, modal split, and network assignment. Although there are technical reports on many of the alternatives described here, the first technical manual for field use was published early in 1973 (27).

Momentum of Capital Programs—The conventional approach, including ongoing programs involving annual expenditures of several billion dollars of federal funds matched by state and local expenditures, has generated considerable momentum.

Delivery Delays for New Buses—Although the production of new automobiles exceeds the demand and inventories are accumulating of both domestically produced and imported cars, several months to a year are required for a transit agency to obtain a new bus. This time lag was particularly painful for transit bus operators during the 1973-1974 energy crisis because they were not in a position to fully take advantage of the increase in demand for bus travel.

Vested Interests—Probably the greatest opposition will be from those who have a stake in the status quo (or at least who perceive that they do). For example, transit operators and some elected officials will resist changes in economic regulations to permit greater use of para-transit, and similarly for labor unions. By the same token, highway departments will resist having their construction programs curtailed.

Lack of Sex Appeal—Low-cost improvements do not have the exotic flavor of SSTs, TLVs, TACVs, DARTs, and PRTs or even METROs and BARTs. More aggressive marketing is needed to tailor service to meet local demand and to promote the principle of noncapital alternatives at all levels of government.

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

This paper suggests an alternative definition of the urban transportation problem and alternative means of dealing with the congestion issue, especially with respect to the journey to work. The principal conclusions are the following.

1. The urban transportation problem is an economic problem: poor use of our present transportation resources to deal with today's transportation issues.
2. The setting of urban transportation has changed in the past decade or so. As a result of the Interstate program and other urban highway improvements (not to mention rail transit systems in operation or nearing completion), we now have at least the rights-of-way for extensive urban transportation systems in our cities and unused capacity during the peak hours (e.g., underused railroad track, empty seats in private automobiles, and potential bus lanes).
3. We are discovering that we have the capability to improve urban transportation service—in many cases reducing average trip times by one-half or more—in the near term and with public sector outlays, which are modest by means of a rich and diverse set of opportunities, to use urban transportation systems more effectively. Even more surprising, for a large share of journey-to-work trips, it may be that the only way to achieve better service is to devote fewer resources to transportation, for the primary concern—congestion—is created by an excessive number of motor vehicle trips during the time period in question. People will be able to travel at higher speeds only as the ratio of passenger trips to vehicle trips increases during the peak hours.
4. Private individuals and local governments have shown considerable initiative in implementing low-cost improvements. Although some of the recent successes in the United States have been federally sponsored, e.g., the Shirley Highway exclusive bus lane, others have not, e.g., the exclusive bus lanes in Puerto Rico, demand-responsive service in Davenport, Iowa, and numerous bus-pool and car-pool projects (18, 19).
5. Increased transportation efficiency appears to be occurring for reasons other than the sole purpose of providing better service or increasing revenues. The proposals advanced here are also advanced in the interests of energy conservation and of meeting air quality standards. These and other influences (e.g., the opposition of citizens to urban freeways) are gaining momentum and may exert more force than transportation or efficiency considerations per se.

6. To say that we are on the threshold of a revolution in our theory and practice regarding urban transportation may be an exaggeration. Certainly the textbooks and the thrust of government programs do not support such a view. Yet the alternatives discussed in this paper have their real-world counterparts in terms of individual commuters, entrepreneurs, and local government. Examined in isolation, they do not suggest major changes in urban transportation. Taken collectively, they imply a major shift in emphasis, particularly if they were planned and implemented as a group in any given city as part of a "continuing, comprehensive, cooperative transportation planning process." In 1990, we may look back and conclude that a major shift in emphasis from capital-intensive to noncapital solutions did indeed take place in the 1970s (41).

Policy Implications

1. The conventional wisdom concerning the urban transportation problem, the solution, the role of government (particularly federal), the role of the private sector, and the question of incentives need to be reexamined. The emphasis should be on near-term, noncapital, and low-capital alternatives, and a new set of concepts and methodologies should be developed. The basic building blocks would include the full range of alternatives available, greater attention to environmental and energy considerations, greater emphasis on economics and on market forces, improved methods of forecasting travel demand, and more emphasis on citizen participation.

2. A federal program consistent with the approach recommended here involves changing the past direction almost 180 degrees. The suggested shift in emphasis offers greater potential for achieving the official U. S. Department of Transportation goals of economic efficiency, environmental quality, safety, and facilitation of local determination than the present long-term, capital-intensive orientation.

3. The elements of an urban transportation program that emphasize making more efficient use of present systems would include the following:

a. Aid programs that make implementation of low-capital programs a prerequisite for obtaining CIP funds and that make much larger amounts of funds available for local planning, implementation, and administration of noncapital and low-capital improvements;

b. Promotion of user charges, fares, and prices that reflect the economic cost (including external costs) of transportation services;

c. Assistance in reducing the institutional constraints, particularly those concerned with economic regulations and support of labor rules and practices that inhibit public transportation;

d. Amending the federal highway code to permit cities to charge congestion tolls on federal-aid facilities;

e. Research and demonstration in the whole area of low-cost improvements, with emphasis on support of local initiative;

f. Development of methodologies to assist urban planning groups in evaluating and implementing low-cost improvements;

g. Revising the urban transportation planning process to give first priority to near-term, low-cost improvements and to link them with long-term, capital-intensive programs;

h. Dissemination of information, especially technical manuals and experience gained from application of new ideas; and

i. Marketing efforts to promote the low-capital approach to urban transportation.

These are bold changes. Even in a period of changing orthodoxies, a program of this nature will be a significant departure from the past.

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ESTIMATING LATENT DEMAND AND COST FOR STATEWIDE TRANSIT SERVICE

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In 1968, the U.S. Department of Housing and Urban Development commissioned a series of studies to define the potential demand for new systems of urban transportation. Among these was a study of latent demand for urban transportation to focus specifically on urban groups who have transport needs that are not met by existing systems. Emphasis was placed on the needs of the elderly, the poor, the young, and the handicapped. Need was identified through a series of questionnaires of select groups in Pittsburgh and Baltimore. In a Minnesota study, transit needs were established through a latent demand survey conducted to determine the extent of travel that would occur under various levels of transit system improvement. The survey also developed information on the perceived needs of individual travelers. The analysis of latent demand at various levels of transit service for rural communities is the subject of this paper.

•IN RECENT years, attention has been focused on the transportation problems of persons without access to the private automobile. In a nation where mobility has been increasing for a large portion of the population, the plight of those segments of society made captive because of an inability to gain access to the highway system has become more pronounced.

Two groups of travelers have been identified as representing the principal categories of captive riders: inner-city dwellers and the rural poor. Studies have been directed at identifying the critical transportation needs of these groups as well as determining the most appropriate transportation facilities and services to satisfy these unmet needs. The urban captive rider has been further identified into categories such as elderly, young, poor, handicapped, and housewives. Each of these groups has specific transportation needs that are not met by present transport systems. Perhaps the elderly represent the group for which needs have been most clearly defined. Present transit systems provide service to the elderly on a daily basis as well as through special programs such as reduced fares, new routes connecting senior citizen projects, and special tours.

In 1968, the U.S. Department of Housing and Urban Development commissioned a series of studies to define the potential demand for new systems of urban transportation. Among these was a study that focused specifically on urban groups whose transport needs are not met by existing systems. Emphasis was placed on the needs of the elderly, the poor, the young, and the handicapped. Need was determined through a series of questionnaires of select groups in Pittsburgh and Baltimore. Latent demand was defined as the necessary trip-making potential of individuals who live within metropolitan areas and have no access to an automobile.

More recent studies have focused on specific transport solutions, for example, demand-responsive transportation and medi-cab, or have refined means for determining mobility deficiencies. Two basic measures have been attempted. The first, based on access opportunities, measures mobility in terms of the number of trip opportunities within a stated time-distance of the origin zone. The second, based on differential trip generation rates, measures deficiencies in transport services, for example, the difference between trip generation rates of families with and without an automobile. A variety of trip-making variables can be identified, such as income, transit service availability, age, and family size. Latent demand, however, deals also with perceived transport needs, and a third approach relies on personal contact with affected individuals. In this latter approach, problems, trip priorities, and major deficiencies in the present transport system are identified through personal interviews and discussions.

The intention here is not to recount in detail the research results that have been forthcoming in the area of latent demand since the HUD Study. The references give publications dealing with latent demand, mobility, and related topics; the preponderance of research has been directed to urban and center-city problems. A significant omission to date has been investigations concerning the latent demand in suburban areas. Transport studies of the noncentral city portions of major metropolitan areas have focused primarily on problems of freeway congestion, highway safety, parking, traffic control, and the like. Closer examination of the relevant issues, however, reveals that unmet transport needs exist in suburban areas that may equal or exceed those in the inner city. Public transportation is either nonexistent or of lower service level in suburban areas than that in the central city, and transit lines are CBD oriented during work hours. Many segments of the population living in the suburbs are without access to an automobile; these segments include housewives in 0- or 1-car families, children, the elderly, and the poor. In fact, the population mix in suburban areas is becoming increasingly diverse, and an increasing proportion of the travel needs of suburban residents is unmet or poorly served.

The most recent interest in latent demand has developed at the state level in connection with rural and small-town needs for public transportation facilities. Data from statewide origin-destination studies do not reveal latent demand because the surveys record travel on existing systems. In a Minnesota study, transit needs were established through a latent demand survey conducted to determine the extent of travel that would occur under various levels of transit system improvement. The survey also developed information on the perceived needs of individual travelers. The analysis of latent demand at various levels of transit service for rural communities is the subject of this paper.

LATENT DEMAND FOR TRANSIT SERVICE

The latent demand for transit service represents the potential number of people who would use transit if new or improved service were provided. It primarily reflects the potential ridership among people whose mobility is restricted because they do not now have access either to an automobile or to transit. A quantitative evaluation of latent demand is necessary to estimate the number of people who need transit and are not now served, to ascertain the potential ridership response to various levels of service improvements, and to provide a basis for estimating the revenues and costs of alternative service levels.

The latent demand in rural Minnesota was determined through a questionnaire mailed to a sample of households in 4 representative cities selected from among 41 cities having populations greater than 5,000. Mankato and Bemidji were selected as representative of cities with local transit service and Albert Lea and Crookston as representative of cities without local transit. Questionnaires were sent to households within the corporate limits of each town and in surrounding areas. The returned questionnaires were then edited, and the responses were coded for computer tabulation. The results were factored to appropriately represent the population of each area and analyzed to obtain a profile of the sample population, their travel habits, and potential ridership on improved public transportation systems.

Questionnaires were sent to the 4,100 randomly selected sample households or about 10 percent of the households in each city and its surrounding area: 1,650 in Mankato, 1,150 in Albert Lea, 850 in Bemidji, and 450 in Crookston. The overall response rate was 32 percent, resulting in a sample of 3 percent of all households in the 4 cities.

The questionnaire contained 2 groups of questions. The first asked about household location, income, age distribution, automobile availability, weekly transit trips, and daily trips by all modes. The second group asked about additional trips desired by members of the household but not taken because of either poor access to public transit or unavailability of an automobile or a driver's license. Three questions were designed to evaluate the influence of access time to the transit stop on potential ridership. The alternative access times proposed in the questionnaire were 15 minutes, 5 minutes, and immediate (door-to-door service). Response to this group of questions provided a measure of the latent demand for transportation in terms of alternative levels of service.

For each city the mean values were computed and tabulated for data on household size, income, age distribution, number of automobiles and licensed drivers per household, daily trips by mode and purpose, weekly transit trips by purpose, taxi trips by purpose, and estimated weekly trips on improved transit.

Some of the parameters that describe the latent demand for transit, as derived from the survey, are given in Table 1. The data show the sensitivity of ridership to access time. The responses constitute quantitative measures of the willingness of people to use transit as a function of its accessibility. The potential ridership among in-town residents on systems having 5-minute and door-to-door access is higher for the cities without transit than for the cities with transit. The estimated ridership per capita by out-of-town residents of Mankato and Bemidji on any of the alternative types of service was similar to that of in-town residents, indicating that these people would like to be offered service similar to the service that their neighbors in town have. The data given in Table 1 were used to estimate the annual ridership on improved transit systems, as described later in the paper.

Another indicator of the need for transit is the percentage of households in which people have difficulty in getting to where they want or need to go. In the 4 cities surveyed this figure ranged between 12 and 15 percent. If trip-making were made easier for these people, the number of transit trips per household could increase by 50 percent in Mankato, 80 percent in Bemidji, 500 percent in Albert Lea, and 1,400 percent in Crookston.

LEVELS OF SERVICE

The provision of a suitable level of transit service on a statewide basis requires a thorough evaluation of the trade-off between the benefits of improved service to currently unserved or immobilized segments of the population and the costs of providing the service. The number of people who will be affected by improved service, the ridership and revenue that improved service will generate, and the cost of implementation and operation depend on the level of service provided. Before decisions can be made on an appropriate level of service or mix of services on a statewide basis, the implications of alternative service levels should be explored. For this reason, several alternative service levels were described and analyzed. Estimates of the ridership that each service level might generate were based on the responses to the latent demand questionnaire and a ridership model derived from a study of present transit operations in 11 cities. Revenues and operating costs were estimated from the ridership model and from an operating cost model based on present transit operating data.

Four service levels were defined as they might apply to out-of-town areas in terms of the number of cities served, the areal extent of service inside and outside of each city, the population of the area served, and the average access time to transit. These levels of service were then used to define transit service for the appropriate cities or city areas for 1973 and 1975. The alternative service levels were then compared according to the following service parameters: annual patronage, bus-miles, revenue, revenue per passenger, amortized capital costs, operating costs, total costs, revenue less costs, and revenue less costs per passenger.

The levels of service defined for latent demand analysis are given in Table 2 and described below.

Level of service 1 retains the present bus system in the 11 cities that have transit. The number of bus-miles and the fare in each city are the same as at present. The average access time for current transit riders remains the same. The service area includes the in-town populations, approximately 430,000 people, of Duluth, Moorhead,

Table 1. Annual trips per resident within and outside cities by access time to transit stop.

Access Time	Within City				Outside City			
	Mankato	Bemidji	Albert Lea[a]	Crookston[a]	Mankato	Bemidji	Albert Lea[a]	Crookston
Immediate (door-to-door service)	45	40	50	42	33	26	18	20
5 minutes	20	10	29	16	17	14	10	11
15 minutes	6	3	8	1	7	6	1	1

[a]Currently without transit service.

Table 2. Levels of service by access time to transit stop.

Level of Service	Description	Access Time[a]		
		Zone A[b]	Zone B[c]	Zone C[d]
1	Present system	5	—	—
2	15-minute access to out-of-town areas	5	15	15
3	5-minute access to in-town areas	5	5	15
4	Door-to-door fare of 5 cents/passenger-mile	5, I	I	I

[a]5 and 15 are minutes, and I is immediate or door-to-door service.
[b]Area within city covered by transit or area in major traffic corridors.
[c]Area within city outside zone A.
[d]Area within region but outside city.

Table 3. 1973 and 1975 patronage and costs for alternative levels of service.

Level of Service	Cities Served	Access Time by Zone			Population Served	Passengers	Revenue (dollars)	Cost (dollars)	Revenue Less Cost (dollars)	Revenue Less Cost per Passenger (dollars)
		A	B	C						
1973										
1	11	5	—	—	431,000	6,400,000	1,500,000	2,600,000	-1,100,000	-0.17
2	11	5	15	15	830,000	7,900,000	1,800,000	3,700,000	-1,900,000	-0.24
3	11	5	5	15	830,000	9,400,000	2,100,000	6,100,000	-4,000,000	-0.42
4	11	5, I	I	I	830,000	29,650,000	7,300,000	19,500,000	-12,200,000	-0.41
1975										
1	11	5	—	—	431,000	5,800,000	1,300,000	3,000,000	-1,700,000	-0.28
2	11	5	15	15	830,000	7,200,000	1,600,000	4,200,000	-2,600,000	-0.36
3	11	5	5	15	830,000	8,500,000	1,900,000	6,800,000	-4,900,000	-0.58
4	11	5, I	I	I	830,000	26,700,000	6,600,000	22,230,000	-15,640,000	-0.59

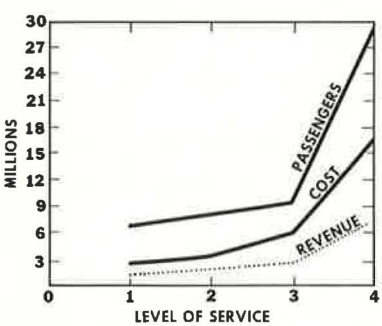

Figure 1. 1973 patronage, costs, and revenue by level of service.

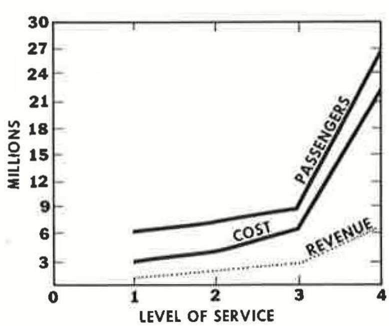

Figure 2. 1975 patronage, cost, and revenue by level of service.

Table 4. 1973 and 1975 patronage and costs for Mankato.

Level of Service	Access Time by Zone			Passengers	Vehicle-Miles	Revenue (dollars)	Amortized Capital Cost (dollars)	Operating Cost (dollars)	Total Cost (dollars)	Revenue Less Cost (dollars)	Revenue Less Cost per Passenger (dollars)
	A	B	C								
1973											
1	5	—	—	297,000	161,000	60,000	0	117,000	117,000	-57,000	-0.19
2	5	15	15	472,000	465,000	95,000	30,000	202,000	232,000	-137,000	-0.29
3	5	5	15	687,000	1,600,000	138,000	144,000	377,000	520,000	-382,000	-0.56
4	5, I	I	—	2,400,000	4,177,000	595,000	99,000	1,563,000	1,662,000	-1,067,000	-0.44
1975											
1	5	—	—	271,000	161,000	54,000	0	134,000	134,000	-80,000	-0.30
2	5	15	15	429,000	465,000	86,000	30,000	231,000	261,000	-175,000	-0.41
3	5	5	15	624,000	1,600,000	125,000	144,000	433,000	576,000	-451,000	-0.72
4	5, I	I	I	2,160,000	4,177,000	535,000	99,000	1,797,000	1,896,000	-1,361,000	-0.63

Rochester, St. Cloud, Mankato, Winona, Austin, Faribault, Hibbing, Bemidji, and Cloquet. For purposes of calculations the in-town populations of Superior, Wisconsin, and Fargo, North Dakota, are included with those of Duluth and Moorhead in the estimates.

