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SEPTA Management Study: Process and Results

James I. Scheiner, Pennsylvania Department of Transportation, Harrisburg

A management study of Philadelphia's Southeastern Pennsylvania Transportation Authority (SEPTA) was completed in May 1978. The study process was designed to quickly focus investigative effort on apparent problem areas by means of a series of diagnostic techniques, including interviews, peer-group analysis, flowcharting, and organizational analysis. The in-depth studies that relied on independent data collection were specially designed to test hypotheses. The study revealed that among the areas where SEPTA performance was strong were rapid-transit crew scheduling, grant applications, employee absenteeism, and short-term investment management. The study identified nine priority areas for improvement: (a) cash handling, (b) Consolidated Rail Corporation's purchase-of-service agreement, (c) surface transit operations planning, (d) vehicle use, (e) surface transit maintenance, (f) capital project management, (g) pension management, (h) quality of transit service, and (i) regional fare integration. Funding agencies should expect large transit agencies to have at least a few serious problems that should be identified and studied by the agency. The number and phasing of improvement activities must be feasible for the transit agency to accomplish.

During the years when transit was predominantly a private enterprise, efficiency was judged by standard profit-and-loss and return-on-investment criteria. Even then, however, there was concern about the effectiveness of transit services. Twenty years ago the National Committee on Urban Transportation published Recommended Standards, Warrants, and Objectives for Transit Services and Facilities (1).

In recent years, as transit has required increased public funding just to keep its head above water, there has been a greater concern about transit efficiency and effectiveness on the part of both transit agencies and the sponsoring governments. The state of California has been particularly active in requiring periodic transit performance audits (2,3). In a policy statement issued on October 13, 1977, the board of directors of the American Public Transit Association (APTA) stated that "There is a universal need for indicators of transit performance" and proceeded to outline key effectiveness and efficiency concepts (4). At the APTA midyear meeting in May 1978, transit performance indicators were a principal topic (5,6). As part of the Urban Mass Transportation Administration's (UMTA) short-range planning requirements, the inclusion of planning to "address methods for improving the efficiency and effectiveness of the operation of the system" (7) has been proposed.

It is against this national backdrop that a management study of the Southeastern Pennsylvania Transportation Authority (SEPTA) was undertaken from April 1977 through May 1978. The SEPTA management study was commissioned by a steering committee of state and local funding agencies because it was "the desire of the elected officials to be assured that SEPTA provides the most efficient services possible in relation to the investment by the various sources of financial assistance. The management consulting team was led by Booz-Allen and Hamilton.

DESCRIPTION OF THE SEPTA ORGANIZATION

In 1964, Pennsylvania State Act 450 created SEPTA to provide for integrated mass transportation services in the five-county Pennsylvania portion of the Philadelphia metropolitan area. The act established an 11-member

SEPTA board of two appointed representatives from each county plus one state appointee. On September 30, 1968, SEPTA took over the transit operations of Philadelphia Transportation Company, which served the city. On January 29, 1970, SEPTA took over the transit operations of Philadelphia Suburban Transportation Company, which served Delaware County. These units were renamed City Transit Division and Red Arrow Division, respectively. SEPTA took over a small transit operator in Montgomery County on March 1, 1976, and changed its name from Schuylkill Valley Lines to Frontier Division.

Today, the SEPTA divisions operate almost 1500 buses and over 100 trackless trolleys on surface transit routes. SEPTA also operates two rapid-transit lines that require more than 350 cars and about a dozen light rail, subway, and surface lines that require about 300 light rail vehicles (LRVs). In total, SEPTA has an active fleet of almost 2300 transit vehicles.

In addition to its operating responsibility, SEPTA administers a purchase-of-service contract with the Consolidated Rail Corporation (Conrail) to provide regional commuter rail service; Conrail runs over 400 city- and SEPTA-owned commuter rail cars. Purchase-of-service contracts are also administered with several small bus companies operating in suburban counties.

To carry out its responsibilities, SEPTA is organized as shown in Figure 1. Nine divisions and departments report directly to the general manager, but 6800 employees, or about 93 percent of the total, work in the transit operations department.

On a typical weekday, the SEPTA system averages about 800 000 passenger trips, to which the Conrail commuter rail system adds approximately 240 000. Although annual transit revenue for 1978 approximates \$95 million and Conrail collected another \$30 million in commuter rail revenue, these revenues do not begin to cover operating costs, which were at the \$255 million level for 1978. SEPTA deficit funding is provided by UMTA, the Pennsylvania Department of Transportation (PennDOT), the city, and the four suburban counties. Each SEPTA transit division, as well as the commuter rail operation, is supported by a different mix of funding. For 1978, SEPTA's total operating deficit of just over \$130 million was covered by 40 percent federal funds, 40 percent state funds, 15 percent city funds, and less than 5 percent suburban counties funds.

SEPTA MANAGEMENT STUDY PROCESS

A transit agency performs many functions that increase in number in a large multimodal operation such as SEPTA. The first step in the management study was to narrow the focus of inquiry through a series of diagnostics.

Interviews were used to ascertain perceptions of problems from both inside and outside the SEPTA organization. As a result of the interviews, investigation of the Conrail purchase-of-service agreement was added to the work effort, and emphasis was placed on review of SEPTA's use of professional services.

Peer-group analysis proved to be the most contro-

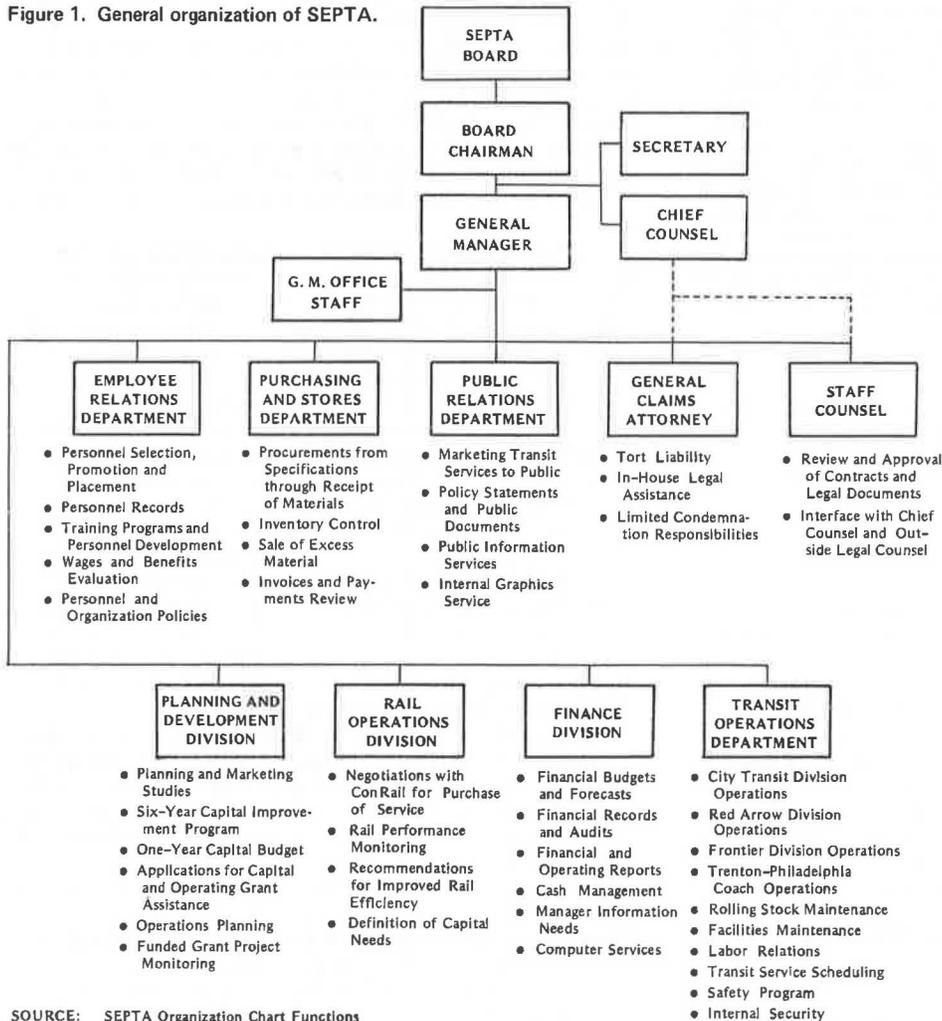
versial diagnostic technique. SEPTA operating data were compared with a composite transit system formed by averaging the data from nine other systems, as shown in Table 1. As a diagnostic, the peer-group analysis was useful and led to detailed investigations in such areas as road calls and vehicle use. It also suggested that there were personnel shortages in finance and public information. Exclusive reliance on peer-group data for

conclusions is inappropriate, and this was cautioned against in the study.

Flowcharts were employed to outline the process by which key functions were being carried out in SEPTA. These proved especially valuable in analyses of cash handling and operations planning.