Level of service 2 includes an extended service providing 15-minute average access time to those who live in the 11 cities with transit but do not now have access to transit and to those who live in areas around these cities. The combined service areas contain 830,000 people, or approximately twice the in-town populations. The fare structure is the same as at present.

Level of service 3 is the same as level of service 2 except that average access time of 5 minutes is provided to the entire in-town population.

Level of service 4 provides door-to-door service at a fare of 5 cents per passenger-mile for the people who live within and in the area of the 11 cities that now have transit. The regularly scheduled bus services in these cities are assumed to operate as at present. The total population of the service area is 830,000, the same as for levels of service 2 and 3.

The inventory of present operations and the latent demand survey provide a data base for estimating general service and financial parameters at a statewide level for each of the previously delineated levels of service. The records of transit operation of 11 companies for the period from 1967 to 1971 were used to develop a patronage model and an operating cost model.

Initial review of the operating data suggested that patronage could be related functionally to fare, number of regularly scheduled bus-miles supplied, and time. Review of the transit company statistics on a city-by-city basis showed that patronage declined with decreases in bus-miles, increases in fare, and passage of time.

The model that was used to correlate these parameters is of the following form:

$$P/P_o = (B/B_o)^{\alpha} (F/F_o)^{\beta} e^{\gamma(t-t_o)} \tag{1}$$

in which P, B, and F are respectively patronage, number of regularly scheduled bus-miles supplied, and revenue per passenger in year t; and P_o, B_o, and F_o represent these parameters in a base year t_o. The exponents α, β, and γ were calculated by regression analysis techniques in which data for 11 cities during a 5-year period were used. The model with calibrated constants is

$$P/P_o = (B/B_o)^{0.90} (F/F_o)^{-0.72} e^{-0.054(t-t_o)} \tag{2}$$

The operating statistics for each transit company provided information to develop an operating cost model that relates annual cost of regular route service to the number of bus-miles supplied and to time. The cost model is

$$C/C_o = (B/B_o)^{\lambda} e^{\mu(t-t_o)} \tag{3}$$

in which C and B are the annual cost and the number of bus-miles of regular route service supplied in year t, and C_o and B_o represent the same parameters for year t_o. The exponents λ and μ were evaluated by a regression analysis of the operating data. The model with calibrated constants is

$$C/C_o = (B/B_o)^{0.51} e^{0.07(t-t_o)} \tag{4}$$

The patronage model and the operating cost model provide a measure of the sensitivity of patronage to fare and the supply of service in terms of route bus-miles, sensitivity of operating cost to supply, and correlation of patronage and cost to time. These models were used with other relevant information to estimate the annual service and financial characteristics for each of the defined levels of service both in a statewide basis and separately for each of the 4 cities surveyed. The results are described in the following sections.

APPLICATION OF DEMAND AND COST MODELS

The levels of service defined previously were analyzed for potential patronage, revenue, and annual cost for the years 1973 and 1975. Specifically, estimates were made of annual ridership, bus-miles, revenue, revenue per passenger, amortized capital cost, operating cost, total cost, revenue less cost, and revenue less cost per passenger. These estimates are given in Table 3. Patronage, costs, and revenues are shown in Figures 1 and 2. The following describes briefly how the results were developed for each level of service.

Level of Service 1

The operating data supplied by the transit operators in the 11 cities with transit were used as the basis for transit cost and patronage determinations. Quantities were added to yield statewide totals and averages for the most recent year that data were available.

The formulas for patronage and cost developed previously were used to project these parameters from the base year to 1973 and then 1975. Basically, these time-variance equations predict changes in patronage and cost respectively from year to year. The cost equation accounts for inflation, which was calculated to be approximately 7 percent per year, and the patronage formula accounts for an approximately 5 percent yearly attrition in transit ridership. The base-year patronage and cost figures and the assumption that the fare and vehicle-miles supplied in 1973 and 1975 would be the same as the base-year figures were used to derive the other 5 parameters for each city for 1973 and 1975. The total cost is estimated to exceed total revenue by more than $1.1 million in 1973, or 17 cents per passenger, and by $1.6 million in 1975.

Level of Service 2

The latent demand survey revealed that if a 15-minute access were provided to all cities that have transit, patronage would increase 80 percent. According to the patronage model, which relates changes in ridership to changes in fare and bus-miles supplied, an 80 percent patronage increase would require a 592 percent increase in the number of bus-miles. This large increase in supply implies that service to the new areas would have the same frequency of bus arrivals as currently exists in the present service areas. Provision of a high frequency service to all outlying areas was judged to be an unrealistic assumption and, accordingly, the number of bus-miles was reduced to reflect lower frequencies for some new in-town service areas and for out-of-town areas. The corresponding assumed number of bus-miles represented a 188 percent increase over present service. The patronage model estimated a resulting increase in ridership of 37 percent. Thus, the 80 percent increase in ridership represents an upper bound, and the 37 percent increase represents a lower bound estimate of patronage if service were increased to level 2, or an average increase of 59 percent. According to the cost model, which relates changes in cost to changes in bus-miles, an increase in bus-miles of 188 percent results in a 72 percent increase in cost.

Because of its relatively large size and extent, the Duluth-Superior transit system was treated separately. Application of the latent demand survey results to Duluth indicated that patronage would rise by 5 percent for level of service 2. The corresponding increase in bus-miles and cost could be 17 percent and 9 percent respectively.

These changes in patronage, cost, and bus-miles were used to calculate the other service and financial parameters for the base year in each of the 11 cities. Then the cost and patronage equations were used to project the figures to 1973 and 1975, and statewide totals and averages were calculated for each year. A change from service level 1 to service level 2 results in a patronage increase of 25 percent, but the deficit increases from $1.1 million to $1.9 million in 1973 and from $1.7 million to $2.6 million in 1975 (Table 3).

Level of Service 3

The method of calculation of level of service 3 is the same as that for level of service 2. The base-year patronage was estimated to increase by 131 percent, bus-miles by 890 percent, and cost by 222 percent over service level 1. For Duluth-Superior, service level 3 is considered the same as service level 2, for the average access time for most of the in-town population is about 5 minutes at the present time. Costs of service level 3 exceed revenues by $4 million in 1973 and $4.9 million in 1975 (Table 3). The ridership generated by level of service 3 is 47 percent greater than that for level of service 1.

Level of Service 4

The results of the latent demand survey (Table 1) were used to estimate ridership for door-to-door service within the 11 cities that now have transit. The patronage and cost models were not applied to door-to-door service because these models were derived from and are reflective of regularly scheduled route service. Instead, estimates of ridership were based on consideration of parameters such as travel speed, travel distances, loading factors, peaking factors, and population to describe door-to-door service characteristics. Revenue estimates were based on an assumed value of 5 cents per passenger-mile. Based on the use of small vehicles for this type of service, estimates are $0.025 per vehicle-mile for amortized capital costs and $0.36 per vehicle-mile for operating and maintenance costs. The results show an estimated annual ridership of more than 29 million in 1973 in the 11 areas that now have transit. This includes ridership on the existing system and on door-to-door service, an increase of 23 million over the existing service. The corresponding figure for cost less revenue is $12.2 million.

Detailed Cost and Ridership Analysis

A more detailed analysis of each alternative service level was made for the 4 cities that were included in the latent demand survey. Each of the levels of service was used for Mankato, Bemidji, Albert Lea, and Crookston. The results given in Table 4 are for Mankato. The analysis showed that the subsidies necessary to support regular route service as now supplied would be 20 to 30 cents per passenger in Mankato and 35 to 50 cents in Bemidji. To provide similar service would require a subsidy of 50 to 67 cents per passenger in Albert Lea and 87 cents to $1.14 in Crookston. Generally, the subsidy per passenger is higher for higher levels of service. For the smaller cities, however, door-to-door service appeared to be more efficient than regularly scheduled route service.

SUMMARY

This paper describes a method for determining the statewide transit demands and associated costs for various levels of service. The results of the techniques developed were applied to rural communities in Minnesota, and estimates were developed for the amount of subsidy required at each level of service. Latent demand was established through a special survey that determined probable ridership. Cost-patronage models were used to establish the levels of investment and revenue that would accrue for each level of transit service. Although the techniques reported are of general applicability, the results of the analysis are directly useful to decision-makers in establishing the extent to which transit will be supported in communities throughout the state.

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SUBURBAN TRANSIT PLANNING AND FORECASTING

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Problems and policy issues of particular concern to suburban transportation planners are identified, including dispersed trip-making, high income and automobile ownership, low densities, significant transit-dependent population, increasing peak-hour freeway congestion, growth policy issues, and short-term availability of less expensive or nonunion labor. Experience in Orange County, 4 areas of Los Angeles County, and Chicago suburbs is discussed. Unique suburban approaches in the planning process are identified, and forecasting problems are discussed. For forecasting implications, 3 high-quality suburban-to-CBD transit services are compared with the range of calibration values for the LARTS model in southern California. Variables compared include the system characteristics in the marginal utility mode-choice model, socioeconomic characteristics of trip-makers, attitudes of trip-makers, and resultant trip-making behavior. The last category focuses on transit's market share, which appears to be a more appropriate planning statistic than the percentage of all trips using transit, as called for in mode-choice models. Some uniquely suburban transit organizational and planning process issues are discussed.

•EVERYONE is familiar with the suburban stereotype of endlessly sprawling single-family homes whose owners use 2 or 3 cars to make 6 to 12 trips per day to downtown jobs, second jobs, schools, and shopping. If a suburban area has any buses at all, they are used by the elderly, children, and domestic workers.

The problem of achieving radically improved levels of transit ridership indicates a need for significantly improved service levels—short headways, possibly door-to-door service, and even preferential treatment. Suburban public officials are beginning to ask for transit service that can attract the owners of 2 cars. In addition, a large number of handicapped, elderly, young, and economically depressed individuals are being identified among these automobile-oriented families. Both high-speed, uncongested commuter service to the central business district for drivers and local service for transit-dependent groups are needed. Experience with these transit problems in Orange County, 4 areas of Los Angeles County, and Chicago is outlined in this paper.

PROBLEMS AND POLICY ISSUES

Dispersed Trip-Making

Travel patterns in suburban areas are generally scattered. Except for some concentration to the CBD, to the airport, or to large shopping centers and industrial parks, travelers do not concentrate in corridors where they could be served by a bus or rapid transit system. Automobile dependency and freeway construction have caused accessibility to become distributed rather evenly throughout the suburbs. We need to find which suburban travel markets have the best potential for efficient transit.

High Income and Automobile Ownership

As their incomes rise, central city residents move to the suburbs and acquire a second car to maintain their mobility. Local-service bus routes simply cannot com-

*The author was with the Orange County Transit District when this research was done.

pete with automobile travel speeds for a resident who has a car in her or his garage and a place to park at the destination.

Low Densities

Standard-sized buses are designed to concentrate trips along street corridors. This is difficult in the suburbs because of the predominance of single-family homes on large lots. Fewer passengers results in less frequent service, which in turn discourages patronage.

Suburban Transit Operations

Remaining operators of bus services in the suburbs generally have had old vehicles, which are poorly maintained and unreliable.

Governmental Responsibility

The fractionalized local governments in suburban areas have been too small in size and too short of funds to help transit. Metropolitan transit operators and metropolitan planning agencies have in the past concentrated on the more critical problems of bus operations in the central city, where they have recognized that the higher densities and lower incomes create the greatest demand for transit and where any new funds are automatically sunk into higher salaries and operating costs. Only in the last few years have these agencies recognized suburban accessibility problems, and the results are evidenced in ridership.

Large Transit-Dependent Populations

Regardless of the high income and automobile ownership in the suburbs, a large number of transportation-disadvantaged persons must depend on others or simply not make trips when they need to travel. Curry (1) reported on this need, and the high populations in these groups indicate a substantial need, regardless of the scattered distribution.

Peak-Hour Freeway Congestion

Even in suburban counties, freeway construction programs are being slowed or stopped by local officials and lawsuits. Congestion on existing freeways in the rush hours is spreading deeper into suburbia. The growth-inducing experience of freeways contributes to the congestion and leads to the conclusion that many of these freeways cannot possibly retain reasonable peak-period speeds unless attractive transit service can divert that number of drivers that makes the difference between a free-flowing freeway and a congested one.

Expanding Transit Need

Growth and development create a demand for improved transit service in newly subdivided areas. This has especially been recognized in new communities, some of which have included transit services in their planning and investment programs. Under these conditions, above-average transit usage has occurred if the short trips and nonwork purposes involved are considered.

Air Quality and Energy Conservation

Regional transportation planning agencies have recognized that, to produce a significant improvement in air quality in the region, a significant improvement in transit service and disincentives to the car may be needed as part of the short-range transportation plan. In fact, such plans for most major metropolitan areas have already been prepared by the U.S. Environmental Protection Agency. Because a significant portion of the vehicle-miles of travel in a region occurs in the suburbs, they are being included in restrictions on distribution of gasoline, reductions in parking, and replacement of the travel by bus and car-pool lanes on all major streets and freeways. However, few buses are available to accommodate a mode shift. To reduce air pollution, congestion, and energy consumption, suburban transit districts may have to use freeways with or without priority treatment if they hope to seduce suburban drivers from cars. Fixed bus routes on local streets cannot compete, and only a few passengers per bus times a few bus-miles per gallon equals the same passenger-miles per gallon that automobiles achieve.

Transit Industry Efforts

Transit operators are beginning to recognize the importance of a total marketing program in building ridership. Assisted by expanded capital grant programs of the Urban Mass Transportation Administration, some transit districts are developing a comfortable and attractive suburban product and are promoting their services agressively with significant advertising budgets. Without long-standing transit habits to sustain patronage as in central cities, new services must be aggressively marketed.

State Legislation

Legislators in recent years have done much to stimulate interest in suburban transit by providing capital or operating subsidy funds to metropolitan or suburban agencies. In states such as California that provide funds to transit districts, suburban riderships are expanding.

Labor Costs

Small fleets of buses run by suburban municipalities are often able to save 25 to 40 percent of central city operating costs by paying lower salaries (2). Larger regional and suburban transit districts generally cannot maintain such a situation for long.

SUBURBAN TRANSPORTATION PLANNING PROCESS

Certain key patronage forecasting elements of the transportation planning process are being given increased attention and funding in suburban studies and in suburban elements of regional transportation network plans. Regional network plans have been prepared everywhere, but increased attention must be given to the suburban elements of those plans, particularly because the forecasting and mode-choice models are less reliable in suburban areas than they are in the central city. Bus improvement studies whose scopes are entirely within suburban areas are receiving increased attention because of the need to serve transit-dependent groups and commuters who work in the suburbs. In the past, suburban planning efforts concentrated on line-haul systems to bring people to their jobs in the city and neglected the internal trips. The following elements of the planning process focus on patronage forecasting problems that do not generally receive sufficient attention in studies of metropolitan freeway corridors or central city rapid transit systems, or if they do, they are not sufficiently important to the agencies.

Inventory of Existing Transit Operations and Ridership

This traditional element of a transit plan will receive less attention than it has in the past in suburban studies. Existing high-fare, dilapidated transit operations carrying few riders on routes that were successful 20 years ago may only create confusion in the transit study by emphasizing obsolete use. But such an analysis in a central city transit improvement study may be useful in projecting ridership on a faster bus or to a rail line. New buses, lower fares, and more frequent service are primarily dependent on completely new ridership coming from new routes designed to serve today's transportation patterns.

Suburban Technologies

Because of the problems with suburban transit in the past (dispersed trip-making, high automobile ownership, and low densities) more modern buses with frequent operating schedules will be needed to attract drivers. For the major corridors, competition between bus and rail modes continues. Benefits of rail rapid transit include comfortable operation, short headways, and reliability. Bus rapid transit provides its own feeder service so that no transfer is required and can be readily implemented on freeways. Because of its flexibility as a feeder, the express bus can serve a broad area of trip origins with several distributor routes focused on a line-haul busway to the CBD. Generally, a bus can operate on a freeway with exclusive lanes if it is mixed with car pools, if there is a significant bus volume (30 to 60 buses/hour), or if it is on a bypass for a metered ramp. A much lower investment cost may be needed for bus than for rail rapid transit (3). On the other hand, rail rapid transit has a much lower operating cost because it can be automated and several cars can be coupled to eliminate the need for a driver for each vehicle. Of course, its investment cost is higher than for buses on an existing freeway.

Variations on the line-haul technologies include use of rapid transit with a demand-responsive feeder system. This would provide high-quality and flexible door-to-door feeder service and could also serve local trips. Cost is an important consideration, but an equally important consideration is the type of operation that will maximize ridership. Although rail transit is penalized by change of mode to the feeder, the bus on the freeway disperses feeder routes so that frequency of service drops, and one or the other may generate more ridership, depending on local conditions. The primary virtue of demand-responsive service is that it is so similar to automobile or taxi operation that it generates more ridership than a fixed bus route. Rather than operate on fixed routes and schedules, which in suburban areas would have to be expensive to be frequent because of the low density, demand-responsive vehicles respond to a specific telephone call to pick up the prospective rider and deliver him or her to the door of the destination or a line-haul station. A disadvantage to either mode is that its higher operating cost as compared with poor fixed-route service requires a higher fare; but suburban income is also higher, and subsidies or free fares could be provided directly by welfare agencies.

Alignments

Alignments for high-speed rapid transit lines either make use of existing freeway lanes or ramps or may take over existing linear rights-of-way, such as those of old interurban railroads and high tension power lines. This approach minimizes the capital cost for alignment, but may put a transit line where the people are not and thus reduce patronage. A suburban corridor, however, must depend primarily on park-and-ride and feeder bus service anyway because the area will not be concentrated enough to generate significant walk-in traffic.

Bus-on-freeway proposals must give strong consideration to the potential for exclusive bus lanes or ramp-metering bypass lanes in terms of the potential detrimental impact on freeway operations and disincentives for automobile use. A recent NCHRP report describes nationwide experience with busways (3).

Sketch Planning

The theoretical basis for sketch planning is complex, but this paper will describe its use in preparing ridership forecasts. Sketch planning is a miniplanning process in which, during a short period of time, a relatively comprehensive analysis, forecasting, and evaluation process is completed for transportation planning without the use of a metropolitan computer model. It depends on availability of a comprehensive range of base data, mapped onto McHarg type of overlays, so that the technical team can take a broad perspective and propose a series of reasonable alignment alternatives. The team computes "indicators" of ridership forecasts, construction costs, and impact evaluations for a wide range of network alternatives in a fairly rapid fashion. The method is particularly useful in a suburban situation where transportation and development corridors are not well defined by historical patterns and a wide range of alignment alternatives is possible. The method allows rapid evaluation of this range of alternatives and reduction to 3 or 4 reasonable alternatives without the time and cost of multiple computer forecasts. Sketch-planning forecasts should not be confused with top-of-the-head "instant plans," which may have received little analysis.

If carefully documented, sketch plans can immediately be submitted for public review and comment and for coding as inputs to the metropolitan transportation planning computer package.

Suburban Forecasting Problems

Data Base—In any transportation study the analyst will usually complain about the age of the home interview survey data. Unless the survey was conducted within the last 2 years, the income, trip rate, trip distribution, and trip length results that are assumed to be consistent over time may have shifted. However, the data become obsolete much faster for the suburban portion of the metropolitan area than for the region as a whole because the most intensive growth occurs in the suburbs. In most suburban areas, the home interview survey data does not include disaggregate survey design or parameters, and key data items are not updated. Residential, commercial, and industrial development may have completely changed the character of many suburban areas and also the types of trips that are generated; in the central city, few major changes may have occurred.

The following approaches to updating the suburban data base for transit planning should be considered (they are not mutually exclusive):

1. Market research sampling of transit and automobile behavior, characteristics of transportation system used, socioeconomic characteristics of trip-makers, attitudes of trip-makers, and advertising media response and forecasting consistency;
2. Annual home interview survey of residents of developing areas, especially a small census-stratified sample survey;
3. Before and after surveys of major service innovations, such as the BART impact surveys;
4. Complete home interview survey that is compatible with a previous outdated metropolitan survey but includes disaggregate sample selection and data;
5. Sample surveys of travelers to major trip generators; and
6. Screen-line counts, vehicle occupancy counts (for preferential treatment), and parking surveys at maximum traffic volume points with revised survey instruments.

Unless the metropolitan home interview survey is recent, no suburban bus improvement needs study should be undertaken that does not include surveys.

Growth Constraints—The rapidly growing areas of the suburbs are also faced with great uncertainty regarding governmental policy on growth and the possible impact of environmental lawsuits on both shore-line and interior growth rates. For example, one water district in a rapidly growing area of Orange County is under court order to limit the water supplied and the connections made for the next 20 years. Thus, the population and travel forecast levels are suspect.

High Socioeconomic Groups—Suburban areas characterized by high income and multiple automobile ownership may be undergoing changing attitudes toward high-quality transit service. These groups can afford to exercise their latent demands for travel and will do so if quality of service is good. Existing forecast models such as the LARTS model show an inverse relation between income and transit use (4, 5). However, surveys taken in suburban areas where significant transit service improvements have been introduced, such as the Skokie Swift in the Chicago area, exhibited a fairly even distribution of transit use propensity throughout the income range (6).

Transportation-Disadvantaged Group Forecasts—A relatively invisible but large number of transit-dependent populations in suburban areas may or may not benefit from transit services that are developed for a majority of high-income travelers who work in the CBD. We need to forecast who will benefit from our proposals. Unless base-year and forecast disadvantaged populations are prepared for each analysis zone, the benefits of the proposals will be difficult to assign to those who will receive them.

Freeway Congestion—A general assumption is that alternative rapid transit proposals will have alternative impacts on freeway congestion in a city area. The impact can be estimated in the transportation study model, but the effects of special freeway bus operations must be added. Both bypass lanes for ramp metering and exclusive bus or exclusive bus and car-pool lanes may have a significant impact on congestion for the remaining cars and affect ridership as was described earlier. Travel models that are not capacity constrained now show 1990 volumes, if no further freeways are built, that would congest a 12-lane freeway on what is now 6 lanes. If this is true, then high-speed transit must be seriously considered.

Significant Service Improvements—The transportation planning forecast models generally produce better results for minimum and expected improvements in service level than they do for radical improvements in transit service, as will be discussed below. Special services that have differing measures of service quality may make the results suspect. New rapid transit lines with short headways have captured as much as 40 percent of all possible trips in the corridor. These values appear to fall at the extremities of mode-choice curves where the regional model is most uncertain.

Three suburban corridors where radical improvements in transit service were made, radical increases in transit's market share occurred, and some useful data were collected were compared (Table 1) to determine whether the data are sufficiently consistent to establish other points on the modal-choice marginal utility curve or whether a different mode-choice model is needed.

Marketing Factor—None of the transportation planning forecasting models takes into account the extensiveness of the marketing and advertising effort that has been invested in a new transit service. This type of evaluation is routinely done in the marketing research field, where marketing expenditures must usually be justified by the extent to which they change peoples' attitudes and choices. Thus, for example, dollars of marketing investment per dollar of operating cost (not per dollar of gross revenue, which is misleading in comparison with unsubsidized private industry) could be considered a system characteristic and might be calibrated like other system characteristics such as frequency of service.

Suburban Mode-Choice Model Verification

As part of the subregional transportation planning work program, the mode-choice model should be able to replicate suburban mode-choice behavior in situations where radical improvements in transit level of service are proposed. There are 2 types of travel behavior or transit market to replicate: suburb to central city (external) and suburb to suburb (internal). Also different methods can be used to verify a mode-choice replication in a suburban area:

1. Obtain data on suburban response to radically improved transit service in other metropolitan areas and apply the data to the marginal utility equation;
2. Use market analysis survey results to calibrate an additional independent variable in the mode-choice equation—either attitudes toward transit, a trip-maker characteristic, or percentage of operating cost for marketing, a system characteristic;
3. Develop a disaggregate, stochastic, behavioral demand model that replicates the suburban life-style;
4. Code a ubiquitous transit system in which a saturation bus system provides service everywhere and transit ridership is never constrained by capacity or level of service (12);
5. Verify the Gumbol distribution calibrated for the Blue Streak service in Seattle (this distribution estimates marginal utility of transit from a policy forecast of business miles per capita, assuming standard fixed-route express service, and has been implemented in Orange County for internal trips);
6. Code a sample sector or subarea of transit improvements and innovations and use suburban transit-calibrated diversion curves to compare travel time and cost impact on diversion by calibration from high-quality suburban transit experience; and
7. Disaggregate total work trips from 1970 census reports or tapes and from home interview survey data, factor out unlikely employers, and factor in population growth.

The verification approach for suburb-to-CBD trips will be analyzed here by method 1. The responses of suburban residents in 3 areas where radically improved suburban commuter service was recently instituted were compared to the Los Angeles Regional Transportation Study (LARTS) mode-choice model parameters and other useful measures of actual ridership (Table 1). For each of the LARTS parameters, the range of transit market share was determined. Market share for transit can be defined as the percentage of total trips between 2 zones and intervening zones that are using the transit mode, or the percentage with a reasonable choice riding transit. The share could be further refined to delete construction workers carrying tools, salesmen using their cars during the day, and those having other occupations that prevent their using transit, but that was not considered here. An arbitrary judgment factor in the definition is the zonal area served, such as circumscribing 95 percent of all existing transit users.

Four types of mode-choice characteristics are compared to normalize the data on 3 suburban response areas in the LARTS calibration. The first, system characteristics, including almost all of the transit system design factors that might affect ridership, are included here and are included in the LARTS model. Values of these model factors are generally within the range of calibration of the LARTS model, but the large percentage of total trips captured by transit sometimes far exceeds the range of market share percentages that have been calibrated as a percentage of total trips. However, market share is a more disaggregate and therefore more consistent statistic than percentage using transit because neighborhoods vary widely in predominant occupation among commuters to the CBD or some other trip-end zone, and some obviously cannot be served by fixed-route transit.

We can then define potential market share with one equation:

$$MS = \frac{\sum_{ij} \sum_{xyz} t_{ij}}{\sum_{ij} t_{ij}} \times 100 \text{ percent}$$

where market share equals the percentage ratio of total trips from $zones_i$ to $zones_j$ for occupations or industries x, y, and z to all trips made from $zones_i$ to $zones_j$; origin $zones_i$ are residential zones within ½ mile of a bus route or within 4 miles of a park-and-ride lot or site; and destination $zones_j$ are employment (peak period), medical, shopping, and so on, trip destinations within ¼ mile (½ mile for park-and-ride) of the bus route. Destination $zones_j$ can be interpreted as the 1970 census CBD, if it is sufficiently compact. Each trip purpose or market segment can be separated, as in census journey-to-work trips to be served by express buses. Fixed routes would serve all trips in their corridor; major transferring trips would be handled separately. Demand-responsive areas would serve all internal trips or all trips from many origins to few destinations. Shuttles would serve internal or screen-line and noncordon trips in a small area. Travel time differences and other system technology variables establish not the potential market share but only a particular system's response and are not part of this equation. The equation is fairly obvious; it is the concept that is not generally understood.

If the transit route serves more than 2 $zones_j$ these can be added in until only, say, 5 percent of transit trips come from outside the group of zones. Occupation or industry data are generally available from home interview survey data or by census tracts, which can usually be aggregated to zones.

For family income, the one socioeconomic characteristic of the trip-makers used in the LARTS model, high-income values in the model equation would predict a low share of total trips in the corridor going by high-speed transit, whereas high-income trips tend to be long trips and are susceptible to express buses and rapid transit.

Among the measures of trip-making behavior, market share appears as 20 percent of all possible corridor trips on the Skokie Swift and as 36.9 percent of all possible trips on the Shirley busway, where only 54.7 percent of all cordon trips are considered a part on the potential market. These figures exceed most of the percentages of trips by transit that might be predicted by the marginal utility model using Skokie and Shirley system characteristics. The 36.9 percent market share of the Shirley busway is particularly impressive in light of the fact that 57 percent of the riders had a car available.

A fourth group of ridership measures, attitudes of trip-makers toward transit, is proposed as a third independent variable affecting mode choice with the automobile and one that is highly competitive not only for a few trips or one corridor but for a large percentage of the trips in the suburban area. If, as in southern California, there is an immediate need for improvement, then programs such as preferential use of express buses on freeways and major streets, local demand-responsive service, car-pooling computer programs and incentives, and subscription bus services may be considered.

Impact Estimation

If high-speed fixed-rail transit service is to be considered for a suburban area, the effects of such investments on concentration of trip-making in corridors should be investigated. Shopping centers and industrial parks could be sites for transit terminals and collection points. Higher densities would be developed in these areas rather than at scattered sites. Such concentration and development may not be appropriate or desired for some suburban areas.

Marketing Plan

Selecting a transportation network plan and forecasting ridership on that network require an assumption about promotion and marketing that is almost never made explicit in planning studies, even if any assumption has been made. Any level of patronage that is forecast shall be achieved with either no advertising or some level of advertising and marketing investment. When any new service or product is introduced, a marketing program is necessary to introduce it to the public, stimulate interest, and sustain ridership growth. This is much more essential to new suburban service development than it is for an existing and fairly well-known transit route in the central city, because the service is often new and because suburban homes have high turnover.

Marketing is a misunderstood term and is generally incorrectly equated with advertising or promotion. It is both, but it is also much more. It is making sure that the product or service that is designed, such as a new transit service, will meet the need and be accepted by the public. Such marketing goals derive from the public's goals. They ensure that the service will be provided where it is needed and not where it is not needed. Marketing ensures that the cost of the transit service—the fare—is acceptable and can be paid in a way that minimizes resistance, such as a monthly pass. Marketing is also promotion, telling the public and the news media what the product is and how to use it, answering the telephone on the first ring, and advertising in the appropriate media for riders. In summary, marketing includes product design, place of availability, price or amount and method of payment, and promotion with advertising and information services.

A design variable in the Skokie Swift program was an investment of 20 percent of gross operating revenues from the project in marketing (Table 1). Either dollar amounts or percentage of gross operating costs is a useful means of bringing the marketing factor into the system design and into the mode-choice model. Patronage results of marketing programs are fairly readily measurable by standardized marketing analysis techniques, such as before and after studies. Such an evaluation program is under way (13).

An important concept in marketing is the term "share of the market." The concept has been used here to determine the total number of trips that could ever be served by the transit service with any reasonableness, as was explained in the forecasting discussion. Any transit ridership forecasts should include explicit consideration of the percentage of operating costs that will be spent on marketing for that route during the next year.

Table 1. Comparison of mode-choice characteristics in corridors where radical service improvements were made.

Mode-Choice Characteristic	Suburb to CBD			LARTS	
	Lindenwold (7)	Shirley (7, 8)	Skokie (5, 9)	Calibration Range (10, 11)	Market Share Calibrated (percent)
System characteristics					
Percentage of gross revenues or operating costs used for marketing	4	na	20		
Transit access time* (walk or drive)	na	na	2 miles max.	2 to 18 min	0 to 30
Transit wait time or headways*, min	10	11 to 18	2½	0 to 16	0 to 19
Automobile terminal time*	Lots fill up	Space available	Lots fill up		
Transit running time*, mph	47	35	46, 5 miles 30, 12 miles	0 to 10 min	0 to 4½
Automobile running time*, mph	12 to 30	10 to 20	30 to 40	27.7, 1 to 20 miles	2 to 14
Transit fare*, cents	35 to 75	40 to 80	45	35 + 8/zone	
Parking cost, cents	25		25		
Automobile operating cost*, dollar/mile	—	—	0.075	0.0476	
Automobile parking cost*, dollar/day	1.75	Generally free	0.75 to 3.00	46 percent free in CBD	
Off-peak headways, min	10	No service on most	15		
On-time performance, percent	99, 5 min, but labor stoppages	32, 6 min	Good		
Trip-making behavior					
Average trip length, miles	8.5	12.7	15	10.2	20 to 29
Automobile occupancy		1.35 to 1.61	1.35 to 1.61	1.1 to 1.2	
Riders/seat during rush hour	1.4	1.1			
Percentage of riders shifted to transit from automobiles	40	25	14 to 20		
Ridership					
Weekday	41,500	24,300	na		
Peak	8,000	8,000	1,400		
Market share, percent	na	36.9	20		
Park-and-ride, percent	35	8	30		
Feeder bus, percent	9	0	17		
Socioeconomic characteristics of trip-makers and community					
Family income*, dollars	14,000	16,400	10,000	7,818	0 to 38 and 60
Automobiles owned	1.3	1.5	1.4	1.4	
Second worker, percent		40 female		27.5	
Have car available, percent	37	57 choice	57.6 licensed		
Elderly, percent	na	0.8	na	8.2	
Population per square mile	3,400	3,700	7,000	5,000	
Attitudes of trip-makers					
Reason for using car	No parking space	Bus too expensive			
Priority design feature	Inadequate capacity	Air conditioning			
Priority service variable	Labor stoppages	Reliable and faster			
Attractiveness of mode	Modern	No interior ads			
Comfort	Smooth ride	Assured seat			

*From LARTS marginal utility mode-choice model.

CONCLUSIONS

1. A strongly suburban point of view needs to be taken and expressed in metropolitan transportation planning programs in order to develop advocacy for improved transit service in the suburbs. Most central city or regional transit operators are preoccupied with what appears to them to be overwhelming problems in the central city, where they must try to maintain financial solvency on a daily basis.

2. Urban transit forecasting models in use today are criticized by others for a number of simplifications and artificialities. However, they are even more uncertain in the suburban areas where growth and change are rapid and response to high-quality transit service cannot always be based on low income. Suburban transit studies will generally produce patronage forecasts with dubious reliability unless primary data collection surveys of some type are undertaken. The patronage forecasting effort should include consideration of comparable improvements in other suburban areas and the ridership response that occurred in those cases.

An important innovative design element of patronage forecasting is estimation of the level of expenditure on marketing transit services. Applying market analysis techniques can help to measure the patronage impact.

3. Data are now available to indicate that certain transportation technologies are particularly adapted to the suburban environments. Research presented at various demand-responsive transportation conferences indicates that this mode of operation can provide an attractive, suburban-responsive, low-density-area service that can become almost as efficient as a short-headway, fixed-route service at those densities.

RECOMMENDATIONS

1. Further detailed comparison of suburban-only ridership response to significantly improved quality of transit service is needed for 2 markets: from suburbs to central city CBD and within suburban areas. A number of case studies and demonstrations have been conducted and should be systematically evaluated by the use of additional approaches.

2. Further analysis of the similarities between market forecasting and transportation planning model forecasting approaches should be made so that each may benefit from the strengths of the other.

3. Further field testing of alternative demand-responsive operations is recommended where low densities and high-income populations discourage the development of efficient fixed-route bus services to determine under what conditions its costs are comparable to fixed-route service.

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MARKETING CONVENTIONAL TRANSIT: INFORMATION PROVISION AND INTRODUCTORY REWARDS

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This paper addresses one aspect of a complex issue: the attempt to develop viable transit systems through the generation of noncaptive patronage. Two general premises underlie the action-oriented study on which this report is based. The first is that middle-income and upper-middle-income residents do not consider public bus transportation as a reasonable mode for intracity travel and in fact do not possess sufficient information to do so. The second is that the best promotion is an actual "initiation" to the services of the bus system. Results from a study involving a small section of Cedar Rapids, Iowa, seem to substantiate the assumptions. In the study, promotional materials and free bus trips were combined with several questionnaires, both before and after a free-trip period.

THE UNQUESTIONED use of private automobiles is one of the reasons for the poor vitality of public transit in U.S. cities. A strong case can be made for using transit as an aid in solving transportation problems from a simple physical distribution sense. This will permit practical solutions to intraurban travel problems only if psychological issues can be adequately overcome. Increased transit patronage requires either diversion from automobiles or generation of extra trips or both. Except for the presumably small number of additional trips such an advance, if not forced by fuel rationing or significant cost increases, must be accomplished by persuading the traveler to leave the car at home. The task of persuasion is the concern of the transit system, and when this is publicly controlled and subsidized, as is almost uniformly the case, then the promotional effort should be of wide concern throughout the supportive governmental structure.

Underlying the concern for understanding promotional mechanisms and making effective use of these for transit is the belief that most urban areas will have to continue operations with essentially their existing systems. A few cities, for example, Iowa City, have been able to initiate completely new bus operations. In Iowa City, the changeover worked to provide its own publicity and promotion. This changeover was sudden and dramatic; it was coincident with the return of nearly 20,000 students and with the start of a free on-campus shuttle and during the high point of environmental concern. Operators of continuing systems working with existing resources must rely on more subtle application of promotional efforts. The allocation of these scarce resources requires an understanding of people's knowledge about transit and transportation, their conception of transit to serve their trip needs, and the role low-cost efforts can play in effecting changes in travel-oriented decision-making.