Organizational analysis, in which functional responsibilities and span-of-control issues were examined,

Figure 1. General organization of SEPTA.



SOURCE: SEPTA Organization Chart Functions added by review of SEPTA internal documents and interviews.

Table 1. Summary of statistics for SEPTA peer group.

Item	City						Transport of New Jersey	Port Authority Trans-Hudson ^a	Port Authority Transit Company ^b	Average	SEPTA
	Baltimore	Chicago	Cleveland	Montreal	Pittsburgh	Toronto					
Active vehicle fleet											
Buses	960	2 400	947	2 004	928	1 225	1 926	0	0	1 484	1 463
Trackless trolleys	0	0	0	0	0	151	0	0	0	151	112
Streetcars	0	0	55	0	95	358	30	0	0	135	343
Rapid transit	0	1 100	116	357	0	494	0	298	75	407	377
Total	960	3 500	1 118	2 361	1 023	2 228	1 956	298	75	2 177	2 295
Employees											
Hourly	1 894	11 971	2 070	5 470	2 429	6 583	2 907	939	173	3 826	5 819
Salaried	184	740	498	1 423	434	1 342	756	88	110	619	950
Total	2 078	12 711	2 568	6 893	2 863	7 925	3 663	1 027	283	4 445	6 769
Average weekly total passengers	1 975 700	11 750 000	2 453 750	6 223 850	2 032 380	11 580 000	2 077 150	801 160	212 000	4 345 110	4 975 310

^aNew York and New Jersey.
^bDelaware River.

was also employed as a diagnostic technique. This technique was particularly useful in dealing with risk management and capital program activities.

After this series of diagnostics was applied, hypotheses were formed concerning the need for improvements in key functional areas. Then specific plans for detailed investigation were developed to test these hypotheses. For example, one hypothesis was that SEPTA had reduced spare-parts inventories to dangerously low levels during a recent budget-cutting cycle. To test this hypothesis, the inventory control cards of 100 items were examined at random. Of these, 51 had been repeatedly out of stock and were then traced through to their impacts on vehicle downtime.

In many cases, it was determined that independent data collection was needed to test hypotheses. One potential pitfall of management studies is to examine only the data the agency provides. If these data are incomplete or faulty, incorrect judgments may be made by the study team.

RESULTS

The study's final report contained a summary of the most important findings and improvement activities developed in five detailed interim reports. For some functions, such as rapid transit crew scheduling, federal and state grant applications, employee absenteeism, and short-term investment management, SEPTA performance indicators were well above average. For several other functions, such as financial management, claims handling, purchasing of noncapital items, and subway-car maintenance, SEPTA management was found to be doing a competent job, notwithstanding some shortcomings in each area. In nine functional areas, however, serious deficiencies that adversely affect SEPTA performance were identified. Each of these deficiency areas is summarized below and given specific improvement objectives.

Cash Handling

Problem

SEPTA cash-handling security is among the poorest in the transit industry. Obsolete equipment is a major contributing factor to this situation. However, even those transit systems that still use old equipment have taken security precautions not to be found at SEPTA.

Improvement Objectives

SEPTA should establish and adhere to a schedule that would result in operational registering fare boxes at all depots except Allegheny by March 31, 1980. Concurrently, SEPTA should initiate a capital procurement to convert the Allegheny depot and the rapid-transit stations to registering fare-collection equipment by 1982. In the meantime, SEPTA should implement specific procedural changes to tighten the security of the existing fare-collection system.

Conrail Purchase-of-Service Agreement

Problem

In the past two years, during the transition from private railroad to Conrail operation, commuter rail unit operating costs have increased by 45 percent. Initially, commuter rail deficits were absorbed primarily by the federal government, but, beginning October 1, 1978, 50

percent of the deficit amount was paid by state and local governments.

Conrail is not providing SEPTA with the data to adequately certify the propriety of charges, which has led to a contingent liability situation for state and local funding agencies. A recent study, commissioned by SEPTA, concluded that Conrail was overcharging SEPTA by improperly applying Rail Services Planning Office (RSPO) cost allocation standards and making erroneous computations. SEPTA and Conrail report that they have jointly selected a consultant to examine commuter rail efficiency, but this study does not have the benefit of a funding agency.

Improvement Objectives

The critical action that was to be accomplished in 1978 was to get SEPTA, Conrail, and the funding agency to agree on commuter rail cost items and computational techniques and thus to make full use of consultant studies. As a target, commuter rail operating costs for the fiscal year ending June 30, 1979, should be budgeted not to exceed costs for the current fiscal year, with savings identified to fully offset inflationary effects. By early 1979, implementation of commuter rail efficiency study recommendations should have begun, the goal being to stabilize commuter rail operating costs for the succeeding fiscal year as well.

Surface-Transit Operations Planning

Problem

For the past decade, SEPTA surface-transit routes and schedule input data have undergone relatively little change. SEPTA does not have a current data base from which to develop a well-focused annual schedule work program to adjust or completely remake schedules as necessary. Given the current capabilities of the scheduling department and the lead times required to develop schedules, the department has a chance to develop only one solution with general budget guidance from top management.

Improvement Objectives

SEPTA should fine-tune 10-15 surface transit routes each quarter over the next three years with an eye to reducing costs in ways imperceptible to most passengers. As an initial program goal, fine-tuning should be targeted to save \$12 million in annual operating costs by the end of the third year.

This does not mean that there is this amount of waste in the system; at least some cuts will inconvenience small groups of passengers. This savings goal may be adjusted upward or downward as the program progresses, but it is important that the operations planning effort be provided with clear fiscal guidelines. Computer assistance should be gradually introduced into scheduling to relieve schedulers of routine chores.

Vehicle Use

Problem

SEPTA's vehicle-related statistics (kilometers per vehicle, kilometers per road call, kilometers per unit of fuel and oil consumption) are among the lowest in the industry. In part, this reflects SEPTA's lack of precision in defining what operational vehicles are and who is responsible for them. Although SEPTA's aggregate per-

centage of surface transit spares is high, it reported a shortage of buses for fall 1977 schedules because of buses assigned to streetcar and trackless trolley routes.

Improvement Objectives

SEPTA should immediately prepare a vehicle inventory to categorize all vehicles in the system into an active, reserve, or rehabilitation fleet status by depot. Based on this inventory, quarterly use reports should be submitted to the board and funding agencies to show distance, days unavailable for revenue service, and other data specified in the management study. Analysis of these data will enable SEPTA to retire the worst vehicles from its fleet and should lead to improved fuel- and oil-consumption rates.

Surface Transit Maintenance

Problem

SEPTA's practice of assembly-line unit overhaul after the failure of just one component may have had some justification in the early 1970s, but it is no longer a cost-effective approach to major maintenance. The failure to keep distance records on overhauled components is a serious deficiency that prevents program evaluation and hinders the scheduling of subsequent component rebuilds. The appearance of the fleet is poor; extensive body damage, loose engine doors, missing battery doors, and interior seat damage compound the unsightliness of widespread graffiti. Transition planning for maintenance of new trackless trolleys and light-rail vehicles is lacking.

Improvement Objectives

By July 1, 1978, SEPTA should have a system in place to analyze breakdown data by vehicle and to track vehicle component distance to failure. As SEPTA proceeds with its vehicle rehabilitation program, each rehabilitated vehicle should require a daily driver's slip to report body damage or vandalism; any unreported damage should be grounds for driver discipline. Personnel freed from bus maintenance as a result of shifting to distance-monitored component rebuilds will be needed to maintain the new trackless trolley fleet and to extend the streetcar rehabilitation program. To support new-technology vehicles, a transition plan is needed to phase in training and tools.

Capital Project Management

Problem

SEPTA takes significantly longer on the average to complete a funded capital project than its counterparts in transit organizations. Projects with funding obligations in 1972 and 1974 are still in various stages of implementation, and a few are still waiting for specifications to be issued.

Improvement Objectives

In April 1978, SEPTA awarded the registering fare-box bid, a milestone in the capital improvement program. By September a contract for surface-transit two-way radio communications should have been awarded. A timetable for implementation of a complete streetcar rehabilitation program that would include maintenance facilities, new light rail vehicles, and track rehabilitation should be prepared to commit SEPTA to key dates.

Although the procurement of Broad Street subway cars is a city responsibility, SEPTA should work jointly with the city to prepare a precise timetable for getting the first new cars into service by the end of 1980.

Pension Management

Problem

For the past several years, SEPTA management has established the modest goal of stabilizing a \$100 million unfunded pension liability. After setting aside restricted funds and reducing the work force, recent increases in the unfunded liability have been relatively small. At the negotiating table, pension increase demands have been valued under the same hold-the-line philosophy. As a result, both SEPTA employees and the funding agencies continue to face uncertainties regarding the sources and expenditure levels for future pension benefits.