Underlying this study, then, is the belief that patronage on existing transit systems can be increased through low-cost public education programs, advertising, and promotional activities (1). As long as fares are charged and subsidies provided, the public seems to be the beneficiary of increased patronage. Increased patronage could reduce the necessary subsidy or, better, justify expanded service. Such effects must be considered as positive contributions toward the quality of life in America's urban areas.

One further note should be tendered before continuing with the paper. According to consumer sovereignty, a fundamental principle of economics [although rigorously rejected by Arrow (2), Baran (3), Rothenberg (4), and others] is that consumers determine with their dollar votes what will be produced during the long run. One could consider that the marketing correlate to this principle is the concept that advocates that firms begin with consumer needs and work backward to develop products that fill these unmet needs. Kotler has often noted this as long-run profits through customer satisfaction (5). In fact, he has gone one step further, because of the controversy, to call for a societal marketing concept. His formulation calls for a customer orientation backed by integrated marketing aimed at generating customer satisfaction and long-run consumer welfare as the key to attaining long-run profitable volume.

The point of this paper is not to extend, evaluate, or refute any of the concepts noted above. This paper is concerned with a product for which demand is derived from the need to acquire income, to buy food and clothing, and to meet other consumer and social needs. Obviously, when one is thirsty for beer, one is not too concerned about the container in which it arrives for consumption. Nevertheless, Alcoa and other companies advertise and assume that aluminum is a more desired container than others. And presumably, as in the case of Denmark, if consumers want their beer only in bottles, there will be no demand for aluminum cans. The point is that derived demand may not adhere to the same characteristics as that which applies to the marketing concept. Furthermore, the central issue of providing public transportation is a societal question that may or may not be applicable to the societal marketing concept. The component of the viability of public transportation addressed in this paper is whether the product is even considered in the consumer's cognitive set. Thus, the assumption that people do not ride the bus because they do not recognize its potential for fulfilling their trip needs is a realistic one.

PROPOSAL AND HYPOTHESES

Much, although not all, of transit patronage today is captive; that is, riders have no other available transportation mode. This is especially true in the small- and medium-sized cities. The captive user initiates the retrieval of public transportation information out of necessity. A possible assumption is that the small percentage of choice riders indicates few noncaptive riders make similar efforts. The purposes of this study were conceived with recognition of the limited resources of smaller cities or towns and directed toward how these resources might be effectively applied to transit promotion. The main objectives of this study were

1. To determine the level of knowledge the middle-income household now has about the city's transit systems,
2. To determine whether a low-cost promotional effort could effect a change in the level of knowledge, and
3. To induce people to ride the city bus system through various low-cost promotional efforts.

Most products in our society are advertised. These include industrial products such as toothpaste and public services such such as libraries or united aid funds. The marketing of the urban transit service has been limited. The small percentage of noncaptive riders indicates, in part, that few potential users have enough knowledge to use the existing system. Thus, a strong case can be made for marketing urban transit. At this stage little can be said as to the direction of this advertising. What can be said is that there needs to be a concerted effort to understand the nature of transit ridership and the potential for promotional activities.

There is no lack of precedent for the task since public libraries, zoos, and the like frequently engage in promotional activities. Insofar as such activities could increase transit ridership through diverted or new demands, the public good would appear to be served as long as there is no deleterious effect on the ratio of total expenditures to services rendered, assuming the total public subsidy does not exceed the capability of the community. Although display space and other means are frequently used to promote transit to the captive rider, much less effort has gone toward reaching the choice rider. This is unfortunate because, although the latter group is of most concern with regard to the purpose of public subsidy of the operation, the former group's patronage is promotionally more rewarding. One must assume that captive riders will make an effort to learn of and use the system, and thus the return on promotional expense at this level is marginal. This does not argue for eliminating existing informational services for such groups because a certain awareness of the system is required for any use to take place. Rather, what is being argued is that the return on promotional activities is potentially greater in the arena of choice ridership.

The consumers or users of urban transportation, naturally enough, are interested in getting to and from work or school, to and from homes of friends and family, and to and from locations of recreational activities as economically and expeditiously as possible. To the consumer, moreover, satisfactory transportation implies not only economy and speed but also comfort, privacy, protection from bad weather, schedule frequency and flexibility, and a host of other considerations. In short, urban transportation is a consumer good or service and, like others, is purchased because of intangible as well as tangible considerations. One of the least understood aspects of urban transportation is exactly what value consumers place on each of these considerations in making their choices.

Blattberg and Stivers tried to test and evaluate various methods of promoting transit (6). Some of the marketing research of the project indicated that information about transit service is an important factor in determining whether people ride the bus. Their main purpose was to present a mathematical model that can be used to test the effect of potential promotion campaigns.

The Blattberg and Stivers study of inner-city residents tested the hypothesis that as people know more about available conventional transit service they will use the bus more often. Advertising in their study consisted of distributing a detailed transit map along a particular route. The route in question was changed by 1-block deviation and was billed as a new route. The results of this study showed that shoppers are more affected by added information than are those who ride (or might ride) the bus to work.

In terms of administrative analysis, Schneider (7) suggested that the promotion function be separated from the existing public relations position under which it functions in most transit systems at the present time. The "new" position would focus on advertising and a continuing program of timetable distribution. This function would, as a first objective of a promotional campaign, inform actual and potential riders of the speed, time of departure, and price of existing service.

Intracity transportation has characteristics of both a public and a private good. As a public good there is the responsibility of providing a quality service within the technological limits of the era and the capability of the economy to provide required subsidies. As a private or consumer good the transit operation is competing with other modes of transportation. In this competitive aspect the public system should attempt to attract riders and promote the system. Little is known about how this might best be accomplished. This study was an initial attempt to grapple with this complex problem.

THE CITY AND THE SYSTEM

Located in eastern Iowa, Cedar Rapids is an urban region of approximately 125,000 inhabitants within an area of about 100 square miles. The development of the region is typical of many other similar-sized communities that have increasing economic growth and diversity. Planned regional shopping centers, major discount stores, and light industrial districts have contributed to the dispersal of trip origins and destinations. The Interstate Highway System was constructed within the city during 1972 and 1973 so that its impact on transit is yet to be realized.

The public transit operation in Cedar Rapids is the Regional Transit Authority (RTA). In 1973, there were 11 scheduled routes throughout Cedar Rapids. During the previous 5 years these routes were revised, combined, or altered to increase service to homes, to provide better running time, to reduce duplication of service, or to reduce the operational losses. Buses run 12 hours daily from 5:45 a.m. to 5:45 p.m. with either 30- or 60-minute headways, depending on the route. The bus system has reduced services on Saturdays and does not run on Sundays.

The area selected for this study contained 693 households and 3 large apartment complexes with a total population of approximately 3,400. This particular neighborhood was chosen as the study area because it represents a typical young middle-income section of Cedar Rapids. Incomes in the neighborhood range from $8,000 to more than $25,000. A bus route with 60-minute headways serves this neighborhood with 20-minute service to the downtown area.

THE STUDY

The rationale of the study is that automobile-oriented young families neither consider transit as a viable transportation alternative nor are fully aware of its potential for meeting their needs. The study was initiated to investigate this general conceptualization through a design fashioned to determine the informational impact of several experimental treatments, each of which would encourage a transit trip in a differing manner. Pre- and post-treatment levels of transit-related knowledge, combined with monitoring of patronage to and from the sampling area, were employed. The control group consisted of 103 residences, which were selected in a dispersed pattern in the study area. A detailed questionnaire was used to assess the level of knowledge concerning the existing system. This questionnaire concentrated on the system's fare policy, schedules, routes, and subsidy and the resident's use of the system.

Promotional and advertising materials were then distributed to preselected households. The 4 treatments (different combinations of those listed below) were dispersed throughout the study area. Each group consisted of 40 households. The promotional and advertising stimuli consisted of

1. Free tickets (each household received 4 tickets that could be used any day during a 2-week period),
2. A map (this map indicated the route of the bus through the study area to the downtown Cedar Rapids area and included the schedule of this bus route),
3. Informative letter (this letter indicated the destination and scheduled departure time from the area of the Cedar Rapids Miami Extension and special programs of the RTA system).

Approximately 3 weeks after the period in which free rides were allowed, the residents who received the promotional material were interviewed. The primary intent was to focus on the level of knowledge and the effectiveness of the various stimuli. Additional controls were also employed in this study. The ridership to and from the study area was monitored daily beginning 1 month before the study and concluded 1 month after the free-ride period. An on-board questionnaire was also used a month after the completion of the free-ride period.

RESULTS

The general characteristics of the 2 respondent groups as obtained from the home interviews were similar. Minor variations in the income distributions of the 2 samples occurred in the groups having incomes of less than $10,000 and between $14,000 and $16,000. An increase of 14 percent in the $14,000 to $16,000 income category of the post-survey group is primarily accounted for in the reduction in the number of households having incomes less than $10,000. This shift to a higher income level for the treatment group indicates that the incentives and information distributed were not directed toward a more captive user group. No attempt was made to seek adults within a household that possessed knowledge regarding the bus system. The neighborhood residents interviewed were primarily distributed in the 30 to 50 age group. More than 76 percent of the households had 2 or more cars; only 1 percent did not own an automobile. With respect to bus use, a negligible difference in the response patterns occurred. In both the control and treatment groups a large minority (27 to 29 percent) indicated some use of the bus system as a means of intercity travel even though only a few (2 percent) ride daily. The ridership responses were for those individuals interviewed and may not be representative of the entire household.

Also of interest in characterizing the individuals are their places of employment with regard to the sampling area. About 30 percent of all those interviewed worked within the sampling area, a figure attributable mostly to women homemakers. The major nonhome employment was in the central business district, where 25 percent of the respondents had jobs. Trip time from the study area to the CBD by bus is approximately 20 minutes. The average commuting distance to the out-of-home employment locations is approximately 3 miles; the maximum is 9 miles.

Information Levels

During the course of this study, 199 individuals were interviewed. Ninety-six of the households interviewed had received some form of treatment designed to increase their level of knowledge and promote usage of the system. A total of 160 households received promotional material, and 120 of those households received 4 free tickets, either alone or in combination with other material. The remaining 40 households received a letter explaining the RTA system and a map indicating the route and schedule of the Miami Extension through their neighborhood. In the postsurvey, an attempt was made to interview all 160 households. Of the 60 percent interviewed, only 72 percent recalled that they had received promotional material.

The general information levels concerning the RTA system of the adult individuals contacted in this study are given in Table 1. The majority of these individuals were within 2 blocks of the bus route; the maximum distance to the bus route was less than ¼ mile. Fewer than two-thirds of the sample knew the location of the nearest bus stop, and only one-third knew when the bus was scheduled through the neighborhood. Most surprising, however, was the small percentage that knew the name of the bus route and the fare. The overall change regarding this fundamental knowledge is positive in every case except for the arrival time of the bus.

Use of Promotional Tickets

Three of the 4 treatment groups received free tickets. Each household in these groups received 4 tickets, which could be used for a free ride on the RTA system during the 2-week period beginning July 17, 1972.

Use and disposition of the tickets by each group are given in Table 2. Free tickets were returned from approximately 1 out of every 4 households. An average of 2.7 tickets were returned by each of these households. The group receiving just free tickets and no additional promotional and advertising material returned the highest percentage. The returns of the 2 groups receiving the supplemental promotional material were similar; the group receiving maps had only a slight increase in returns.

Initial prestudy thoughts were that the groups receiving additional promotional material would have the highest returns, not the lowest. Free tickets alone necessitate the individual's retrieval of route and schedule information to use the system; supplemental materials supply that information. Several explanations for such findings are possible.

A high quantity of advertising mail is received by middle-income households. Much of this is in the form of a packet of material similar to that distributed for this study. A very small percentage of advertising and promotional material received by a household actually provides something free. Thus, it is conceivable that the packet of promotional material elicited a junk-mail reaction.

Another possible explanation is that the households reacted negatively to the supplemental material. Coercion can boomerang. Brehn and Cole postulated that, when a subject's freedom to act is restricted, he or she will react by attempting to regain that freedom (8). Applying this postulated reaction to this study, the people who received only tickets felt that they, in fact, had a choice to make. However, the people who received a letter or a map and a letter with the free tickets felt that, by this explicit information, their freedom of choice was being channeled and controlled. Thus, they reacted by derogating the restricting agency—the bus—and thus did not use the free tickets. The bus system not only is new to nonusers but also has a very negative image. Thus, if their choice is perceived as being restricted, then they avoid using the system. Possibly the free tickets alone did not present this threat.

The distribution of treatment groups with respect to the route should not have been a factor. Each treatment group was spatially distributed with respect to the route in approximately the same manner. Of the 33 households using the free tickets, 58 percent were located within 1 block of the route and 36 percent were located between 1 and 2 blocks.

Study Area Generated Patronage

Daily tallies of boardings and departures within the study area were kept by the bus driver before, during, and after the promotional activity. The tallies began on June 19 and were continued until August 25. Figure 1 shows a summary of the average daily patronage. The low ridership monitored on July 3 and 5 was not included in the average daily patronage shown in this figure. The bus system did not operate on July 4. Ridership on Mondays, Fridays, and Saturdays exhibited the desired result; patronage increased during the free-ticket period and was sustained thereafter.

Any interpretation here must be cautious. There is no way of determining whether the people choosing to use free tickets on Tuesdays and Thursdays did not choose to ride again or whether they then rode on a Monday, Friday, or Saturday. The patronage data record the result of aggregate behavior over time and not individual behavior. Only an extended trip diary would appear to offer a solution to the behavioral questions raised by these data.

DISCUSSION OF RESULTS

This section summarizes factual findings of the research, gives conclusions regarding bus system use and promotion among middle-income households, and reflects on the study with a view to improving similar promotional efforts and their evaluation.

The research reported here focused on courses of action relating to the marketing and promotion of urban transit. It presumes that, barring substantial improvements in service levels or radical changes in attitudes, the appeal of conventional urban transit to choice riders rests largely on marketing strategies. It suggests that awareness about the service, its quality, and the expected return all influence the probability of choice ridership. The purpose of the study was to examine the level of transit operation knowledge among potential choice riders and to evaluate the effectiveness in terms of information gain and ridership increase of several promotional activities.

Findings

With regard to the study area and the methodology conducted to date, the following are the principal findings emanating from this effort.

1. The majority of the middle-income households having the availability of bus transportation in their immediate neighborhoods did not possess sufficient information to use the service that they subsidize. The percentage of those knowing the minimal information necessary to complete a trip by bus—the name of the route, the fare, and the schedule—reflects the relatively few regular and occasional riders.
2. The promotional efforts increased the level of knowledge of those reached (based on the assumption that the comparison between the control and treatment groups is valid).
3. To discern variation in information gain with respect to treatments was not possible, but in terms of ticket usage, more than half of the tickets returned were from the ticket-only treatment.
4. Free tickets were returned from approximately 1 out of every 4 households, although it was determined that not all of this usage was new or first-time ridership. In several instances occasional riders used the tickets; in a few other cases the tickets were given to domestic help. However, a majority of the free tickets used represents newly generated use from the study area, as determined by post-treatment surveys.
5. Bus ridership, as measured by departures from and arrivals to the study area, increased during the free-ticket period. The additional ridership was most strongly reflected in the number of bus boardings (departures from the study area) on Tuesdays and Thursdays.

Table 1. Percentage of group expressing correct information.

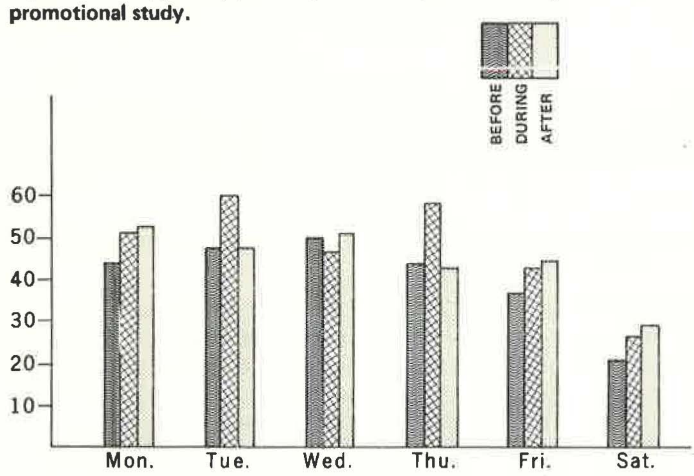
Information	Control Group	Treatment Group	Relative Change
Normal adult fare	18.4	34.8	89.1
Name of bus route	19.4	29.0	49.0
Uniformity of daily schedule[a]	32.0	42.0	31.2
Nearest stop to home	57.3	62.5	9.1
Number of routes in RTA system	0.0	4.3	-
Time of bus through neighborhood	34.0	29.4	-10.6

[a]With the exception of a 5-minute perturbation during the peak evening hours, the schedue is uniform, and that information was given in the letter sent to the treatment groups. Therefore, a uniform schedule is interpreted as the correct response.

Table 2. Disposition and use of free tickets.

Treatment	Tickets Returned		Households Returning Tickets		Average Tickets per Household Returned	Distribution of Tickets (percent)
	Number	Percent	Number	Percent		
Free tickets alone	50	31.3	17	42.5	2.9	55.5
Free tickets with promotional letter	17	10.6	7	17.5	2.4	18.9
Free tickets with promotional letter and map with schedule	23	14.4	9	22.5	2.6	25.6
Total	90	18.8	33	27.5	2.7	100.0

Figure 1. Average daily patronage from sample area during promotional study.



6. The ridership increase was not fully sustained following this period, but continued at a slightly higher rate than before the promotional activities.

Conclusions

1. Middle-income households do not generally possess enough information about the existing transit operation to evaluate this alternative in fulfilling their trip purposes. A minority of the households interviewed knew the basic prerequisites for use: name of the bus route, schedule, fare, or where the bus stops.

2. Information levels of middle-income households regarding existing public transit systems can be improved through relatively inexpensive promotional activities. The change in information level will not necessarily equate to changes in ridership levels, however.

3. Free-ticket incentives, which are almost no cost to the bus operation, apparently prompted the individuals to acquire information about the transit operation. Free tickets distributed in conjunction with additional promotional material were used less frequently.

4. Methods of promotion used in this study appear able to generate short-term increases in ridership; long-term effects could not be determined from this study.

Reflections

In the past decade researchers and theorists have discussed in the transportation literature the concept of mode choice. The real or abstract attributes of a transportation mode are viewed as being evaluated by the choice rider. Such work appears to suffer from 2 complementary problems. The first of these weaknesses rests on inadequate understanding of evaluatory mechanisms; that is, a psychological behavioral approach has only recently begun receiving adequate treatment (9). The second weakness stems from an incorrect assessment of how people actually behave. The distinction between the 2 problems is this: The first asks how choice or evaluation takes place given all relevant information about the courses of action, modes, or whatever is the object of evaluation; the second asks whether people actually engage in this evaluatory process before making a trip in an urban area. The research being discussed reflects on the second of these 2 issues.

To exemplify the issue being raised, consider the usual association hypothesized between automobile ownership and mode choice. A transit trip by an automobile-owning family is usually interpreted as a choice ride within this schema. However, ownership and availability are not synonymous so that many such trips may result from temporary captivity. Nevertheless, in either case information is required to make use of the transit service. The choice may have been not one of which mode but one of whether a trip would be made. Many intraurban trips that might be made by transit may possibly be delayed until the family automobile becomes available. The question then is not one of mode choice; if a trip is not considered, a mode cannot be chosen!

The trip-delaying behavior and nonconsideration of modes other than the automobile may be attributable to the knowledge level requirements that must be satisfied prior to use, or they may be a function of a preordained decision to travel only by private automobile and exclude all other less desirable modes. The former problem is amenable to transit-marketing strategies as attempted in the present research. The latter behavior would seem to require a major mental adjustment that might be, but is not likely to be, attained through such approaches. Therefore, interest is directed primarily at the knowledge-consideration dilemma as expressed above.

How does an individual make the decision regarding the existing public transit systems? Does the choice individual examine the exterior and interior design of the vehicles, the system's fare, route, and schedules and then evaluate the set of opportunities and amenities against his desire set? Or is there a more simplistic decision process?

Evidence from this study seems to point toward a near absolute type of decision rule: When the automobile is available, make the desired trip. When the automobile is not available, delay the trip if possible; otherwise, consider other modes. The "otherwise" clause in the above decision rule may on occasion initiate consideration of the public bus system. More often than not, however, it initiates a phone call to a friend or neighbor!

When use of the bus is considered by an infrequent user or nonuser, the evaluation process requires the attainment of considerable knowledge about the system. Since in almost all cases this requires the individual's initiative, his or her desires to use public transit on an occasional basis may be diminutive. In essence, why should the effort be made when the automobile is readily available or soon will be? A substantial number of individuals in this study within 3 blocks of the bus route did not know and were not interested in knowing the name of the bus route, where the bus went in the neighborhood, and where it stopped in the neighborhood. If forced into a temporary captive position in conjunction with a necessary trip, maybe then they would seek out the information. It is reasonable to assume that with only 1 automobile in a family there are times when occasional usage of transit would be desirable or required. A group less than 20 percent of the total interviewed occasionally used the system and possessed a basic knowledge of the system's attributes. The variability in their information levels indicates that many initiate information on a trip basis, probably in part a function of the time since the last use.

Boosting information attainment among the occasional users may promote ridership because the intent is not a major alteration of behavior but rather an encouragement to continue past patterns. The key group in promoting choice ridership, however, is the current nonuser who lacks information and experience but has not ruled out the mode entirely. The precise size of this group is currently unknown but probably includes a majority of the nonusers. How can the public transit system get these individuals to try the system for the first time, provide the ability to evaluate the system on its merits, and thereby place the bus system within this group's consideration? Not all will become regular users, but occasional use should be promoted including other than temporary captive situations. Free tickets, as demonstrated in this study, are sufficient incentive to promote some usage by this group. This is an extremely low-cost incentive. Other levels of incentives, such as ride-and-shop programs, cost even less and have demonstrated some success. Still others are needed and possible. If the Flint, Michigan, study is a yardstick, amenities on board the bus may be an overly expensive and nonproductive means of attracting initial riders, but in the long run may be effective in retaining riders.

For travel to a desired destination, even a system having user-preferred design characteristics and amenities may never actually compete with the private automobile. Unless people know about and understand the bus system, it cannot be used as a means of accomplishing a desired trip and it will not be evaluated on the attributes whether minimal or extravagant. To accomplish this, the individual must try the system to personally perceive and evaluate its merits.

ACKNOWLEDGMENTS

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RURAL PUBLIC TRANSPORTATION IN VIRGINIA

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Travel in most rural areas is now confined to one mode: the private automobile. Those who cannot own or operate cars either do not travel or must arrange, sometimes paying high prices, for others to take them where they need to go. Public transportation should be made available to those in rural areas. This paper analyzes the rural transportation problem in Virginia and suggests how public transit systems can be developed and operated in rural areas of the state. A number of projects are reviewed that are in operation or are proposed for rural areas in other states. The study concludes that, although scattered, sufficient resources are available in Virginia for the planning and development of rural public transportation systems.

• MOBILITY in rural regions has almost always been limited to one mode: the private automobile. Most governmental attempts to increase the mobility of the rural populace have been confined to road development or improvement. Yet, certain groups—the poor, the young, the elderly, and the handicapped—derive few benefits from such programs. They are either unable to afford the purchase, maintenance, and operating costs of an automobile or incapable of driving one. Some are forced to own a car even though the cost of this ownership limits their purchasing power for other necessities.

Several states have initiated studies of public transportation in rural areas. This paper attempts to bring together information on identification of problems and goals, types of data needed, types of solutions, availability of funding, and organizational alternatives. Various solutions as they relate to situations in Virginia have not yet been tested.

PROBLEM

Some very basic human needs are not being met because of the lack of travel opportunities for many rural people. In our increasingly mobile society these individuals are, in a sense, being left behind. The physician, hospital, and health clinic are nonexistent to those who have no means of getting to them. Welfare programs such as food stamps or job training, educational, recreational, and religious facilities cannot be used by those who do not own an automobile and cannot afford to hire a taxi or have no family or friends who can transport them. Even obtaining essential goods like groceries and medication is difficult.

The Resource Management Corporation studied 5 rural areas and found that the poor in rural America make only 15 percent of the trips that the average American makes (1). Statistics for rural Virginia counties within the Appalachian region show that 30.6 percent of the households have no access to cars, one of the highest percentages in the entire Appalachian region (12). And in one somewhat typical case, a woman was found who owned no car, lived in a rented, dilapidated shack 15 miles from town with her 2 mentally retarded sons, earned $2,000 per year as a domestic helper, and spent $20 a week (or $1,000 per year) for taxi fare to town to pick up groceries and go to the welfare office. Obviously many rural residents of the state are suffering economically, socially, and physically because of their inability to travel. The lack of a car means that fewer trips can be made, which in turn decreases one's opportunities for self-betterment. The situation can almost be characterized as a downward spiral: The $10 paid an acquaintance to drive to the drug store is that much less money available for medication or food stamps.

Not only is the single individual or family harmed by the lack of transportation but so is the rural community as a whole. Because those persons lacking transportation cannot participate fully in the activities of their community, valuable manpower is going unused. The economy of most rural areas cannot afford the loss of the potential income of those who are unemployed because they have no way to get to jobs. Retailers lose business; taxpayers must pay relief for the unemployed; labor is not available, and fewer industries move into the region; those who are mobile (especially the young) leave for better job opportunities; even groups such as community volunteer organizations lose potential workers.

The loss of jobs is of particular interest in rural Virginia. Data from the Bureau of Labor Statistics show that the fastest industrial growth is in the South, particularly in small towns and rural areas (8). Many reasons account for this industrial growth: attitude of officials toward industry, lack of unions, low wages, and available labor supply. Unfortunately, Virginia's share of this growth has been small compared with most other southern states. According to a report in the Roanoke Times (8), "In terms of capital investment in new and expanded industry in 1972, Virginia trailed eight of the other ten Southern states. And growing industrialization has not yet made much dent in the poverty of cotton-belt blacks or Appalachian whites. Probably those groups will run behind the pack indefinitely. More will have to be done to help them catch up." Although not the only solution to Virginia's lag, public transportation in some form would certainly help make labor more available, thereby attracting firms to rural areas of the state.

Why all this fuss now over public transportation? Rural folk seemed to get along before without it. The most important reasons are urbanization and technology. With the improvement in the efficiency of farming techniques, the number of people dependent on farming has declined. In 1950, 3.8 million southerners were employed in farm work and 2.4 in manufacturing. In 1972, 1.5 million still were on the farm, but 4.4 million were in manufacturing (8). Instead of staying home and working their own land, the one-time farmers now must commute to factories or other places of employment. In addition, services are tending to congregate in certain locations. Less visible today is the county grocery store or rural family doctor. These functions are now found in the urbanized areas, especially in large shopping centers. The small rural businesses find it hard to compete and are forced out of business. Trips become longer.

A second reason for the present need of public transportation, especially for the elderly, is the decline of the extended family. Relatives do not always live near by and thus cannot be depended on for transportation. Sons and daughters leave early in life to find jobs and usually establish their homes in distant cities.

GOALS FOR A RURAL TRANSPORTATION SYSTEM

Before a rural transportation system is designed, goals must be established. Although the goals may vary somewhat depending on the characteristics or needs of the areas, most rural transportation systems should accomplish these basic goals:

1. Improve the mobility of those who cannot provide their own transportation;
2. Increase the poor person's income by offering low-cost transportation;
3. Provide a means for the rural poor, elderly, handicapped, and young to take advantage and receive the benefits of existing resources and opportunities, such as mental and health care, welfare programs, employment, job-training and other educational facilities, religious facilities, recreational and cultural activities, and shopping areas; and
4. Promote community interaction.

DATA AVAILABILITY IN VIRGINIA

Little information on the need for public rural transportation is now available in Virginia; that is most likely the case throughout the country. Most research and data collection has focused on metropolitan areas where funds have been available for such studies. Origin and destination surveys have been taken for Virginia's metropolitan areas (and for urbanized areas with populations over 3,500), but not for rural areas.

Even the U.S. census is biased toward the urbanized areas. Valuable transportation information such as means of transportation to work, place of work, income, and automobile ownership is available only for SMSAs, urbanized centers, census tracts, and unincorporated places of 1,000 inhabitants or more. The rural area researcher is interested in enumeration district data, which unfortunately include the more general information.

Some information is available at the county level, especially from community action agencies, welfare and health offices, and some planning districts. These agencies can give a general idea of the transportation needs of the region and have data on the number of individuals for whom transportation should be provided. Yet this information represents only the visible need and does not recognize those individuals who might not be in contact with the human resource agencies even though in need of transportation. Neither do we have good estimates of the latent demand for transportation services, which may be great.

The only coordinated data collection effort concerning rural transportation in Virginia was a questionnaire distributed by the Division of State Planning and Community Affairs to 6 state human resource agencies (Education, Health, Mental Hygiene, Vocational Rehabilitation, Welfare and Employment), 19 planning district commissions, and the cooperative extension agents in each county (20). The questions concerned existing programs or projects designed to provide rural public transportation, needed programs and their nature, and means of funding rural transportation. Although the questions were general in nature, the survey clearly indicated that little was being done about transportation problems in rural areas and action is needed.

That action will require more data including an inventory of potential public transportation facilities in every rural area, a survey of present travel patterns, and a survey of the transportation needs of the rural resident. (In 1973, the Virginia Highway Research Council started the latter 2 types of studies; volunteer interviewers from the particular rural area were used.)

POTENTIAL SOLUTIONS

A variety of ideas might be applied to help solve the rural transportation problem. Each idea, of course, is not feasible for every rural area, but depends on the characteristics of the region, such as available human and monetary resources, population density, and travel needs. Two or more systems could be used together. A number of options are available for the operation of each of these systems. They might be privately owned and operated for a profit. A cooperative may be formed with subscription service, or some governmental agency might be responsible for its operation. Again, the organization depends on the characteristics of the region needing the system.

Transit

Conventional Bus System—A conventional bus system has 30 to 60 passenger buses running on fixed routes and fixed schedules. A variation, which might be more feasible for low-density, rural areas, is periodic scheduling where buses serve different areas on different days of the week. Every citizen is then offered a dependable means of transportation at least once a week to the local town or closest urbanized area. In this manner capital and maintenance costs are kept low because of the small number of buses needed. Also, the system need not use new, expensive buses, but could use school or church buses, governmental surplus vehicles, or even old buses from urban areas that have acquired new ones under UMTA programs.

Minibuses—The minibus has a capacity ranging from 12 passengers in most vans to 25 in the larger models. Because of their low capital and operating costs, minibuses can operate on routes that are economically infeasible with conventional buses. Also, they can be more easily maneuvered on the narrow, rough roads near which many rural people live. Another potential use for minibuses is as a feeder system: Passengers are collected on the back roads and dropped off at waiting stations on the main routes where they are picked up by larger buses. Special designs could be made for the elderly and handicapped (10, 26).

Demand-Responsive Buses—No matter how small and economical the bus, the demand in many rural areas is too small and too scattered to warrant fixed schedules and routes. Demand-responsive systems may be more feasible. They use minibuses and offer door-to-door service as requested by telephone (4). In many situations, a 24-hour reserve-a-bus system for citizens may be more practical. If the rural area is characterized by low telephone ownership, the postal system may be more effective as a means of transmitting information concerning desired rides. Requests put in the mailbox during the day would be collected at the post office that night by a dispatcher who would then schedule buses for pickups and deliveries the following day. In some situations, the mail truck itself could serve as a passenger conveyence, as has been done in England. Other possibilities include the use of highway department, telephone, milk, and electric company vehicles.

Jitneys—The jitney is partially demand-responsive. It is usually a private passenger car or station wagon that travels basically one route but will vary it somewhat to offer door-to-door service. The jitney may offer reserved seating but more often cruises along until waved down by an individual desiring a ride. In urban areas no strict schedules are adhered to, but in rural areas a somewhat fixed schedule would be necessary because of the fewer number of jitneys traveling on the back roads.

School Buses—Most rural areas are served by a central school system, which usually has a fleet of school buses that generally are idle most of the day and could be used for other needed transportation functions. In addition to legal problems in most states, another difficulty is scheduling: School buses are available for nonschool purposes in the late morning and early afternoon, which is not when work trips are made. Part-time drivers for the short period of nonschool use would have to be found, and use during the off-peak periods might hinder maintenance operations in the bus garages. Despite these problems, the Virginia General Assembly has just passed a law allowing certain counties to use school buses for purposes other than the transporting of school children.

Rail—Rail transportation is extremely limited in its usefulness because of difficulties in scheduling and limited access to rail lines by many rural residents. In some particular cases, though, the railways might offer a feasible solution.

Personalized Modes

Taxis—Taxis, unlike jitneys, are completely demand-responsive. One problem with the taxi is that the practice of carrying only a few passengers makes the cost of using this mode prohibitive to many rural families. Yet, if subsidized or coordinated with other modes, the taxi could help in solving the rural transportation problem, especially for the following: (a) passengers who can split the cost of a taxicab that has been filled to capacity by a dispatcher-controlled operation; (b) service organizations that can pool resources and hire taxis by the day so that they do not have to purchase and maintain their own transportation system and in addition do not waste employee time by sending them out in departmental cars to pick up patients or other service recipients; (c) those requiring emergency services where ambulances or rescue squads are not readily available; and (d) intercity bus passengers who must rely on taxis to complete their trips.

Automobile—Although not all people in rural areas are located on good roads, most are at least on roads passable by car. Therefore, one solution is to provide cars to members of the rural population either through subsidies or extended loans, reduced prices, or outright donations of surplus vehicles to those who are able to drive on the condition that they take care of the transportation needs of those in the surrounding area too old, young, or handicapped to drive. Junk cars could be given to automotive-repair classes in the local school (or prison) for practice and then when repaired to needing families.

Car Pools—Car pools can be used not only for work trips but also for shopping or other trips. All that is needed is a major trip generator, a means of informing the public as to the pool's availability, and a way of processing trip offers and requests (15).

Vehicles of Community Volunteer Groups—In some rural areas, community groups volunteer their time and cars to provide transportation to those needing it. They usually operate like a taxi company and publicize a telephone number to call to request transportation. Requests are filled according to the availability of cars and the nature of the need. Members take turns driving during the week and receive no payment for their services.

Other Solutions

Relocation—Relocating dispersed rural residents and congregating people moving into a rural area will ensure easier pickups by a transportation system serving the area. However, rural families may not want to move from their homes to more accessible locations.

Mobile Services—Instead of moving people to the services, services can be transported to the people. In areas where there are railways, trains can be used as an interagency service vehicle (16). On the train would be a general medical clinic, an X-ray machine for detecting TB, counselors in nutrition, family planning information, social security information, a dental clinic, legal services, and so on. The train would move to different locations as needed. On a less comprehensive scale, vans or tractor trailers can be used to take services to a central location in the community.

FINANCING

Although urban public transportation receives federal aid in the amount of approximately $1 billion a year, rural transit is virtually ignored by all major funding programs. State funds for such projects are even more scarce, but fortunately federal and state funds are slowly becoming more available. Discussed below are some potential and currently used sources of funds for rural transportation systems.

Federal

Department of Transportation—Until the Federal-Aid Highway Act of 1973, the transportation department's concern for public transportation was limited to urban areas. The 1973 act however specifically recognizes rural transportation in Section 147, which states:

> To enhance access of rural populations to employment, health care, retail centers, education, and public services, there are authorized to be appropriated $30,000,000 for the two-fiscal-year period ending June 30, 1976, of which $20,000,000 shall be out of the Highway Trust Fund, to the Secretary of Transportation to carry out demonstration projects for public mass transportation on highways in rural areas.

The funds can be used for projects such as the construction of passenger-loading areas and facilities and the purchase of passenger equipment other than rolling stock for fixed rail.

Revenue Sharing—Approximately $3 billion was appropriated in 1973 to the 50 states and more than 38,000 localities under the revenue-sharing plan. The guidelines for this program stipulate that these funds can be used for the capital, maintenance, and operating expenses for public transportation.

Office of Economic Opportunity—Although OEO has been the largest source of funding for rural transportation projects, it does not earmark funds for such projects. Instead local community action agencies (CAA) can request funds to be used for such programs in their general budget. These requests for aid generally cover the cost of transporting those in special programs, such as children in the Headstart Program. But funds can be made available for general transportation projects that are designed to assist low-income families, including the elderly poor.

Department of Agriculture—Funds may be made available for the development and operation of transportation systems through the Rural Development Act of 1972, but the specific guidelines have not been completed at this time. The language used in the act itself suggests that transportation projects might be eligible for funds as long as they facilitate development of private businesses in rural areas.