Improvement Objectives

SEPTA should present to its board and funding agencies year-by-year pension payout projections, from calculations based on the actual age distribution of participants, of all plans under the current benefit provisions. Plan assets and earmarked income should then be applied against these payouts, by using realistic ranges for economic parameters, to yield annual shortfall estimates. The SEPTA board must make a policy decision, based on these data and the inputs of the funding governments, as to whether further pension benefit increases can be permitted without some participatory arrangement to move toward fully funded plans.

Quality of Transit Service

Problem

Although SEPTA compiles many records within its organization that pertain to quality-of-service measures, there is no top management analysis of trends in this vital performance area. A statistically valid and reliable monitoring system is needed to cover at least the following service-quality factors: missed trips, on-time performance, load factors, safety and security, condition of vehicles, condition of passenger waiting areas, employee courtesy, and public information.

Improvement Objectives

A short (15-page) service-quality report was to be submitted to the SEPTA board and funding agencies to cover the July-September 1978 period, and every quarter thereafter. This report should be laid out so that performance trends can be compared with those of the previous quarter and previous year.

Regional Fare Integration

Problem

SEPTA is going into its second decade as an operating agency without having made significant progress toward regional fare integration, despite the mandate of its 1964 enabling legislation and the repeated requests of funding agencies. An unusual opportunity was missed when SEPTA raised fares in May 1977 without incorporating any fare integration features into the revised structure. Within the commuter rail system, however, there have been successive fare adjustments that have acted to increase pricing uniformity and to improve convenience.

Improvement Objectives

By the end of 1978, SEPTA should be offering monthly passes to transit users within each division, as well as a monthly pass to the passengers who must transfer to 69th Street. A monthly pass good for both commuter rail and transit should also be considered. Because monthly passes are priced in the range of 40 times the cost of a transfer trip, this convenience fare should result in virtually no revenue loss if properly marketed. By the end of 1978, the SEPTA board, with staff technical assistance, was to have adopted a set of regional fare policies to guide the design of an integrated fare system in 1979.

Other Improvement Areas

In addition to the above nine priority improvement areas, many other recommendations were made for improving SEPTA's efficiency and effectiveness. The seven most important of these are summarized below.

1. Street control and supervision: Operators should be required to adhere to intermediate time points as well as to end-of-the-line times. The installation of two-way radios in the surface-transit fleet is critical to improving street control.

2. Passenger security: The Philadelphia police department is doing a good job of apprehending criminals on transit, and the city's department of public property is pursuing capital improvements for subway security. SEPTA should play a role in coordinating security programs and improving customers' security perceptions.

3. Sole-source procurements and inventory management: SEPTA bidders' lists and specifications should be more broadly drawn to encourage competitive bidding. Across-the-board inventory cuts are creating shortages of items needed to keep vehicles on the street.

4. Cashier handling: That SEPTA's commitment of peak-period cashier augmentations is not always justified was shown by independent station queue-length observations. On a weekly basis for the Broad Street subway only, it would appear that about 300 cashier-hours could be saved, without appreciably reducing service, for an annual savings in the \$130 000 range.

5. Service contracts: Annual savings of \$80 000 are achievable, without detriment to current activities, through consolidation of electronic data-processing contracts. SEPTA spends a relatively large amount for outside legal services: 1977 outside general legal fees were \$450 000, about \$200 000 more than a reasonable SEPTA target. Ongoing activities, such as the extended Conrail negotiations, should be high priorities for transfer to in-house counsel. SEPTA independent auditing and marketing expenditures are relatively low, and increases may be justified to support expanded activities.

6. Investments and receivables management: Although SEPTA's finance department is doing about as well as could be expected in these areas, given its staffing level, additional staff for investments and receivables should more than pay for themselves. In the area of investments, intensive management would allow another \$5-\$10 million to be put into government securities. These yield a \$100 000 annual income gain to SEPTA. There is also the opportunity to reduce error rates on receivables to a level that would protect against tampering with the accounts.

7. Risk management: Although SEPTA's claims department has done a good job relative to trend, there is potential for reducing insurance and claims cost through an aggressive risk-management program. Risk management would encompass those functions now scattered

throughout the SEPTA organization: safety programs, insurance coverages, workmen's compensation claims, and claims for injury and damages.

To support these improvement actions, the following specific organizational changes were recommended for first-year implementation.

An internal audit group should be created to report directly to the board and be responsible for in-house as well as contracted audits. The scheduling section should be relocated in the planning and development division and should have increased access to computer facilities. The three engineering sections should be centralized into one engineering department headed by a chief engineer and reporting to the general manager. A director of passenger security programs should be established to initially report to the general manager and to work under a joint city-SEPTA board policy committee. Finally, a risk manager should take responsibility for all insurance coverages, safety programs, accident analyses, and claims handling.

All major improvement activities were pulled together in concise, readily understandable narrative, then phased over the succeeding two years on a quarter-by-quarter basis. The resulting milestone schedule can be used as a checklist for noting accomplishments. The list below displays excerpts from the milestone schedule.

1. April-June 1978 milestones:
 - a. Award registering fare-box contract (accomplished by SEPTA),
 - b. Complete study of Conrail commuter rail charges under RSPO standards (accomplished by SEPTA),
 - c. Collect operating data on the initial 10-15 routes designated for fine-tuning, and
 - d. Prepare a SEPTA revenue vehicle inventory, by depot, that classifies all vehicles into an active, reserve, or rehabilitation status.
2. July-September 1978 milestones:
 - a. Complete a program of near-term, low-cost, cash-handling security improvements as recommended in the management study,
 - b. Achieve agreement by Conrail, SEPTA, and the funding agencies on commuter rail cost items and computational techniques,
 - c. Complete route profiles and proposals on the initial 10-15 routes and start data collection on the next set, and
 - d. Gather vehicle-use data as specified by the management study and submit monthly use reports during this quarter.
3. October-December 1978 milestones:
 - a. Commission an independent audit of cash-handling procedural improvements,
 - b. Cut schedule changes based on initial 10-15 route profiles and proposals (after public hearings, if necessary), complete second set of profiles and proposals, and begin data collection on the third set,
 - c. Convert to a quarterly vehicle-use report for this quarter and thereafter,
 - d. Award contracts for shop and garage equipment capital items that will improve maintenance efficiency, and
 - e. Identify maintenance cadre responsible for new trackless fleet and schedule manufacturer-sponsored industry and in-house training courses.

LESSONS LEARNED

The specific findings of the SEPTA management study cannot be generalized. SEPTA's improvement areas are unique to SEPTA; another transit system may perform well in a functional area of great concern to SEPTA but need improvement in an area of strong performance by SEPTA.

There are, however, some attitudes and procedures apparent from the SEPTA study that should have general applicability.

Funding governments can expect transit agencies, particularly those serving the larger cities, to have at least a few serious problems. Running a transit agency is an extremely difficult enterprise.

Modest cost increases lead to substantial deficit increases if revenues do not grow. Change is hard to effect, given strong unionization and the habits of transit riders. Public financial assistance results in red tape and pressures to undertake projects that exacerbate deficits. As a service well used by the young and the poor, transit is prone to security problems. In this environment, it would be highly unusual for a big-city transit system to be problem free. In order for a transit management study to be properly evaluated, funding governments must have an appreciation of these inherent difficulties.

Management studies are more effective if transit agencies recognize problem areas and enlist study efforts to develop solutions. These studies run contrary to human nature. People who work in an organization may be apprehensive during the course of a management study and defensive in review of study findings. These reactions are normal and should not reflect on either the employee or the study effort. Such responses can be attenuated by the transit agency's definition of its own problems, by placing the study team in a problem-solving capacity. However, the problems defined must go beyond general types, such as needing more money, to specific difficulties that can be improved through management action.

Diagnostic tools of themselves are not strong enough to support definitive conclusions. Peer-group analysis is a particularly controversial diagnostic tool. Peer-group statistics alone should never be the sole basis for a study finding. What the analysis can do, however, if carefully applied, is to focus detailed study efforts on critical areas. Other diagnostic tools, such as interviews, flowcharting, and environmental analyses, are similarly unreliable as the sole basis for conclusions.

In-depth research is needed for each suspected problem area and often requires independent data collection. After diagnostics are used to form hypotheses, in-depth

research tasks should be specially designed to test these hypotheses. There is no cookbook approach to this phase of a management study; the work must be tailored to fit the situation. One possibility that cannot be overlooked is that management is making the wrong decisions based on erroneous data. In these cases, independent data collection can provide a new perspective for management.

The improvement program resulting from a management study must be digestible in terms of both feasibility and phasing of improvement objectives. A management study that concludes with 118 shotgun recommendations is generally not very useful. Recommendations should be focused, prioritized, and phased into an implementable improvement program. This is not to say that each activity will be easy to accomplish or that all activities will be completed on schedule, but only that, as a program, it appears to be within the limits of management's capabilities.

REFERENCES

1. National Committee on Urban Transportation. Recommended Standards, Warrants and Objectives for Transit Services and Facilities. Public Administration Service, Chicago, 1958.
2. Peat, Marwick and Mitchell. Transit Operators Performance Audit Guide. Comprehensive Planning Organization of the San Diego Region, July 1976.
3. Financing and Evaluating Public Transit Systems in California: Report of the Office of the Auditor General to the Joint Legislative Audit Committee. California Office of the Auditor General, Sacramento, 1977.
4. American Public Transit Association. Policy Statement: Transit Performance Indicators. Oct. 13, 1977.
5. D. H. Goss. System Performance Indicators—The Need for Action Is Now! Presented at American Public Transit Association Mid-Year Meeting, Houston, May 18, 1978.
6. W. C. Underwood. Performance Indicators—A Necessary Management Tool? Presented at American Public Transit Association Mid-Year Meeting, Houston, May 18, 1978.
7. C. H. Graves. A Preliminary Proposal to Improve the Review of Short-Range Planning Activities. UMTA Memorandum, Dec. 14, 1977.

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Impact of the 1977 Transit Strike in Knoxville

Frederick J. Wegmann and Arun Chatterjee, Department of Civil Engineering, University of Tennessee, Knoxville
 Samuel Parnell, Knoxville Department of Traffic Engineering
 G. Lindstrom Welch, Metropolitan Atlanta Rapid Transit Authority

The six-week strike from February 14 to March 28, 1977, of the Knoxville Transit Corporation (KTC) stranded 7000-8000 daily riders of regu-

lar bus routes and 600 daily riders of the express bus service. It also provided an opportunity to assess the impact of a temporary interruption of

public transportation service on a city of 200 000 people. Small sample surveys performed during and after the strike focused on those groups expected to be most severely affected. The study revealed that, although many discretionary trips of elderly and economically disadvantaged transit users were not taken, few cases of severe hardship were reported. Most individuals were able to satisfy their needs with the help of relatives, friends, and social service agencies. Many of the downtown merchants lost substantial business, and some were forced to temporarily lay off sales personnel. The transit system itself felt the most adverse and continuing impact from the strike. The decline in ridership on the regular routes was estimated to range from 7.2 to 16 percent; for express buses the ridership dropped by approximately 15 percent. The adverse impact on downtown parking was noticeable, but general traffic was not affected appreciably. Overall, everyone involved with public transportation—the city, labor union, transit users, and downtown merchants—would have been better off by averting the strike.

One question confronting many small and medium-sized cities today is what role public transportation ought to play in meeting the mobility needs of individual citizens. While transit operating costs continue to rise but fare revenue usually covers less than 50 percent of total costs, public decision makers are raising questions about the nature and extent of community benefits derived from public transit.

It is difficult to directly measure the benefits of public transit. However, an indirect approach is to examine the consequences of an interruption of service. Several hypothetical questions can be raised: How do citizens respond if transit service is no longer available, even on a temporary basis? What impact does this have on individual mobility? What is the impact on the total transportation system?

The six-week strike (February 14 to March 28, 1977) of the Knoxville Transit Corporation (KTC) stranded 7000-8000 daily fixed-route bus riders and 600 daily express riders (1). It provided an interesting and realistic opportunity to assess the impact of a temporary interruption of transit service on a medium-sized city.

Although transit service in Knoxville carries less than 3 percent of the total daily trips made, a recent transit planning study, the Transit Development Program, concluded that 84 percent of the riders on the fixed-route system could be classified as transit dependent. These individuals either possess no driver's license (60 percent of riders), own no automobile in the household (47 percent of riders), or have no automobile available at the time of a transit trip (61 percent of riders). It is also noteworthy that 22 percent of the riders are elderly, and 31 percent of the riders have annual household incomes (in 1976) of less than \$3000. It was feared that the loss of transit service might cause severe hardships to those individuals least able to make adjustments.

The impact of a transit strike also could spread to the business community. Employers might lose workers unable to commute and merchants might lose customers. Other institutions might have their operations hampered because of inability of users to gain access to their services. Activities in the central business district (CBD) might be adversely affected because more than 20 percent of daily transit trips were identified as ending in the CBD.

Express bus users, most of whom are riders by choice, might create a different situation. All express buses converge on the CBD at 7:45 a.m. and 4:45 p.m. each day. If riders shifted from the 13 KTC express buses, they could bring 300-500 additional automobiles into the already congested downtown area. All-day storage of these vehicles might further aggravate the downtown parking situation.

The object of this study was to identify the impact of the six-week transit strike on

1. Travel behavior and modal choice decisions of individuals representing major transit user groups,
2. Ridership and revenues of KTC,
3. Other suppliers of transportation services,
4. Traffic volumes and the use of downtown parking, and
5. Selected businesses, institutions, and employers.

The impact study was initiated when the transit strike began. Therefore, descriptions and data concerning prior conditions were based on secondary sources. Some impact data could not be obtained in precise and quantifiable form. For instance, because specific records either were not available or were proprietary in nature, effects on the business community were described in terms of general estimates.

Telephone surveys were used to collect as much information as possible from former transit users throughout the strike, but many transit dependents had no telephone access. Therefore, sampling procedures could not be used. Major emphasis was placed on interviewing individuals residing in housing clusters where large numbers of transit riders were known to reside.

It must be remembered that this research dealt with a temporary interruption in transit service, so impacts may not reflect long-term effects in many cases.

SURVEY AND DATA-COLLECTION PROCEDURES

In order to obtain current information, surveys were conducted during and immediately after the strike. The basic strategy was to identify and focus on users and institutions most likely to be affected.

Transit Users

Information on the strike's impact on transit-user households was obtained through telephone interviews and mailed questionnaire surveys during and after the strike. A transit-user household was defined as one having at least one individual who usually made at least one transit trip per week. The following segments were targets for the surveys:

1. Elderly (age 65 and over) living in public and private senior-citizen complexes,
2. Economically disadvantaged transit users living in public housing,
3. Regular transit users selected at random from individuals residing in areas of known high transit ridership, and
4. Express bus commuters working in the CBD area (largely middle-income, choice transit riders).

The survey was designed to gather information from each household on (a) use of KTC service before and after the strike for trip purposes; (b) changes, if any, in travel characteristics during and after the strike; (c) transportation modes used as substitutes during the strike; (d) reasons for continuing to use other modes after the strike and the likelihood that such changes would continue; (e) difficulties, inconveniences, and hardships caused by the strike; and (f) basic demographic characteristics of the selected group.

The surveys for the elderly, poor, and regular transit riders were conducted by telephone, and the sample sizes for these groups were 101, 100, and 50, respectively. After the strike 50 percent of the same households were contacted again. The express bus commuters of the Tennessee Valley Authority (TVA) were contacted by mail questionnaires.

Merchants, Employers, and Institutions

During and after the strike personal interviews were conducted with owners or managers of establishments whose employees and clients relied on public transit as a primary mode. The main focus was on those establishments in the CBD expected to be most severely affected. Larger manufacturers outside the CBD also were surveyed.

Automobile Users

Secondary data sources, such as volume counts, vehicle occupancy counts, parking lot inventories, and pedestrian counts, were used to ascertain the degree to which former transit riders switched to automobile transportation and how this change affected traffic congestion and parking availability. The study focused on traffic arteries leading into the CBD and on use of parking space in the CBD and fringe areas.

Transportation Operators

Personal interviews were conducted with transportation suppliers, such as private bus companies, taxi companies, social service agencies, and the Knoxville Transportation Brokerage Service, to obtain information on transit use. In addition, detailed data were compiled on KTC ridership and revenue for several weeks before and after the strike.

SURVEY RESULTS

The purpose of the telephone survey was to determine the impact of the transit strike on the four categories already mentioned. Although these categories may be expected to have different socioeconomic characteristics, an analysis of their demographic profiles revealed that, except for express bus riders, characteristics were similar in many respects.

Category 1: Elderly Living in Senior Citizen Housing

The elderly group consisted of 101 households comprising 121 people. More than 85 percent of those interviewed were women. All who answered the income question had an annual income of less than \$5000; 80 percent of the households had one member, and the remaining 20 percent were two-member households. More than 90 of the households had no operating automobiles, and 81 percent had no member with a driver's license.

Impact on Travel

Before the strike, the elderly group averaged 2.11 trips per household per week by transit or 1.76 trips per person per week. The main uses of transit were for shopping, medical reasons, and personal business. Other uses were visits to friends and relatives, religious-purpose trips, travel to work, and trips for leisure and recreation.

More than 32 percent of their normal trips were cancelled during the strike. The trips most frequently cancelled included those for religious purposes, visits to friends and relatives, leisure and recreational trips, and personal business trips.