Department of Health, Education and Welfare—The Older Americans Act makes a number of provisions for the transportation of the elderly. Under Title III, grants can be made available for transportation services where necessary to facilitate access to social services (Section 302), for special model projects that provide transportation for the physically and mentally impaired older persons (Section 308), and for special transportation demonstration projects (Section 412).

Also, under Titles I, IVA, X, XIV, and XVI of the Social Security Act, federal funds can be given to the states to ensure transportation for those eligible for the social service programs outlined in this act. The funds are available to the state on a matching basis—federal 75 percent and state 25 percent—and must be used for the payment of taxi or bus fares incurred by those eligible to receive assistance under the act. This money cannot be used as grant funds to develop or subsidize a transportation system.

Funds are also available to cover the cost of transportation to health facilities for those who receive Medicare funds (Title XIX). These funds are distributed to the states on a formula basis, the federal share ranging from 50 to 83 percent. The funds cannot be used for project grants.

State

Little coordination now exists among state human resource agencies in their attempts to provide rural transportation: Each provides its own funds to pay taxi and bus fares or uses its own employees to drive departmental vehicles. These efforts are costly in terms of both money and employee time and are only partial solutions in that the rural public generally cannot use these systems. One solution to financing, therefore, is to have all agencies use one public transit system. Each agency would pay the fares for those passengers connected with its program, and the income might be enough to subsidize an inexpensive transit system for the general public. Listed below are some potential sources of funding for such a system.

1. The Board of Vocational Rehabilitation has funds to pay taxis, though they could be paid to a rural transportation system on a prorated basis.
2. The Department of Mental Hygiene has no funds available except for those who are being committed to mental hospitals.
3. The Employment Commission through the Work Incentive Program (WIN) makes funds available on a prorated basis. WIN enrollees could be used as drivers.
4. The Commission on Visually Handicapped pays the fares of the blind to needed services and of the blind counselors to points of assignment.
5. The Office on Aging has funds available through the Older Americans Act and could make prorated funds available to transportation systems for the elderly.
6. The Department of Health has funds only for emergency ambulance service and Medicaid recipients. The high cost of the present alternatives limits this department's ability to fund transportation for those not eligible under the above programs.
7. The Department of Welfare and Institutions either includes transportation money in an individual's monthly public assistance grant or uses local agency cars driven by the employees, but could make funds available on a prorated basis to a rural transportation system.
8. Action funds RSVP, a federal program to organize elderly volunteers for projects that benefit the community, and has money available to cover transportation costs of the volunteers.
9. The Virginia Department of Highways and Transportation has funds available under the amended Transportation District Act of 1964, which allows local bodies or transportation district commissions to use state highway funds for transit facilities such as bus lanes, shelters, and possibly in the future buses. Upon approval by the State Highway Commission, these funds are used in lieu of proposed local road projects. Operational costs are not covered. Funds distributed to the state by the Federal Highway Administration can also, upon approval by the State Highway Commission, be used for capital costs of a transit system. As of July 1, 1974, buses may be purchased under this program. Although both of these laws were meant to be used basically to help solve the urban transportation problem, funds can be approved for rural systems if a strong case is made before the highway commission.

ORGANIZATION

Virginia has a number of options with regard to who should be responsible for the planning and development of a rural transportation system: The Virginia Department of Highways and Transportation, the Office of the Secretary of Transportation, or the Transportation Services Section of the Division of State Planning and Community Affairs has the capability. These agencies already possess the organizational skills necessary for planning and developing a rural system. Other options include the following.

Cooperatives

The people of rural areas could own and operate transportation cooperatives in a fashion similar to the highly successful rural electrification cooperatives, which provided power to local farmers when the electric companies found the profit margin too small to enter an area. The members would determine policies and operating criteria for the cooperatives, but would receive technical and planning assistance from the governmental body responsible for providing the service. This agency might be an existing organization or could be an agency set up specifically for this purpose. If funds were available, this agency might also provide low-interest loans to those cooperatives whose projects meet the approval of the agency. The advantage of this form of organization is that it combines technical and local inputs and places the planning close to the people who know local conditions.

Private Enterprise

A privately owned charter service should be an efficient operation, for it is guided by marketplace demands and is motivated by profit incentives. Unfortunately, most rural systems would not be money-making operations and would require some sort of subsidy. This aid could be given directly to the charter company (e.g., grants for capital equipment or deferred taxes) or could take the form of increased ridership by giving the rural poor money to be used for the purchase of transportation.

Public Corporations

A government-regulated corporation that provides transportation could be recognized by the state. Because it would be nonprofit and pay no taxes, this corporation would need less income than a private company to continue operation.

Transportation Districts

Like public corporations, these districts would be nonprofit and tax free and could issue bonds to cover the costs of operating a transportation system. Advantages of the districts are that the lawmaking provisions for their formation have already been passed and that they can use state highway funds for transit facilities.

Community Action Agencies

Since CAAs work closely with the local people, could make use of in-house skills and personnel, and do have some experience in the operation and funding of rural transportation systems, they might be used as the organizing body. This potential is dependent on the fate of OEO.

School Boards and Welfare and Health Offices

These organizations work closely with the local populace and are confronted with the rural transportation problem. A drawback, though, to their interests is that they are directed toward specific groups. A general public transportation system would be out of their jurisdictions.

SOME EXISTING APPROACHES TO THE PROBLEM

The approaches given here are probably the most successful. They, along with others, will be discussed in a report to be released soon by the U.S. Department of Transportation.

One of the most interesting studies done on rural transportation was completed in 1969 by Burkhardt (1, 6). This study evaluates the impact of the free bus service that ran in Raleigh County, West Virginia, from September 1967 to May 1969. The project was funded entirely by grants from the Office of Economic Opportunity. Although discontinued because of termination of the demonstration funding, the system had the following impacts: (a) the average rider saved $8.94 a month in transportation expenses, (b) the extra trips made because of the free bus would have cost $2.09 per person per month otherwise, (c) the benefits from additional program participation (food stamps, welfare, Social Security) raised the rider's income by $8.12 a month, (d) the rider saved $2.55 per month by being able to travel to lower priced stores, and (e) an estimated $100 per year per person in health care was provided to many riders who received such care for the first time with the operation of the free bus.

The Mercer County (West Virginia) Community Action Agency uses 6 driver-education cars donated by a local car dealer to provide transportation for the poor within the community. The cars are distributed to individuals (usually the elderly) who have safe driving records and volunteer their time for driving. Those needing a ride call the volunteers at their homes and request a ride at some date in the future. No fare is specified, but contributions are requested to cover gas costs. The CAA provides the money necessary for taxes, licenses, and insurance. Besides being used for driver education and transporting the poor, the cars are also used for the hot-meal program in which food is distributed daily to those poor who are eligible for the program. The cars are also occasionally used for long-distance trips to large urban areas.

The Pride-in-Logan CAA, also in West Virginia, has set up a nonprofit contract carrier corporation using a CAA grant and short-term loans. The corporation's 7 minibuses are contracted at 30 cents per mile by programs such as Headstart and WIN and by the Board of Education (Expecting Mother Program) to transport recipients to and from training centers. The funds received from these charters are then used to "subsidize" free transportation offered to the poor and elderly. The drivers of the buses are WIN enrollees, who will receive, after their training period, a full-time salary for their work. Administrative costs are low because of the use of CAA personnel. This program is now realizing a profit and is expected to expand.

The West Virginia Department of Welfare will undertake a Transportation Remuneration Incentive Program (TRIP) to partially underwrite public transportation costs "to insure that low-income elderly and handicapped individuals can purchase transportation services deemed appropriate and necessary for their health and general welfare" (25). The program will operate like the food stamp program in that those eligible will be able to buy transportation stamps at less than their face value. These stamps can be used for all local trips; the transportation provider redeems them at face value at the local welfare office. The intent is to increase the consumer's ability to pay for transportation so that the existing transportation systems will find the rural routes more profitable. Where transportation services do not now exist in rural areas, funds will be made available to nonprofit agencies to develop such. Proposed funding will be from the state and the Office of Economic Opportunity.

Progress-on-Wheels is a program sponsored by the Northwest New Jersey CAA in which surplus General Services Administration and privately owned vehicles are coordinated to provide public transportation for this rural area. Funds were made available through OEO and by a community campaign, which collected trading stamps to be redeemed for cash. Vehicles include 2 vans, 8 sedans, and 3 station wagons. The program's emphasis is directed toward the elderly, and even 30 of the 32 employees are older persons. The operation is on a demand-responsive basis; the elderly phone in trip requests to the dispatcher at various POW offices. The amount drivers are paid depends on whether they own the vehicle, mileage driven, and time accrued. Most drivers prefer part-time work to keep their incomes below $1,680 a year, the amount above which they start losing their Social Security benefits.

The Green Eagle Rural Transportation Cooperative was formed when OEO made a grant through WAMY (the CAA for the Watuga, Avery, Mitchell, and Yancy counties of western North Carolina) to study the feasibility of transportation cooperatives. In this rural area where the lack of transportation has always been a problem, residents could pay a $5 membership fee, which entitles all family members to ride on the bus. Membership reached a peak of approximately 530 members, and 4 cooperative buses operated within the region. Because of lack of subsidy, this system has now been discontinued.

SUMMARY

The rural transportation problem is slowly coming to light. Major groups of rural people are being identified who must have public transit to be mobile. Planners and governmental officials are realizing the effects of urbanization on the poor living in rural areas; one is that opportunities are now much farther away than they once were. Public transportation is needed by some individuals to get to those services and opportunities.

The resources necessary for the planning and implementation of rural public transportation systems are few and scattered. In Virginia, few data exist on the specific transportation needs of the rural poor, elderly, and handicapped. No coordinated state effort has been undertaken to determine where and how these people travel, where they would like to travel, how much they pay for transportation, and what opportunities are missed because of the lack of it. More research will be done as interest increases in this area. Although no agencies or organizations are responsible for public rural transportation in Virginia, a number of them could provide this service. Funds are not overabundant and are spread throughout many different sources, but they are there. More should be made available in the future, especially as the purposes for which federal and state highway funds can be used become more varied and as more agencies realize that there is a mobility problem in rural areas. The solutions are present; all that is needed is coordination, cooperation, and commitment to solving the rural transportation problem.

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APPLICATION OF GUIDELINES FOR IMPROVING TRANSIT SERVICE AND OPERATING EFFICIENCY

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Considerable public funds are being allocated for transit operations, and a method is needed to ensure improved quality of transit service and increased efficiency of operations. Operating guidelines and standards developed in Pennsylvania specify elements of service, such as speed, reliability, capacity, and comfort, that must be provided under different conditions. Transit agencies are also required to improve public information, undertake marketing, and collect technical, operating, and financial data and submit them to the state transportation department on a regular basis. The department uses the data to evaluate operations of each agency and bases distribution of funds among the applicants on their compliance with the guidelines. The department also provides all applicants with professional assistance for improvement of operations.

•THE POTENTIAL of transit systems to improve mobility in urban areas, provide reliable transportation, contribute to more desirable forms of urban development, reduce air pollution and other adverse environmental aspects of transportation, and use energy more efficiently is being recognized. Support by the public and among professionals for improving the systems is broadening.

On the other side, operating costs of transit systems have been rapidly increasing. The policy that the operating expenses must be covered exclusively by revenues from fares has been largely abandoned, for it proved to be self-defeating in terms of the social goals of public transportation. The required fare increases and service reductions lead to decreases in patronage, deterioration of service, and further need for fare increases. In many areas, transit has been eliminated or reduced to low-quality service at high fares and used nearly exclusively by captive riders.

Despite an increase in funds to public transportation at the local, state, and federal levels, the problem of financing is far from resolved, particularly the provision of operating expenses for transit agencies. The subject of this paper, however, is not the source of funds but their use in achieving improved transit service. The paper discusses guidelines that have been developed in Pennsylvania and are being applied, tested, and evaluated.

STATE TRANSIT PROGRAMS AND LEGISLATIVE POLICY

Since 1965, Pennsylvania has been financially assisting various urban areas in providing necessary transit services. This assistance, which has consistently received bipartisan support in the General Assembly, has been of 2 general types: (a) matching grants for transit capital improvement projects and (b) matching grants to help finance transit studies, demonstration projects, and advertising and promotion campaigns and to help maintain essential local transit services where fare-box revenues are insufficient to meet the actual costs of providing such services. As much as two-thirds of such annual operating losses have been financed by the state, and the remainder is paid from local public sources under what have been designated Purchase of Service agreements with the local transit agency.

The financial assistance contributed to transit by the state has been significant: More than $100 million in state matching funds has been authorized by the General Assembly for transit capital improvement projects, and more than $140 million in general funds has been spent in support of transit operations. Compared with other states, Pennsylvania ranks high with respect to the scope of the program and magnitude of the expenditures for transit.

Two other pieces of legislation spell out rather precisely the state's general policies with respect to public transportation. Expressed in Act 7 of the Pennsylvania Urban Mass Transportation Assistance Law of 1967 and in Act 8 of 1968, the legislative policy states:

1. The social and economic development in urban areas is dependent upon efficient and co-ordinated urban mass transportation systems, facilities, and services.
2. Mass transportation is essential to the solution of urban problems.
3. Mass transportation will promote the health, safety, convenience and welfare of the citizens of the Commonwealth.

Based on these policies, Act 120 of 1970 specifies the following powers and duties of the Pennsylvania Department of Transportation relating to public transportation systems:

1. To develop programs designed to foster efficient and economic public transportation services in the State.
2. To prepare plans for the preservation and improvement of the commuter railroad system.
3. To develop plans for more efficient public transportation service by motor bus operation.
4. To prepare and develop plans and programs for all modes of urban transportation, including in addition to commuter rail and motor bus, rapid rail, trolley coach, surface rail, corridor rail, and other innovative modes of urban transportation.

PRESENT CONDITIONS

Implementing this legislative policy is confronted by extremely difficult conditions in those urban areas that have transit operations. For several decades transit agencies and companies have had survival rather than progress as their main objective. Starved from any capital improvements, they tried to minimize the immediate costs of the system, thus developing gradually into highly undercapitalized systems with high operating costs per passenger. Urban transit systems are typically characterized by the following major deficiencies:

1. Obsolete equipment, inadequate fixed facilities, inefficient operations, and low level of service;
2. Partial or total neglect of transit services by other agencies, such as transportation planning bodies, traffic engineering departments, and public utility commissions;
3. Ineffective management that has became discouraged by many years of adverse developments for transit and no assistance from any side, is unaware of modern developments in public transportation, particularly in other countries, and is reluctant to initiate many changes, even some that would lead to improvements (for example, some transit agencies believe that improving public information about transit systems is a wasteful proposition!); and
4. Apathetic public that has been exposed to deteriorating service and increasing fares, is often unaware of potential improvements to the system, and is discouraged about the prospects for change in the downward trend.

In this situation, if transit agencies are simply provided with funds to operate their systems, they will likely use the funds to perpetuate the existing low-quality service. The required amounts of funds will thus steadily increase, and the quality of service and the ridership will remain constant or decrease. From the point of view of operating efficiency, there is a danger that eliminating the break-even requirement for systems operation might weaken the stimulus for efficiency unless the operations are controlled by certain standards and guidelines.

Despite the bleak picture of the present conditions of transit, several examples in Pennsylvania cities clearly indicate that improvement in service does result in a favorable response by the public. First, commuter railroads in Philadelphia have had steady track deterioration and only limited rolling-stock renovation, but their high speed and constant high reliability have led to a steady increase in patronage from 23.7 in 1960 to 32.0 million annual riders in 1972. Second, the Lindenwold Line from Philadelphia into low-density, automobile-oriented suburbs of southern New Jersey has attracted 42,000 daily passengers. Third, free bus service provided after the flood of 1972 in Wilkes-Barre resulted in more than doubling (a 108.7 percent increase) of ridership. Although the emergency situation in the city has undoubtedly played a significant role in this increase, the continuing high ridership at the present 15-cent fare (still lower than the initial 35-cent fare) indicates that the response was not only forced but also induced by increased and improved services. Fourth, the city of Allentown introduced a new ride-and-shop service (transit-validation program), which was intensively promoted and recorded significant increases in ridership on several of its bus lines (exact passenger counts were not made). Fifth, in the city of Erie a highly competent transit authority management took over the private company in 1967, and ridership has been increasing steadily from 3.3 million to 4.0 million annual riders in 1972.

PROGRAM OBJECTIVES

The Pennsylvania Department of Transportation and a research team from the University of Pennsylvania developed a program for improvement of transit services and efficiency of operations (Fig. 1). The objectives of this program are

1. Determine the required quantity and quality of public transportation service in various urban areas;
2. Evaluate the efficiency of transit operations;
3. Analyze the effectiveness of transit management in implementing the policies, objectives, and procedures established for the administration and operation of the transit system;
4. Identify areas in which improvements could or should be made in the management and operations of the transit systems;
5. Provide a mechanism by which transit authorities and agencies can evaluate and analyze their operations;
6. Form the basis on which the department will allocate funds under the state's Mass Transportation Assistance Program; and
7. Assist the transit agency in defining its own realistic needs for capital improvements.

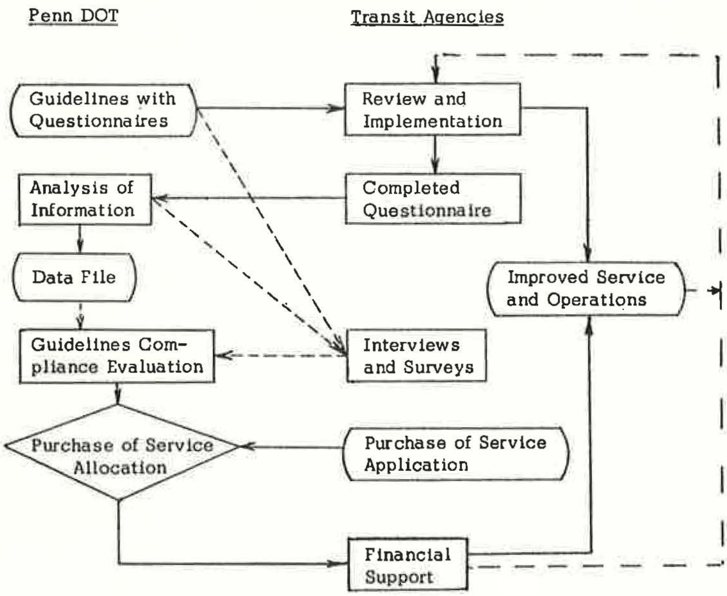
The program will provide tool for controlling the quality of transit service and efficient use of allocated funds and for obtaining operating and service data that in most cases are either inadequate or nonexistent but needed by management. In addition, the transportation department will provide to both public and private agencies expertise that they cannot afford to include on their staffs.