Nondiscretionary travel still was made for shopping, medical, and work purposes. The alternative modes of travel used most frequently were either riding with

family and friends or traveling by taxi. Notably, almost 18 percent of the trips made by the elderly households were by social service vehicles. A portion of the sample group indicated that pride and a sense of dignity kept them from calling on friends and relatives for transportation unless it became a necessity.

Post-Strike Travel Behavior

When asked during the strike if they would return to using the bus when the strike was settled, 100 percent indicated that they would. Yet five weeks after the strike was settled, six individuals, or 12 percent of the 50 households contacted again after the strike, had not returned to using the bus as frequently as before.

Economically Disadvantaged Households Living in Public Housing

A total of 100 economically disadvantaged households with at least one regular transit rider were contacted by telephone. More than 90 percent of the respondents were females, but all respondents spoke on behalf of the entire household. The ages of these individuals interviewed were 45 years or older. Of those reporting income, 90 percent had family incomes of less than \$5000 per year.

Forty-four percent of the economically disadvantaged individuals interviewed lived alone, 24 percent lived in two-member households, and the remaining 32 percent lived in households varying in size from three to eight members. Only 28 percent of the households had members commuting to work regularly.

Impact on Travel

The economically disadvantaged group indicated that before the strike they had averaged 3.27 trips per household per week by transit, or 1.60 trips per person per week. The most frequently mentioned trip purpose (75 percent of the households) was shopping. Forty-three percent of the sample reported using the bus to conduct personal business and 11 percent to commute to work. Other transit trips were for medical purposes, school, visiting friends and relatives, leisure and recreation, and religious purposes.

The economically disadvantaged group did not make 11 percent of their usual trips when transit service was not available. The trips most frequently eliminated were those for religious purposes, visits to friends and relatives, and leisure and recreation. Thus, a larger segment of the economically disadvantaged group than of the elderly group maintained their usual mobility. The trips that were made most frequently, in spite of the loss of public transportation service, included shopping, work, medical, personal business, and school and were made with a friend or relative. About 15 percent of the trips were made by taxi; another 8 percent were made by social service vehicles.

Post-Strike Travel Behavior

When interviewed during the strike, 99 percent of the households indicated that they would return to using the KTC buses when service resumed. Four weeks after the bus service was reinstated 84 percent of the 50 households contacted again had returned to pre-strike bus use.

General Transit Users

A telephone interview survey of 50 randomly selected

households in residential areas near bus routes was performed to determine the impact on general transit users, that is, users out of choice, not captive riders. However, a large proportion of this group also was found to be transit dependent; 86 percent had an annual family income of less than \$5000.

Thirty-five percent of the households contacted in this sample were single-member households, 47 percent were two-member households, and the remaining 18 percent were three-member households. Forty-one percent of the households reported having regular commuters.

Car ownership for this group was higher than that for elderly and economically disadvantaged groups: 26 percent had one operating car and 8 percent had two operating cars.

Impact on Travel

The general transit-user group indicated that before the strike they averaged 3.01 transit trips per household per week, or 1.62 trips per person per week. Transit trip purposes mentioned most frequently were shopping and work. This group contained a greater proportion of commuters than did the elderly and economically disadvantaged groups. Other transit trips included personal business, medical, school, and visits to friends and relatives.

The general transit-user group cancelled 10 percent of their normal trips, primarily those for shopping, work, and personal business. The most frequent alternative means was traveling with a relative or a friend. Eight percent of the households traveled alone in their own cars for trips that would have been made by bus. No use of social service vehicles was mentioned by this group, and a shift to travel by taxi was not reported.

Post-Strike Travel Behavior

When asked during the strike if they would return to using the bus when the strike was settled, 100 percent of the respondents indicated that they would. Yet five weeks after the strike was settled, 40 percent of the households that were contacted again were not using transit service as frequently as before the strike.

Commuter Travel by Tennessee Valley Authority Employees

During the transit strike, 259 out of an estimated 600 TVA employees using the KTC's express bus service completed a mail questionnaire about their travel modes to work. TVA personnel could be characterized as highly mobile and choice transit riders.

The analysis of these questionnaires revealed that 35 percent had formed carpools of three or more members, 28 percent were driving with one other individual, and 29 percent were driving alone. Five percent of the sample were able to use one of the private express buses that operated during the strike. It is interesting to note that the 600 TVA employees denied their usual bus service only caused an increase of about 300 vehicle trips. Unlike the other groups of transit users discussed earlier, TVA employees used carpooling as the predominant substitute for KTC express bus service.

Regardless of the substitute travel mode selected, the main complaint was the added travel expense. Problems frequently mentioned were that the new travel arrangements caused parking problems, were inconvenient, or were more time consuming. More than 90 percent said they would return to the bus when

service resumed; 5 percent were uncertain; and 4 percent expressed full satisfaction with their substitute modes of transportation.

Summary of the Experience of Transit Users

During the transit strike, the elderly living in senior-citizen complexes cancelled 32 percent of the trips they normally would have made. The economically disadvantaged and the general transit-user groups had to cancel only 11 and 10 percent of their normal weekly trips. The main alternative mode of transportation for these three groups was driving with relatives or friends.

The elderly group used taxi service for more trips (18 percent) than either of the other two groups. The elderly and economically disadvantaged relied on social service vans for transportation during the strike to the extent of 9 percent of all elderly group trips and 7 percent of all economically disadvantaged group trips.

Most of the nondiscretionary trips such as shopping, medical, personal business, school, and work trips were completed during the strike by all three groups. However, the elderly and the economically disadvantaged did not make many of their normal religious-purpose, social, and leisure and recreational trips.

Few cases of severe hardship were found among these three groups. Those finding the greatest difficulties were school children and domestic workers who normally used the bus to travel to and from school and work. Of all the households belonging to the three groups contacted after the strike, 8 percent indicated that they had found new modes of travel more convenient than the bus.

TVA express bus riders compensated for the loss of bus service by using other ride-sharing modes (carpools, private bus lines, etc.). Only 29 percent elected to drive alone in their own vehicles.

IMPACT ON REGULAR AND EXPRESS OPERATIONS

Two major impacts of a transit strike are on transit patronage levels and on the financial condition of the transit operation. Because of the different characteristics of the regular and express bus programs, these two services were analyzed separately.

Effect on Revenue of KTC Regular Routes

Ridership headcounts taken by bus drivers after the strike on regular KTC routes were found inaccurate and could not be used for analysis. The impact of the strike on patronage of regular bus routes could therefore be analyzed only in terms of revenue. The comparison of weekly revenues just before and after the strike was not sufficient because of possible seasonal fluctuations within a year. To identify seasonal variations, the weekly revenue data for the previous year (1976) were examined. Two additional sources of variations had to be taken into account: Service hours were reduced when the transit service resumed, and the fare was increased two weeks later.

Reliable information about the impact of the fare increase on ridership was not available. In the revenue analysis performed as a part of the Transit Development Program, a price elasticity value of -0.3 was used. This means that the 33 percent overall increase in fare on regular routes reduced ridership by 10 percent. However, telephone interviews with transit

users indicated that the fare increase had minimal impact, which makes a 10 percent decrease seem high.

To avoid any bias, a second estimate of the impact on revenues was derived. As the conservative estimate, the effect of the 33 percent fare increase was assumed to cause a 10 percent drop in ridership (an overall 20 percent increase in revenue). For this estimate the post-strike weekly revenues for the weeks after the fare increase, therefore, were reduced by dividing by the factor 1.2. For the second estimate, it was assumed that the fare increase had no effect on ridership and the post-strike weekly revenues after the fare increase were reduced by dividing by the factor 1.33.

The effect of reduced service hours was ignored for two reasons: First, pre-strike ridership during the period from 9 p. m. to midnight was extremely low, and, second, the post-strike telephone interviews found few cases in which frequency of transit use actually decreased with service reduction.

To identify the strike's effect, the average of the adjusted weekly revenues for a seven-week period after the strike was compared with the average for a six-week period before the strike. The post-strike period selected began three weeks after the strike was settled. The three-week period immediately after the strike was considered an adjustment period for transit users. Average weekly weekday revenues for the post-strike period were found to be 11.3 percent and 19.9 percent lower than the corresponding values for the pre-strike period according to the conservative and maximum estimates, respectively. However, an adjustment was made to reflect probable seasonal variations because the revenue comparison with 1976 revealed a difference of 3.9 percent. Considering this variation, the net decreases in revenue for weekdays due to the strike were 7.4 percent and 16.0 percent, respectively, according to conservative and maximum estimates. Similar calculations were completed for the weekend revenues. Considering the weekend increase in revenue of 4.0 percent during 1976, the net decreases in revenues for weekdays due to the strike were found to be 5.3 percent and 15.0 percent, respectively. Based on the combined figures of weekday and weekend revenues, the net reduction of revenue from KTC's regular service attributable to the strike was estimated to be in the 7.2-16.0 percent range.

Effect on KTC Express Bus Ridership

Unlike the case of regular KTC routes, accurate headcounts were available for the express bus routes. Therefore, no adjustments were made to the actual ridership for the increase in express bus fare from 50 to 60 cents per ride. Based on trip purpose and the income characteristics of the express bus riders, demand was considered to be highly inelastic with respect to fare. Also, it was assumed that the express bus riders did not go through an adjustment period immediately after service was resumed.

The average weekly ridership for 10 weeks after the strike was compared with that for 6 weeks before the strike. The post-strike ridership was found to be 22.1 percent lower than the average pre-strike ridership. A comparison of the ridership for the same two time periods during 1976 shows that average weekly ridership for the 10-week period from week 13 through week 22 of 1976 was 7.2 percent less than that for the first 6-week period. If this difference can be attributed to seasonal fluctuation in transit use, the net decrease due to the strike is 22.1 - 7.2, or 14.9 percent.

Overall Impact on KTC Revenue and Ridership

The analysis just presented indicates the adverse impact of the transit strike on the revenue generated by the regular and express KTC routes. Although the analysis was carried out for a relatively short time, (10 weeks after resumed service), the decline in revenue attributable to the strike appeared to continue and to vary in magnitude from week to week.

If the decline in ridership is indeed permanent, the long-range loss in revenue could be large, depending on the time allowed for analysis. However, future events are inherently uncertain, so it is difficult to ascertain how long the loss of revenue will continue. To the extent that the lost riders do not return, there will be a latent permanent loss, even if new riders appear.

In addition to the potential loss, revenue during the 6 weeks of the strike was lost totally. This loss, estimated to be \$158 000, was accompanied by savings in operating costs estimated to be \$228 000. This gives a net savings in operating costs of approximately \$70 000 during the strike, but such savings will be offset by the estimated permanent loss in revenue. However, the ridership trends and characteristics of users in terms of the return of lost riders must be monitored if definite conclusions are to be drawn.

IMPACT ON OTHER TRANSPORTATION SUPPLIERS, PARKING, AND TRAFFIC VOLUMES

The transit strike meant that more than 7000 daily KTC riders had to find alternate modes. Such a large and sudden shift in travel modes could easily have surpassed the capabilities of private bus and paratransit operators and could have increased automobile traffic and parking problems.

Transportation Suppliers

Interviews were conducted with 5 private bus operators, 13 taxicab companies, and several social service agencies to determine the impact on their operations of the 6-week KTC strike.

In general taxi operators and bus operators did not encounter any significant increase in business from the strike. The larger taxi firms did receive some additional business, but it was far below their expectations. Smaller firms did not benefit from the strike, which can be attributed partly to their limited operations and inaccessibility by telephone.

A number of private and publicly supported social service agencies provide transportation for special needs. The strike caused a significant increase in demand that in certain cases far exceeded agency resources. These situations were usually handled by maintaining or tightening eligibility requirements for services and by making other informal arrangements.

Parking and Traffic Volumes

One consequence of a transit strike that can be expected is an increase in automobile use and parking demand. Most public-transit routes in Knoxville are oriented to the CBD, where parking supply relative to demand is lower than that in other areas. Therefore, it was expected that any impact on parking would be felt in the CBD. Surveys were conducted during and after the strike to identify any increase in parking de-

mand in the CBD area that might be attributable to the strike.

These surveys identified certain impacts that can be related to the transit strike. One noticeable change was increased use of downtown parking spaces, most of which were long-term parking lots near the TVA complex. TVA is the major employer in downtown Knoxville.

Pedestrian counts suggested an increased use of free curb parking in the Fort Sanders residential area adjacent to downtown. Revenues from on-street parking meters also increased, because long-term parkers used fringe metered areas and because short-term parkers were squeezed out of off-street parking lots by commuters. A number of merchants indicated that their patrons complained about the difficulty of finding parking spaces during the strike. Surprisingly, the Coliseum parking complex, a large low-cost parking garage located a kilometer (0.5 mile) from the CBD and about 1.5 km (1 mile) from the TVA office, showed no noticeable increased use.

No noticeable increases in vehicle traffic volume were identified. However, increased vehicle occupancies were observed during the peak periods on major roadways. The parking and traffic volume study suggested that the strike did add to the burden of an already overtaxed downtown parking supply.

IMPACT ON KNOXVILLE'S BUSINESS COMMUNITY AND OTHER INSTITUTIONS

The business community in Knoxville experienced a wide diversity of impacts on sales and general business activities during the KTC transit strike. Some establishments with primarily transit-dependent clientele suffered as much as a 75 percent decline in retail sales. In other instances, sales were better than expected compared to the same period in 1976. Most of the major employers in the Knoxville area did not experience any significant difficulties with their employees getting to and from work, but a few small employers did face problems with employee transportation.

More than 100 merchants in the Knoxville CBD were interviewed to obtain information on their sales and business activity during the strike and on sales and business recovery after it. Because of the sensitive nature of the questions asked in the survey, not all of the merchants and others interviewed gave specific or quantifiable answers. The results can be presented by groupings of retail establishments.

Specialty Shops, Jewelers, Florists

Thirty-three establishments in this category were surveyed. Most of them sell small, low-priced goods that can be purchased quickly. Transit patrons often buy these items while waiting for buses. Of all businesses, these were affected most severely by the strike.

Of the 33 businesses, 28 reported a sales decrease. About one-half of the group experienced a loss in sales of more than 25 percent. Five reported a 50 percent or more reduction in sales during the strike. Only five businesses—a pawnshop, a watch repair and jeweler, a bookstore, a clothing shop, and a florist—indicated that they had experienced no sales decline. Four of these added that their clientele are primarily people who rarely use the KTC system. No business reported an increase in sales during the strike period.

After the strike was settled, the majority of merchants indicated that their sales had or had almost

returned to normal pre-strike levels. Of the 33 businesses, 19 had reestablished their normal sales levels within a month after the strike and another six were nearly normal.

Department, Furniture, and Major Appliance Stores

The second group of businesses surveyed included eight establishments including Miller's (a large department store in the Knoxville area), the Boston Store, J.C. Penney, Rolen Furniture, Fielden's Furniture, Sterchi Brothers, Fowler's, and Woodruff's. The lack of transit service during the strike did not affect Miller's significantly. Minor problems in getting to work for a few employees were solved fairly easily. Despite the fact that this department store is served directly by five of KTC's eight regular routes, retail sales during the strike exceeded those of the previous year. Woodruff's, a furniture store, also enjoyed sales increases during the strike. It is reasonable to assume there that the strike itself was not a major reason for the sales increases and that these two businesses did not depend on transit-riding customers.

Two of the four furniture stores reported sales declines of more than 70 percent. When managers were interviewed approximately a month after the settlement, both stores had continuing sales drops of 20-25 percent. Not surprisingly, both merchants believed that the strike had permanently damaged their businesses. The other two furniture stores experienced no change, but did report complaints from their customers who had difficulties finding parking spaces.

The two remaining stores in the group, the Boston Store and J.C. Penney, experienced sales slumps of 20-25 percent and 10-15 percent, respectively. The manager of J.C. Penney added that he was not sure if all his sales decline was attributable to the strike, because inclement weather also affected sales. Both of these stores' sales improved soon after the strike, but there seemed to be a continuing lag.

This group of eight stores revealed a wide diversity of impacts. Despite some similarities in location and product lines, the consequences of the strike for these stores were influenced to a large extent by the mode of access and affluence of their customers.

Package Store, Bars, Taverns

Six establishments were surveyed in this group. Five of these can be considered bars or taverns; the sixth is a package store. During the strike, four of these, including the package store, reported sales slumps of at least 40 percent. The other two bars hardly were affected and did not consider themselves dependent on bus riders.

Within one month after the strike was settled, two of these businesses with lower sales had returned to previous sales levels. Sales were still lower by 10 percent and 25 percent at the remaining two operations, and the managers believed that permanent damage had been done by the transit strike.

Banks, Savings and Loan, Consumer Finance, Bail Bonding, Public Utility

The fourth group of businesses in the survey consisted of the financial institutions (banks, savings and loan associations, consumer finance companies), one bail bonding company and the business office of the Knoxville Utilities Board (KUB). The various types of institutions

in this group were affected by the strike in distinctly different ways, but the consumer finance companies were the most impaired.

Most banks were not significantly hurt financially during the strike. They did, however, experience noticeable decreases in pedestrian traffic in their lobbies, especially in early March after social security checks had been received by bank customers.

Four of the consumer finance companies had noticeable declines of up to 20 percent in new business, but all except one said that their greatest problem was customers not being able to make loan payments. This problem was attributed almost entirely to the lack of transportation.

Beauty School, Hair Styling Salons

The smallest of all the groupings was two hair styling salons and one beauty school. According to the managers of the hair styling salons, the strike did not cause any problems other than parking inconveniences for some customers.