OPERATING GUIDELINES

The technical guidelines and standards were developed on the basis of practices of the best managed transit systems on this continent and in Europe. To define, largely in quantitative terms, transit service aspects that are valid for a considerable number of diverse cities is not an easy task. There are great differences in scale between the Philadelphia multimodal transit system, which accounts for some 65 percent of total transit ridership in the state, and a small-city system, which may have fewer than a dozen buses. Therefore, we had to specify policy and planning procedures in general terms only and to define service in relation to the demand and type of service required. Those requirements that could be precisely (usually quantitatively) specified were defined as standards, and compliance with them is mandatory. Other requirements are recommended. Some of the guidelines are summarized here.

1. The transit network service area is the area within a 5-minute walk from stop or

Figure 1. Public transportation improvement program.



station. The maximum frequency of stopping is 7 stops per mile.

2. Exact specifications are given for computation of offered capacity for both off-peak and peak hours.

3. Headways are specified with respect to their length as well as to their actual values. Except in special cases, headways must always be divisible in an hour so that they are repeated every hour and are therefore easily remembered by passengers.

4. Elements of vehicle design influencing speed are specified as well as a number of regulatory measures, such as optimal stop locations, preferential treatment at the intersections, reserved lanes, and private rights-of-way. In addition, information is given on increasing speed through different types of scheduling, express services, reduction of stop density, and improved fare collection methods.

5. Reliability of service is specified precisely in standards for peak, off-peak, and weekend services with different headways. The measurement is given in terms of percentage of trips on time where all departures between 0 and 5 minutes late are considered on time.

6. Passenger comfort and convenience are provided by requirements for vehicle maintenance, seating capacity, cleaning of interiors and exteriors, lighting, and passenger shelters.

7. Directness of service is discussed in general terms.

8. Fares are specified in considerable detail, including aspects of different fare structures, fare levels, and various potential promotional and experimental actions.

9. Standards for marketing activities specify the forms of public information in terms of maps, schedules, transit stop signs, and so on. Possible advertising and promotional schemes and required marketing analysis are also specified.

10. The guidelines specify the information that transit agencies must submit when they apply for Purchase of Service funds. The first requirement is that they specify the goals and objectives established by the local government and the transit agency. They must also submit detailed information on services. The agencies are also required to project Purchase of Service needs for the following year and to develop a plan for improvement in the transit service. Since the compliance with the guidelines will in some cases increase the cost of operation, the agencies are required to estimate these increased costs and inform the transportation department about this specific cost increment. The department will then review the planned improvements and approve

them or suggest modifications. The agency is required to define capital improvements and to develop a plan for their implementation. An increased emphasis in the evaluation of proposed capital improvements is the analysis of their impact on increased ridership and increased efficiency of service, which will be directly reflected in the compliance with the guidelines.

Data on Transit Services and Operations

Traditionally, transit companies were considered primarily as business undertakings, and their reports consisted of financial data only. The data were reported in a nonstandard way so that comparisons among the companies are difficult to make. (UMTA is sponsoring a study (1) on standardizing the financial reporting of transit agencies and companies). However, reporting of data on service and operations has been extremely poor so that data are not available on basic operations such as the number of passengers carried, average trip length, commercial speed of vehicles on lines, and hourly fluctuations of demand. Analysis of system improvement is difficult without such data.

Data have been requested on 3 questionnaires that were sent (a) to city planning agencies for data about the city and metropolitan area, (b) to transit companies in large cities, and (c) to transit companies in medium and small cities.

The questionnaires were designed to obtain all the information required by the Pennsylvania Department of Transportation, the U.S. Department of Transportation, and the Public Utility Commission so that duplication of requests for information is avoided or minimized. Only the minimum data needed to compute various indicators were requested. The indicators are computed by the state transportation department to minimize the paper work of the transit agencies and to provide higher accuracy.

The questions are in 4 categories: (a) information on city and metropolitan area, including size of area, population, employment, automobile ownership, and parking capacity in CBD; (b) transit service offered to the passengers, including number and length of lines, cycle times, headways, number and characteristics of vehicles, fares, and reliability of service; (c) use of the system, including revenue and total number of passengers, daily fluctuations, average passenger trip length, and annual passenger-miles; and (d) organization and finance, including number of employees and their classification, number of garages and rail yards, and work performed in terms of vehicle-hours and vehicle-miles.

DATA FILE

When the completed questionnaires are received, their data are transferred to data file forms. In addition to this basic information, the data file contains a number of computed indicators. Examples include annual seat-miles offered per square mile of served area, annual revenue rides per capita, annual passenger-miles per mile of line, passenger-miles per seat-mile, average operating hours per vehicle per day, average miles per vehicle per day, average weekday passengers per operating employee, and total revenue per vehicle-hour.

Implementation of the Guidelines

The main purpose of the guidelines is to improve transit service and operations, but agencies may not voluntarily comply with them. Therefore, financial aid in the form of Purchase of Service can be used as a leverage for compliance. Consequently, the guidelines explicitly state that compliance will influence the Purchase of Service fund allocation by the transportation department. Thus, an objective method to evaluate compliance was needed.

The standards, i.e., the specific, exactly defined requirements within the guidelines were selected to be used as the major basis for rating an agency in the compliance evaluation. The evaluation items are divided into 4 categories: city, transit agency, planning and marketing; transit service; transit usage; and financial and administrative aspects. The data for the evaluation are taken from the data file, other reports submitted by the agencies, meetings and discussions with their officials, and field surveys. The most important 24 items are selected for quantitative evaluation, and each item consists of several elements. A total of 400 basic points are distributed to the 24 items. Each item thus has the maximum number of points that can be allocated to it and exact breakdown of these points to all elements of that item.

In addition to the 400 basic points, a maximum of 100 bonus points can be allocated for changes that an agency implements. In the first year the agency is evaluated only on the basis of the 400 points. In each succeeding year the basic points are allocated not only on the basis of the status of the system but also on the difference in each item from the preceding year. This difference determines allocation of bonus points in the case of an improvement or subtraction of them in the case of deterioration.

If an existing deficiency is caused by forces outside the agency's control (such as traffic congestion or poor timing of traffic signals), the agency is required only to prove that it has done everything in its power to improve the condition. If it has done so, all points are given, regardless of performance. If it has not, the evaluation is based on the current performance exclusively.

Use of Compliance Evaluation

The total number of points given to an agency, divided by 400, represents its guideline compliance rating. This rating and the general evaluation, which includes some subjective elements, such as organizational conditions for implementing improvements and characteristics of the population and of the region, are used in the allocation of Purchase of Service funds based on the following 2 conditions.

1. There are adequate funds. If funds are available, an agency that obtains 400 or more points (more points may be obtained in the years in which improvements take place) is allocated the full amount required. If the agency has fewer than 400 points, downward adjustment in the amount of money is made.
2. Available funds are lower than the requested ones. If adequate funds are not available, money is allocated to agencies according to their ratings. The allocation formulas are being devised and tested.

PROGRAM EVALUATION AND FUTURE PERSPECTIVES

Already there are indications that the guidelines, including the technical standards, instructions, and suggestions, the data file, and a continuing program of evaluation of agency operations are useful tools in helping the agencies to improve their services, in equitably distributing Purchase of Service funds, and in ensuring their efficient use.

The major difficulty is that compliance with the guidelines in some cases increases immediate costs. Although the transportation department believes that these increased costs are justified and will eventually be recouped from increased ridership, higher revenues, and improved transit service, the fact remains that these funds must be found. If the funds appropriated by the legislature (as well as the required local matching funds) for this purpose are adequate to satisfy all requests for Purchase of Service and also contain a sum that could cover the additional costs of complying with the guidelines, the program will operate smoothly. But if funds are insufficient to cover all the requests, the problem of cutting the least necessary expenses will usually eliminate first any changes that will increase costs. This may defeat some portions of the program. However, compliance with the guidelines in some cities will result in actual demonstrable improvements in services, in ridership, and in mobility so that the usefulness of the guidelines will thus be proved and their acceptance by transit and other agencies will be facilitated.

The basic question about the permanent financing of contributions to operating expenses of transit agencies is outside the scope of this paper. The solutions may be found in forming metropolitan area transit districts that have taxing powers, in continuing the state contribution of two-thirds of the funds and the local contribution of one-third, or in creating a federal program for transit operating subsidies. Whatever solution is found, the progress achieved through the program described here will be extremely useful in this or somewhat modified form because it helps to ensure good service and efficient operations when the transit agency is not financially self-supporting.

Experience will also show how effective the state's professional guidance provided through this program will be in the internal operations of the agencies. At this time, the state may be able to provide greater professional expertise than individual agencies have and at the same time develop a more manageable program than the federal government would be able to do. However, the federal government already has direct contact with some agencies, particularly with respect to the capital improvement financing. Improved cooperation among all 3 government levels is important to ensure that duplication of work, potential discrepancies in intentions, and excessive paper work are minimized.

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LEVEL-OF-SERVICE CONCEPT FOR EVALUATING PUBLIC TRANSPORT

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A system of evaluating service variables common to all public transport modes is proposed so that an existing system may be managed or improved and a new system may be built on the basis of its ability to fulfill a desired level of service. The variables discussed are those directly perceived by the user regardless of mode: overall trip speed and en route delay and comfort factors associated with the vehicle including density, acceleration, jerk, temperature, air flow, and noise. Improving one or more of these measurable variables bears an associated cost and design requirement. Since better service is desirable in certain situations while average service is sufficient in others, levels of service A through F are adopted for each variable. In the proposed system, level of service is determined by the use of a weighted average of rankings assigned to individual factors. Within tolerable limits, 40 percent of the overall ranking should be based on speed and delay and 60 percent on comfort factors. When an individual comfort variable becomes intolerable, the entire ride is at service level F. Application of the procedure results in reasonable comparisons of both systems and individual trips within a system.

•SINCE the late 1950s, Americans have sought improved public transport. The technology of the automobile has continued to advance, and efforts are being made now for public transport technology to catch up. A host of new, innovative transport concepts are being tested, and the Bay Area Rapid Transit System in San Francisco has just started operations. What is needed is a precise way to measure public transport service so that transit systems can become more competitive with the private automobile. A service measurement system could be used for daily rating and managing of existing modes as well as for specifying the desired level of service for planned improvements.

Each mode of public transport has a different assortment of physical characteristics; but all modes have common service characteristics such as speed and density, and the most important characteristics, particularly as they affect patronage, are those that the user perceives directly. Speed, density, and other individual characteristics such as acceleration, temperature, and noise are easy to measure individually. This paper proposed that the individual measurements be combined to determine an overall level of service for each mode of public transport.

SERVICE CHARACTERISTICS

Other system features such as design standards, operating costs, access, fares, and safety requirements are directly related to basic service characteristics. For example, higher speed, a service characteristic, involves better design standards, more costly construction, and higher operating costs for energy and track maintenence. This section discusses the selection of those characteristics common to all modes of transport that most reflect the quality of service.

One of the basic level-of-service characteristics in highway design is speed (1, p. 7). The speed advantage that users associate with automobiles occurs in part because automobile trips are made directly from origin to destination without intervening transfers, another important service characteristic. However, there is even more to the popularity of the automobile than speed or direct routing. For example, the driver frequently has the ability to vary speed and route. The transit patron can neither select the exact leaving time nor detour if the route is congested. Thus schedule frequency and delays to patrons also must be considered in establishing the level of service for public transport.

Another basic characteristic of level of service is density. The density of automobiles on the highway is related to speed of service; poor service occurs at low speeds. The density of the motorist's personal space is self-determined because he or she selects the vehicle and the passengers. A sedan encloses 25 ft^2 (2, p. 35). Typically, automobiles carry 1 or 2 passengers so that each has 25 to 12.5 ft^2. The space inside the automobile cannot be reduced even in the most severe traffic snarl. In a subway car or local bus, personal density is routinely reduced to as little as 2 ft^2/passenger. This crowding coupled with the absence of personal control of the vehicle can lead to a feeling of panic for transit users and has probably resulted in the diversion of large numbers of persons to the privacy afforded by automobiles.

The absence of control on a public transport vehicle denies the transit patron other service advantages enjoyed by the motorist. The motorist not only can detour around delays but also has a better opportunity to avoid bumps and potholes and can accelerate and decelerate gently so that passengers are not thrown against the seat. The rider of public transport must accept whatever ride is offered whether it be on cobblestone streets or unaligned track. The motorist can cool, heat, or circulate air in the automobile for his or her comfort. The public transport patron must increasingly accept whatever conditions the vehicle can provide.

THE CONCEPT

This paper discusses levels of transport service (LOTS) to apply to all line-haul systems of public transport. The values are based on the patron's environment and travel speed. Comparisons can then be made of the relative service offered by different modes and of variations within the same mode such as those that may occur for different trips on the same route. All transport systems can be compared, but the process described in this paper is intended primarily for commuter trips in the 2- to 40-mile range.

Level of service is frequently associated with the peak hour. However, an off-peak level of service also may be computed. For complete analysis, LOTS value must be computed for each pair of stops on a given route. In practice, computations may only be made for selected station pairs to establish a range of service values achieved on a particular system. If a single value is to be applied to a route, a weighted average should be used. The average is computed by multiplying the percentage of total traffic between each pair of stations by the level-of-service values for that pair.

CHARACTERISTICS USED TO ESTABLISH LEVELS OF SERVICE

The following paragraphs discuss each of the major characteristics used to establish the levels of service for public transport systems.

Travel Time

In selecting a transit mode, most commuters regard travel time as the most important factor. Travel time depends on average speed on the system. Some systems now operate equipment that can travel 80 mph, while local buses traveling through a heavily congested district may average less than 6 mph. Speeds this low or lower are comparable to walking on high-volume people-moving mechanisms such as moving belts and moving stairs.

More than 90 percent of all automobile commutation trips are 20 miles or less (2). A transit system could accommodate these trips with a maximum travel time of 35 min if the system achieves an average speed of 35 mph. This means that if 25 min is allowed to reach the public transport mode and to go from that mode to the ultimate destination the total commuting would be 1 hour or less. Therefore a speed of 35 mph is selected as a desirable goal. For exurban areas served by commuter railroads, an even higher average speed might be a more appropriate design goal.

In central business districts, commuting trips often are no longer than 5 miles. An average speed of 6 to 15 mph would keep total trip time under 1 hour in these locations. A design goal of 15 mph is the minimum that is recommended, although in existing situations a speed of 6 mph may be tolerated. Higher rates of acceleration and deceleration can save time, but excessive rates of starting and braking are uncomfortable.

Headway

The automobile commuter experiences no delays due to scheduling. Thus, people may be discouraged from using public transport if the time between departures is excessive. Transit headways also interact with density since the latter can be reduced by scheduling more trips on all but the busiest transport routes. Headways are reflected in the calculation of average speed by adding half the headway to the basic travel time on heavily traveled routes. But this would unduly penalize low-density routes with infrequent headways. Therefore, the maximum headway allowance can be limited to 5 min.

Transfers

The public transport user may make one trip from his home to the public transport station and a second trip from the station to his or her destination. A method of accounting for the first trip, the access trip, is given later in the discussion of multimode trips. The computation is omitted from the initial procedure because computing a typical access time is extremely difficult if various patrons use different access modes. Any additional transfers within the transit system represent inconvenience, and a transfer penalty of 5 minutes per en route transfer is added to the basic travel times for the approaching and the departing route. Also added are the walking time associated with the transfer and half of the headway on the departing route.

Fare Collection

Automated fare collection is definitely a patron convenience. The major causes of patron inconvenience probably are waiting to purchase fares and waiting to enter the system. Fare collection should be included in computing trip speed when the delay to the patron exceeds 30 sec.

Speed Adjustment and Values

The following computations show average adjusted peak- and off-peak travel times for the 8.9-mile ride on the Port Authority Trans-Hudson system between Newark and the World Trade Center in downtown Manhattan. The computations yield adjusted average speeds of 26 and 22 mph respectively. Normal running times are used to compute speeds and are defined as the time that the commuter generally encounters rather than the published running times. Fare collection in the example usually takes less than 1 minute, and no en route transfer is needed.

Item	Peak (min)	Off-Peak (min)
Fare collection	0	0
Headway	$(0.5 \times 3) = 1.5$	$(0.5 \times 10) = 5$
Running time	19	19
Transfer	0	0
Total	20.5	24

The selected LOTS values for scheduled line-haul speed plus fare collection, headway, and transfer adjustments are as follows:

Adjusted Speed (mph)	LOTS Value
>60	A
35 to 60	B
25 to 35	C
15 to 25	D
6 to 15	E
0 to 6	F

Delay

Delays represent a reduction in the level of service and are defined in this paper as unexpected increases in normal running time. They are introduced so that unique occurrences may be reflected when a level of service is needed on a daily basis. Boarding delays are not a characteristic of travel by private car. Therefore, the absence of boarding delays is particularly important in attracting motorists to public transport. In this analysis delay is expressed as minutes per trip. The times for individual delays that occur during a selected trip are added to obtain a total delay time for that trip. If a trip involves 2 or more transit services, the delays on each service are added to determine total peak-hour delay. The level-of-service values are as follows:

Delay (min)	LOTS Value
0	A
0 to 1	B
1 to 2	C
2 to 4	D
4 to 8	E
>8	F

Individual delays could be included in the previous computation of overall speed. They are considered separately because they represent a more immediately correctable situation. Delays are frustrating because users are aware that the basic capability of the system is not being used but they are powerless to take corrective action.

Density

Speed and delay are service characteristics that relate to travel time. Density and the other remaining characteristics deal primarily with user comfort. Passenger densities encountered inside the vehicle reflect, in part, the level of service of a transport system. Actually, the reciprocal of density, area per passenger, is used to avoid fractional values. Table 1 gives examples of space offered on transport vehicles in the New York metropolitan area.

The area per passenger varies markedly from a commuter railroad with spacious seating arrangements and no standees to a jammed subway car with few seats and many standees. Fruin's descriptions of the various levels of service for standing passengers in terminals are given in Table 2 (3).

The areas given bear an interesting relation to those given in Table 1. The cost of producing transportation is reflected in the absence of public transport vehicles with levels of service A and B. (An example of level of service A is railroad parlor cars used for intercity travel.) The Erie-Lackawanna Railroad cars are level of service C. Those cars are equipped with doors at each end and are used for long commuting trips. Rail cars allow for an appropriate degree of circulation, and the subway car, which has 4 doors on each side to reduce the need for interior circulation and a minimum number of seats to permit maximum loadings, is at the low end of the density scale.