Supermarket, Health Foods, Meats, Variety, Drugstore, Dime Store

A total of nine businesses in this category were surveyed. In general, these businesses were seriously affected by loss of customers. Except for one health-food store, which had a 5 percent increase in sales, all suffered sales slumps of at least 10 percent, and four exceeded 40 percent. Two meat markets and a drug and variety store reported sales declines of at least 50 percent. Of the other four establishments, three experienced losses of business in the 10-15 percent range, while the fourth lost 30 percent.

After the strike was settled, three of these nine businesses reported complete recoveries and five others indicated that they had almost recovered. The business that suffered the heaviest loss had returned to about 90 percent of its normal sales after the buses had been running again for four weeks.

Eating Places

Of 10 establishments surveyed, all except 1 lost sales during the strike. Three were slightly affected; 3 others had declines of 20 to 33 percent of their sales; and the remaining 3 had at least a 40 percent drop. One experienced a 75-80 percent loss.

When interviewed one month after the strike had been settled, 5 of these 10 businesses had returned to pre-strike sales levels, and another 2 had almost recovered. The coffee shop's sales, which had dropped by 75-80 percent during the strike, were still off 40 percent, and another business was still off 20 percent.

Women's Clothing, Men's Clothing, Tailor, Shoes

Nineteen establishments formed this group. During the strike period sales ranged from an increase of 6 percent to a decrease of 70-80 percent. Five businesses indicated that their sales did not change during the strike, although one manager felt that sales in his store would have improved somewhat over the previous year if the strike had not occurred. Five other businesses experienced sales drops of 15-25 percent, four businesses experienced losses of 50-60 percent, and another four reported losses exceeding 70 percent.

Recovery from the lower sales losses was generally very good compared to most of the other business

groups. Twelve businesses reported that normal sales had been reached, and 3 others had returned to at least 90 percent of their normal sales within a month after the end of the strike. Two businesses, which had dropped at least 70 percent during the strike, were still about 20 percent off when interviewed. The only business that enjoyed a sales increase during the strike lost a small amount of business when the strike was settled.

Miscellaneous Business

The survey's final groupings of businesses contained seven establishments, none of which was greatly affected by the strike. Included are three wholesale businesses, a charitable organization, a print shop, a hotel, and an intercity bus terminal. The wholesalers were involved in beauty supplies, food service equipment, and optical supplies. Of these, only the food service equipment wholesalers experienced a slight downturn in business.

Impact on Employment

The same survey used to gain information from CBD retail merchants about the effect of the strike on sales and business was used to collect data on the strike's effects on employment in downtown Knoxville. Compared with retail sales, employment in the CBD during the strike was a lesser issue. However, 34 of the 107 businesses surveyed made some employee adjustments during the strike. Most of these changes were minor, such as rearranging work schedules, slight cutbacks in employee hours, and promoting informal carpooling among employees. About 75 employees were laid off due to the strike; however, most of them were rehired after the strike was settled.

Surveys were also conducted at selected institutions, hospitals, and manufacturing plants outside the CBD to determine the impact of the strike on personnel. Few difficulties in getting to work were reported by employees.

Reports from a sample of social service agencies indicate that, based on commonly accepted measures such as unemployment levels and the demand for public assistance, the transit strike caused no highly significant aggregate impact on those who depend on services from these agencies.

CONCLUSIONS

The transit-strike impact study has shown that the temporary loss of transit service for six weeks in a medium-sized city can have adverse effects on the community and its citizens. As expected, the strike most decidedly affected those segments of the population who directly rely on public transportation as their principal means of mobility. For captive transit riders, the loss of mobility resulted in a reduction in trip making, especially for trips of discretionary nature, and forced shifts in travel modes and destinations. Elderly persons living in senior-citizen complexes were most affected; these individuals had to suppress almost a third of their normal travel. To a large extent, the impact on the elderly group was more severe than on the other captive groups, because, as the elderly people contacted said, they were reluctant to impose on others for transportation assistance, except for essential trips.

As a whole, the captive group was able to find alternate arrangements for essential travel by relying on relatives and friends and to a lesser extent on taxi service. Most shopping, work, school, and medical trips continued to be made; however, discretionary trips previously made by transit, such as religious trips,

visits to friends and relatives, leisure and recreational trips, and personal business trips, were cancelled in many cases. Among the 250 people interviewed, few severe hardships caused by the strike were actually identified. Besides private arrangements, some captive riders were able to rely on social service agencies, which, however, were not able to accommodate all requests for service, because of inadequate supplies of vehicles and staff and strict eligibility requirements.

The impact of the strike on transit ridership and revenue was substantial. The net reduction of revenue from KTC regular routes attributable to the strike is estimated to be in the range of 7.2-16.0 percent. In the case of the express buses, it was estimated that the ridership dropped by 14.9 percent.

With the shift in travel patterns of transit users, downtown merchants, who cater to transit dependents, lost substantial amounts of business. A number of firms reported drops in sales of 50-80 percent, which forced reduced operating hours and layoffs of sales personnel. The downtown business establishments that were affected most seriously were specialty shops, clothing and shoe stores, restaurants, and fast food, drug, and variety stores. Interviews with store managers, however, revealed that sales returned to normal levels within two months. Many CBD merchants felt only minor repercussions that ranged from no loss to a 5 percent decline in sales during the strike. Patrons of many of these merchants were automobile oriented or commuters.

Most of the major Knoxville employers reported little difficulty for their employees in getting to work during the strike. Some special accommodations were required, but, in most cases, these were worked out easily.

No evidence suggested excessive traffic congestion. Only in the CBD area was parking a problem. The addition of an estimated 300 commuter automobiles in long-term lots or in the fringe residential areas made an already tight parking situation worse. It was more difficult for shoppers to find short-term parking spaces. Yet the Coliseum parking garage, which is located near the CBD and charges a third the rate of long-term lots in the CBD proper, recorded no significant increase in use.

The transit system itself felt the most adverse effect from the strike. Although some operating costs were deferred during the strike, the loss of revenue and the subsequent loss of ridership offset any savings. All

parties involved with the KTC strike—city officials, operating company, labor union, and consumers—would have benefited more by averting the strike or at least by attempting to shorten its duration. The loss in ridership almost nullified the gain from the fare increase that had been scheduled before the strike. Preventing the work stoppage could have kept many choice regular and express bus transit users from switching to another mode.

The six-week KTC strike showed that transit is a significant public service provided by the community. Most captive and choice riders returned to transit, which suggests that transit was judged superior in terms of cost and convenience to the alternative modes used during the strike. At the same time, the total transportation system showed capability and flexibility in responding to the crisis.

Few severe hardships, apart from minor inconveniences, were reported by former transit users. Most individuals were able to satisfy their travel needs through informal arrangements with relatives and friends. These arrangements were negotiated without the involvement or initiative of any public agency, and it is significant to note that the role and strength of such informal services usually are not recognized. However, the captive riders were less able to participate in these informal transportation arrangements and encountered more difficulty with the strike. It is not clear whether these alternative arrangements would have persisted if the strike had continued even longer.

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REFERENCE

1. Knoxville Metropolitan Area Public Transit Study. Transportation Center, Univ. of Tennessee, June 1977.

Publication of this paper sponsored by Committee on Public Transportation Planning and Development.

Interim Analysis of the Free-Fare Transit Experiments

A.H. Studenmund, Occidental College, Los Angeles, and Transportation Systems Center, U.S. Department of Transportation
Sherrill Swan and David Connor, De Leuw, Cather and Company

This paper summarizes the early results of the two systemwide off-peak free-fare transit experiments being conducted in Trenton, New Jersey, and Denver, Colorado. These experiments, which are sponsored by the Urban Mass Transportation Administration (UMTA) under its Service and Methods Demonstration Program, are the first free-fare programs of such size and comprehensiveness. The demonstrations have already

provided a number of interesting, if still tentative, conclusions. The first major conclusion is that, while free fare induces large and sustainable ridership gains (19 percent in Trenton and 34 percent in Denver), the general aggregate behavior of the population in making their modal choices is not significantly different from what it would be with any other absolute change of an equal amount. The price elasticity of

demand for transit implied by the Trenton results was -0.42, which is virtually identical to the transit industry's experience. Saturday evening youth riders and walk trips made up fully 7 percent of the ridership in the free-fare system in Trenton. The demonstration appears to have reduced the peak-load capacity requirements in Trenton's transit system and caused a dramatic shift from the peak to the off-peak. The most surprising finding was that complaints of rowdiness, vandalism, and other incidents increased at both sites to such an extent that some groups called for the abandonment of the experiments.

This paper summarizes early results of the analysis of systemwide off-peak free-fare transit experiments being conducted in Trenton, New Jersey, and Denver, Colorado. The Service and Methods Demonstration Program of the Urban Mass Transportation Administration (UMTA) sponsored the experiments, which are funded by local as well as federal money. These experiments are the first free-fare programs of such size and comprehensiveness and are so costly that they may well be the last. As such, they provide a unique opportunity to examine the efficacy of free transit as a method of alleviating transportation, energy, and pollution problems; they also provide an unusual chance to observe passenger behavior at zero out-of-pocket costs.