The Fruin standards (Table 2) naturally were not intended to account for sitting passengers. In the railroad cars, each seated passenger occupies at least 3.5 ft^2, leaving too little space in the aisle to achieve an average density of 2 ft^2/passenger when the

Table 1. Space on transit vehicles.

Vehicle	Operator	Seats	Normal Peak Passenger Loading	Interior Area[a] (ft^2)	Area per Passenger (ft^2)
Commuter rail car	Erie-Lackawanna	108	108	829	7.7
Suburban bus	Transport of New Jersey	50	50	272	5.4
City bus	Transit Authority	40	80	290	3.6
Subway car	Transit Authority	46	272	535	2.0

[a]Includes area for seats, but excludes areas allocated to operators and conductors.

Table 2. Levels of service for standing passengers in terminals.

Description	Area per Person (ft^2)	Level of Service
Adequate area for standing and free circulation	13	A
Adequate area for standing and restricted circulation	10 to 13	B
Same as B except circulation occurs by disturbing others	7 to 10	C
Can stand without contacting others, but circulation severely restricted	3 to 7	D
Adequate standing room, but contact with others is unavoidable and circulation is impossible	2 to 3	E
Equivalent to body area, close unavoidable contact, physical and psychological discomfort, and potential for panic	1½ to 2	F

Table 3. Level-of-service values.

Characteristic	A	B	C	D	E	F
Adjusted speed, mph	>60	35 to 60	25 to 35	15 to 25	6 to 15	0 to 6
Delay, min	0	0 to 1	1 to 2	2 to 4	4 to 8	>8
Space, ft^2/passenger	>13	10 to 13	7 to 10	3 to 7	2 to 3	<2
Horizontal acceleration, ft/sec^2	<1.0	1.0 to 2.0	2.0 to 3.0	3.0 to 3.5	3.5 to 4.0	>4.0
Vertical acceleration, ft/sec^2	<1.5	1.5 to 3.0	3.0 to 4.5	4.5 to 5.2	5.2 to 6.0	>6.0
Jerk, ft/sec^3	<1.0	1.0 to 2.0	2.0 to 3.0	3.0 to 4.5	4.5 to 6.0	>6.0
Temperature, deg F	72 to 76	68 to 78	64 to 80	58 to 84	50 to 90	<50 to >90
Ventilation, ft^3/min/passenger	>35	30 to 35	25 to 30	20 to 25	15 to 20	<15
Noise, dB	<60	60 to 75	75 to 85	85 to 90	80 to 95	>95

Table 4. Points for achieving each level of service.

Characteristic	A	B	C	D	E	F
Adjusted speed	30	24	18	12	6	0
Delay	10	8	6	4	2	0
Space	25	20	15	10	5	0
Acceleration and jerk	10	8	6	4	2	0
Temperature	15	12	9	6	3	0
Ventilation	5	4	3	2	1	0
Noise	5	4	3	2	1	0
Total	100	80	60	40	20	0
Range	100 to 90	90 to 70	70 to 50	50 to 30	30 to 10	10 to 0

Table 5. Hypothetical level of service on BART system.

Characteristic	Level of Service	Points
Adjusted speed (34-min travel time and 3-min gap for 28 miles = 48 mph)	B	24
Delay	A	10
Space (no standees, 647 ft^2, 72 seats = 9 ft/passenger)	B	20
Acceleration (3 ft/sec^2)	C	6
Temperature[a]	A	12
Ventilation[a]	B	4
Noise	A	5
Total	B	81

[a]Level assumed by author.

aisle is filled. However, the cars are not intended for use at these densities. The subway car, in which higher densities are intended, has fewer seats, and standees share the leg room allocated to seated passengers. Therefore, the above standards are offered as a satisfactory first approximation for public transport vehicles.

Passenger Comfort

The effect of crowding on passenger density has been noted. Levels of comfort on public transport systems also are affected by temperature, odor, ventilation, noise, vibration, acceleration, deceleration, and position change (or jerk). Each of these effects can be divided into 3 tolerance levels (4):

1. An upper physiological limit beyond which the condition is physically intolerable;
2. A limit beyond which the body survives but is uncomfortable; and
3. A psychological condition in which the body is comfortable but the situation is not pleasant.

This area of transport service is much talked about, but there are a number of serious deficiencies in the present selection and application of standards of tolerance. A level of service F for even one comfort factor is far more serious to the passenger than a level of service F for characteristics such as speed or delay. In other words, the author's opinion is that the operation of one comfort factor at service level F at any point in a trip causes the patron to judge the transport service as completely unsatisfactory.

In setting minimum comfort levels, one should also keep in mind that the commutation trip is normally made about 500 times a year. A motorist may never encounter a physically intolerable situation (serious accident) during a driving lifetime. A daily intrusion on upper physiological limits would leave transit systems riderless. The more appropriate design limit might be the second in which the body will survive but be uncomfortable. Such was the case in stalled traffic prior to air conditioning. However, even this limit should never be a recurrent feature of a public transport system, for the thought of facing a psychologically uncomfortable ride each day will also divert users to other modes. Therefore, comfort levels should be established within the area of psychological comfort.

Acceleration

Fast acceleration and deceleration (backward acceleration) yield an increase in system speed at the expense of passenger comfort. Rapid acceleration is more easily tolerated by a seated passenger than by a standee, although the latter can make adjustments if the speed changes are consistent. Even long commuter trains will handle occasional standees. Therefore, the levels of service are selected with the comfort of standing passengers in mind. The positive effect of acceleration on speed is reflected indirectly in the previously discussed service standards for overall trip speed.

Accelerations also occur in other axes, with both linear and torsional (rotational) characteristics. The most common on public transport systems include sway and jouncing. Therefore, acceleration standards are adopted for both the horizontal (longitudinal, lateral, and other horizontal) and vertical planes. As with other comfort values, the maximum desirable comfort value for acceleration is considerably less than the physical limit of 1 g or 32.2 ft/sec^2. Furthermore, the maximum value need only be reached once during a ride in order to have the system rated at the associated lower level of service. Values below service level D should occur rarely, and values below service level E should occur only at the time of an accident. The selected acceleration values are as follows (5, Tables I and II and Figs. 1, 2, 5, 6, 7; 6):

Horizontal (ft/sec^2)	Vertical (ft/sec^2)	LOTS Value
<1.0	<1.5	A
1.0 to 2.0	1.5 to 3.0	B
2.0 to 3.0	3.0 to 4.5	C

Horizontal (ft/sec^2)	Vertical (ft/sec^2)	LOTS Value
3.0 to 3.5	4.5 to 5.2	D
3.5 to 4.0	5.2 to 6.0	E
>4.0	>6.0	F

Jerk

Jerk is defined as the buildup in acceleration and is given in feet per second per second per second. The effect of jerk in the axis of travel is most noticeable to passengers on side seats during the final phase of deceleration. Jerk values also should be applied to changes in lateral or vertical acceleration caused by faulty track or poor roads. Values presented for this condition are considered tentative pending further research (5, pp. 3-4, Figs. 3, 4, Table II). Random testing of actual systems is advocated, for a poor operator can negate many of the ride benefits of an excellent roadbed, vehicle suspension, and throttle control.

Jerk (ft/sec^3)	LOTS Value
<1.0	A
1.0 to 2.0	B
2.0 to 3.0	C
3.0 to 4.5	D
4.5 to 6.0	E
>6.0	F

Temperature

There is general agreement that 72 F is a desirable temperature for heating transport vehicles and 76 F is a suitable temperature for air-conditioning equipment. However, the actual temperature will vary with the amount of clothing that people wear in the vehicle. During the winter, thermostat settings on subways and local buses should be lower, say 60 F, so that the passenger is not uncomfortably hot in a topcoat. Heating units should provide the heat needed to raise interior temperatures to comfortable levels when outside design temperatures are reached. In New York City, a design temperature of 0 F can be used, but in colder cities, temperatures as low as -40 F may be appropriate.

Air-conditioning or cooling equipment must be designed to offset heat loads caused by heat transmission through walls and ceilings and heat generated by passengers, lights, motors, and outside air that is circulated for ventilation. The heat load from passengers is often the largest load. However, the effect of door openings at stops also is significant for local bus and subway routes. The design temperature for cooling is usually 95 F in New York City and may be as high as 115 F in southern locations.

The level of service is determined by taking the worst value of temperature that occurs inside the transport vehicle during the line-haul portion of the trip. For systems where the patron is faced with a potential wait of more than 5 minutes, the temperature of the waiting area should be assessed because the patron achieves thermal equilibrium or a steady-state condition of comfort or discomfort after 5 minutes (7). The LOTS values are as follows (4, 8):

Low (deg F)	High (deg F)	LOTS Value
72	76	A
68	78	B
64	80	C
58	84	D
50	90	E
<50	>90	F

A subway car temperature of 60 F in winter could be given a value of A if the patron wears sufficient clothing so that he or she perceives a temperature of 72 F.

Ventilation

Ventilation is closely associated with temperature. Thus, outside air required for heating and air-conditioning systems can be modulated to provide needed ventilation as well as comfort during off seasons. Usually 25 percent outside air represents good design. Ventilation standards are expressed in cubic feet per minute per vehicle (8, pp. 62, 68, 71). It is proposed that the standards be revised to provide cubic feet of air per minute per passenger at maximum contemplated passenger occupancies. A sufficient amount of air is required to maintain a comfortable environment and prevent strong odors from persisting (8, p. 10). As with temperature, the worst en route ventilation controls and the standards apply to stations if waits of more than 5 min occur. The LOTS values are as follows (4, p. 38; 8, pp. 10, 62, 68, 71):

Ventilation (ft^3/min/passenger)	LOTS Value
>35	A
30 to 35	B
25 to 30	C
20 to 25	D
15 to 20	E
<15	F

Associated Characteristics

More sophisticated standards might include requirements for associated characteristics such as air filtering and humidity control. Also important to the passengers are separate safety standards that relate to carbon monoxide and other noxious gases.

Noise

Noise is defined as noise perceived by passengers while inside the transport unit. Loud noise is universally recognized as an undesirable feature of a transit system. The selected unit of measure is decibels or noise level sound pressure ratio. A recent Port Authority design specified a maximum permissible noise level of 68 dB for an airport people-mover that traveled at 30 mph and had auxiliaries and air conditioning in operation (9). A system is rated F if vehicle or station noise exceeds 90 to 100 dB, for 2 hours per day of sound of 100 dB or more can cause permanent hearing loss (10). The selected LOTS values are as follows (6, p. 56; 11):

Noise (dB)	LOTS Value
<60	A
60 to 75	B
75 to 85	C
85 to 90	D
90 to 95	E
>95	F

Vibration

Vibration is defined as repetitive, oscillatory movements in any direction. Severe vibrations described by the Institute for Rapid Transit (11, pp. 43-44) should be eliminated during equipment testing. Occasional vibrations should show up during acceleration and jerk tests. Therefore, a set of values is not recommended for vibration at this time.

LEVEL OF SERVICE

The following is a discussion of the individual levels of transport service that lead to an overall service rating for each pair of stops on a transit system. A summary is given in Table 3. Since a weighted average is used, the desired value for all individual characteristics does not have to be attained to achieve an overall level of service of the same value.

Level of Transport Service A

Average speeds are 60 mph or more after adjustments are made for processing and en route transfers and no peak-hour delays exist. Personal space is at least 13 ft^2/passenger. Horizontal acceleration and deceleration are no more than 1.0 ft/sec^2, and temperature does not vary more than 2 deg from normal. Ventilation is 35 ft^3/min/passenger, and noise levels are below 60 dB. Only intercity rail systems operate at this level today. Design of commuter systems at this level of service is suitable for exurban commutation systems that have light volumes and line-haul distances of more than 40 miles.

Level of Transport Service B

Average adjusted speeds are between 35 and 60 mph, and delays do not exceed 1 min. Personal space is 10 to 13 ft^2/passenger. Standards of temperature, ventilation, and noise are maintained at high levels. The Bay Area Rapid Transit System meets or exceeds most of the criteria for level of service B, which is a standard for modern public transport systems that carry moderate volumes and serve suburban communities.

Level of Transport Service C

Average adjusted speeds are between 25 and 35 mph, and peak delays are no more than 2 min. Personal space is 7 to 10 ft^2/passenger. Acceleration of 3.0 ft/sec^2, a temperature range of 64 to 80 F, and a noise level of 85 dB are permitted. Level C is a suitable standard for an urban transport system that has moderate to heavy use.

Level of Transport Service D

Average adjusted speeds are between 15 and 25 mph, and peak delays are no more than 3 min. Personal space is 3 to 7 ft^2/passenger. Acceleration and deceleration of 3.5 ft/sec^2 are acceptable, the temperature and other environmental features are within tolerable limits. Level D would be suitable but not desirable for a heavily used urban transport system that carries predominately short trips or has construction costs such that heavy use of the system is desirable or has both of these characteristics.

Level of Transport Service E

Average adjusted speeds are as slow as 6 mph, and peak delays are as long as 8 min. Personal space is 2 to 3 ft^2/passenger. Acceleration and environmental features approach the border line of human psychological tolerance. Level E is not used for design, but may occur as maximum capacity is reached on existing systems or for short periods on new systems that are designed for higher levels of service.

Level of Transport Service F

Average adjusted speed is below 6 mph, delays are more than 8 min, and personal space is less than 2 ft^2/passenger. Acceleration, deceleration, temperature, ventilation, or noise exceeds human psychological tolerance levels. That is, horizontal acceleration is more than 4.0 ft/sec^2, high temperatures are above 90 F, low temperatures are below 50 F, ventilation is less than 15 ft^3/min/passenger, and interior noise is more than 95 dB.

Transit systems operating with any one of the above comfort features at level F are not suitable and should be upgraded as soon as possible. When speed, delay, or density reaches level F on an occasional basis, the operating system should be halted until the deficiencies are corrected. Daily or near daily operation at level F should lead to immediate improvements or, if this is not feasible, to either intentional diversion of passengers to other modes or a forced reduction in demand.

WEIGHTING OF SERVICE CHARACTERISTICS

Not all service attributes are equally important. What is most difficult to determine is the relative importance of those attributes for which LOTS values are proposed. One of many available surveys found the following criticisms of public transportation by residents of Washington, D.C., where transit is provided by surface buses (12, Vol. 1, p. 18):

Criticism	Respondents (percent)
Overcrowding	60
Waiting	57
No seat	54
Slower than car	50
Cannot choose own time	38
More walking	25
Not so dependable	25
Hot	21

The same study notes that time savings and comfort are the 2 most desired characteristics of a new system (12, Vol. 2, p. 18). The criticisms deal with many of the previously discussed characteristics such as density (overcrowding, no seat), headways (waiting problem, cannot choose own time), speed (slower than car, not so dependable), and temperature (hot). Empirical weightings are proposed below to reflect the results of this and other studies. The weights are tentative pending further research into their relative importance.

Speed

Speed is of paramount importance in attracting patrons from automobiles to public transport. As the primary service feature, it is assigned the highest value that is used, 30 out of 100 total points.

Delay

Delay is given a weighting of 10, which is selected so that an unexpected increase in travel time has a slightly greater effect than a recurrent speed reduction. A total of 40 points are allocated to speed and delay, leaving 60 points for comfort features.

Density

The most important comfort feature in modern systems is believed to be adequate space for each passenger. Therefore, this feature is assigned 25 points.

Acceleration and Jerk

Rapid or uneven acceleration is one of the most important causes of discomfort. Therefore, these 2 items are given 10 of the remaining 30 points. The points were selected on the basis of the worst condition that occurs for either characteristic.

Temperature

Temperature and humidity are closely related and are important because the transit user cannot personally control these items as he or she can in an automobile. A weighting of 15 is assigned.

Ventilation

A weighting of only 5 is used for ventilation, for its requirements are often satisfied if the temperature requirements are met.

Noise

This characteristic is assigned a weight of only 5 because the proportion of patrons upset by severe noise is deemed to be small. It must be included, however, since the affected riders will be lost to the system if reasonable levels are exceeded (13, p. 68).

SERVICE MATRIX

The service matrix is given as Table 4. Values for each characteristic of an existing or proposed public transport service are converted to equivalent levels of service established in the text. The points of each characteristic are added to determine an overall level of service. A hypothetical analysis of a trip during the peak hour with all seats filled on the Bay Area Rapid Transit System from Concord in Contra Costa County to downtown San Francisco is given in Table 5.

Effect of Weighting

Under the weighting process, a system may offer an overall level of service that is higher or lower than the level of service indicated by an individual characteristic. This is particularly important for existing systems whose geometrics may preclude any remedial action aimed at increasing speed. On some systems, the same route may exhibit a high level of service between a remote station and a downtown terminal and a low level of service between a close-in station and the CBD terminal. This is entirely appropriate, for lower levels of service can be tolerated for short trips.

Multimode Trip

The level of service can be determined for a multimode trip by the use of a weighted average for each characteristic of each mode based on the time spent riding that mode. The time to transfer between the 2 modes and a 5-min transfer penalty are suggested when overall speed is computed. The multimode technique is useful when the quality of access is studied. An example is a comparison of a commuter bus offering local pickup services to a rail transit line that requires users to drive to the station.

CONCLUSIONS

Many of the individual LOTS standards are based on firm findings. The list of selected characteristics is not necessarily complete and is subject to revision. The weighting process is the least firm because of lack of data. Nevertheless, the overall level of service obtained by the application of the weighted values to various existing modes of transit does produce relative rankings that are consistent with the level-of-service concept. (In some CBDs, the level of service of existing transport is very low. However, the user is forced to ride the system because surface congestion and parking costs make the automobile an even worse alternative.) The rankings provide a more precise measure of service, which is the intent of this paper.

Uniform standards capable of quick and easy measurements can assist in selecting a mode for a new service or pinpointing the places along an existing route where inferior service is rendered. The values can be combined with costs to select an option for upgrading an existing service.

A set of uniform national standards of service such as those advocated in the preceding pages appears desirable to facilitate both the daily management and the uniform improvement of public transport. Federal capital assistance programs might then be based on local conditions and a local plan for attainment of appropriate minimal levels of service. Priorities could include upgrading the routes that exhibit the lowest levels of service. Local and other operating subsidies could be based on the maintenance of a specified level of service if the contributing organization finds that LOTS values provide a more rational basis than those now used for monitoring performance.

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