THEORETICAL BACKGROUND

The concept of providing transit service as a free or public good has been suggested as a means of solving a number of transportation problems simultaneously. The argument has been that, as the cost of making a transit trip decreases to zero, the mobility of those dependent on transit for transportation will increase. Also, decreasing fares to zero will offset what some have felt to be an unfair cost comparison between transit and the automobile, given the low perceived cost of driving an automobile on a trip and the level of spending on roads and similar automobile-oriented facilities.

The decreased relative cost of transit would attract present automobile users and, by decreasing vehicle kilometers traveled (VKMT), help to ameliorate congestion, energy shortage, and air pollution problems. These positive properties of free-fare transit have been known for quite some time, but little in the way of theoretical or empirical investigation of the concept has been undertaken until the last 10 years. Studies propounding or criticizing free transit have been fairly numerous since then (1-3).

The prevailing conventional wisdom with respect to free-fare transit is that reducing fares is inferior to improving service as a method of increasing the mobility of the transit dependent and attracting people from their automobiles. In their classic study on free transit (4), Domencich and Kraft make this argument from economic theory and existing observed elasticities. Testing their conclusion about zero fares is a major goal of this project.

The object, then, is to improve understanding of the characteristics of demand for an item (to be eventually applied to the case of a ride on a bus) as the price of that item approaches zero.

Traditional economic theory often describes this demand as approaching infinity (in a nonlinear asymptotic way) as the price approaches zero. When the items being sold can be stored for future consumption or possible resale, of course, such a characterization makes sense. In most other cases, however, it seems unlikely that demand would ever even remotely approach the very high levels postulated. One reason is quite simple: Severe constraints on voluminous consumption of particular items will always exist.

In terms of transit, it is difficult to imagine an individual taking or even desiring more than one peak-hour trip to work per day. In addition, even trips for shopping, school attendance, and medical or recreational purposes are basically functions of a derived demand; that is, the demand for transit increases because the demand for some other activity has also increased (possibly because of the decrease in price of the transportation of that activity). Only in the case of joy-riding is the transportation likely to be considered an end (or consumption good) in and of itself.

It also seems unlikely that most consumers consider the out-of-pocket price of an item to be the true perceived cost of the purchase. The opportunity cost of the time spent making the purchase, the cost of getting to the market (or bus route), and any other similar costs are quite likely to be incorporated into the decision making of all but the most unsophisticated consumer. Nevertheless, these additional costs can be so low that the purchase price of an item could stand as an excellent proxy for its total perceived cost; in the case of a transit ride, however, most individuals appear to pay more attention to the value of the time lost than they do to the fare (5).

If this is true, then reducing the out-of-pocket cost to zero is unlikely to reduce total cost to zero, and we probably will still be in a fairly linear portion of the demand curve. That is, demand for transportation at a cash price of zero, rather than being infinite, can be analyzed as it is at any other price. Thus, free transit seems quite likely to appeal most to those individuals whose value of time is quite low.

One complicating factor, obviously, is that at zero out-of-pocket costs transit is preferable to walking as a mode for a higher percentage of parallel-route walk trips. For both reasons, not only will it be important to measure the increase in the number of transit riders induced by free fare, it will also be vital to analyze the distribution of ages, incomes, and trip purposes of those riders if we are to properly measure the impact of the program. It may well be that the non-pecuniary costs of riding are so high that the changes in out-of-pocket costs will seem insignificant to a majority of the riders, but this same impact may well be reversed for young, unemployed, or retired individuals.

THE DEMONSTRATION PROGRAM

What is difficult about obtaining solid empirical data needed for conclusions about free transit is that, until the Denver and Trenton programs, no large systemwide free systems were in operation. Previous forecasts of zero-fare ridership were obtained from extrapolations of existing elasticities, from studies of small fare-free zones in the shopping and central business districts of a number of cities, and from other limited observations of free-fare behavior (6-8).

Domencich and Kraft, among others, pointed out that it would be possible "to perform experiments to generate observations for analysis by conducting demonstration projects, rather than by relying on the observations given the existing environment" (4). The authors go on to warn, however, that, unless the time frame of the experiment were long and careful attention were given to planning, it would be impossible to obtain useful analytical results from the projects.

To meet this need, Congress authorized, in Title 2 of the National Mass Transportation Act of 1974, the "research and development, establishment, and operation of demonstration projects to determine the feasibility of free-fare urban mass transportation." This assign-

ment was given to the UMTA Service and Methods Demonstration Program.

In its first annual report on the program in 1975, UMTA echoed Domencich and Kraft's concern by stating that "answers about the costs and efficacy of fare cuts in achieving their objectives . . . can only be achieved if a strong emphasis is placed on matters of experimental design." At present, the demonstration program aimed at meeting this research goal consists of the two fare-free off-peak experiments in Trenton and Denver.

Trenton Demonstration

In the Trenton (more technically Mercer County), New Jersey, demonstration fares are reduced to zero from a previous level of 15 cents for the hours of 10 a.m. to 2 p.m. and after 6 p.m., Monday-Saturday and all day on Sundays and holidays. Other fares varied from 5 cents for a senior citizen State Complex Shuttle ticket to 50 cents for particularly long express routes. The typical peak fare is 30 cents.

The free service was begun on March 1, 1978, and was scheduled to run for a full year. Free off-peak service is provided on all intracounty routes, including 10 regular fixed routes and 3 small shuttle loops.

The project was funded by a \$500 000 grant from UMTA, but the total cost of the demonstration, including evaluation, may reach \$750 000. Trenton, despite being the state capital, is experiencing many of the difficulties that inner cities around the country have been facing. Its population is diminishing at the rate of almost 1 percent a year (to 104 000) (9), and much of the remaining populace is low-income, elderly, and/or carless. The rest of Mercer County is twice as populous as Trenton, growing, and fairly affluent. However, most of the bus lines are concentrated inside Trenton, so the demonstration is at least partly aimed at helping to revitalize the downtown area.

Extensive pre-implementation planning and data collection, followed by comparable "during" data, will allow accurate and comprehensive measurement of those changes that take place. Level-of-service (schedule or route) changes in Trenton will be limited to "trailer" buses handling excessive loads, which will further isolate the effects of the demonstration.

Denver Demonstration

The Denver demonstration, in contrast to that of Trenton, includes a much larger system with a greater variety of route and service types and is not limited to the fare reduction; during the course of the demonstration, the Denver Regional Transportation District (RTD) system will undergo major route restructuring.

On February 1, 1978, the RTD, which includes several counties, initiated a one-month experiment entitled "transit awareness month." Weekday fares in the district were reduced to zero (from previous levels averaging 25 cents) for all hours except 7-9 a.m. and 4-6 p.m. An UMTA grant provided for approximately half of the nearly \$7 million necessary to continue the program for a full year, and data were to be collected during and after the demonstration. On May 1 the morning peak period was redefined as 6-8 a.m.

Denver is a large, vital, growing city of a million and a half people. One of the main reasons for the experiment was to measure the city's potential to counter growing air pollution and energy worries. Thus, this experiment is different enough from the one in Trenton to offer opportunities to learn about varying free-fare impacts in alternate settings.

In addition, the larger fare change in Denver and the liberal definition of the off-peak increased the potential for major ridership impacts. The lack of pre-implementation data, the midcourse service changes, and changing ridership estimation techniques, however, complicate the Denver evaluation.

EVALUATION METHODS

The differences in availability of before data have resulted in different evaluation approaches for the two demonstrations. In Trenton, direct comparisons between before and during free fares can be made. In contrast, the main analysis of impacts of the demonstration in Denver will come from a comparison of during and after data and from free-fare program riders' recollections of pre-free-fare behavior.

The major pre-implementation data collection in Trenton took place during the fall of 1977 and included a 300-household random telephone survey, interviews at two major activity centers (a downtown shopping mall, the Commons, and a major suburban regional shopping center), two ridership counts, a 4000-person on-board survey, and a follow-up telephone survey of 150 bus users. Post-implementation data collection has included five ridership counts, a 2000-person on-board survey, and a round of surveys matching those administered in 1977. Numerous other observations and interviews have either already been or will be made to address specific issues in greater detail.

The analyses conducted to date for Trenton are not based on the full evaluation's data. Data taken from the fall 1977 surveys were analyzed to estimate before conditions. However, in some cases those data are not completely adjusted and weighted and therefore may be modified in subsequent analyses. The after data are taken from an interim on-board survey conducted in May 1978. The analyses of these data have the same adjustment shortcomings described for the before data.

In addition, there are two inherent limitations to the use of the May data. First, the sample size is less than half as large as that of the fall 1977 on-board survey, and, second, the effects of seasonality (i.e., May versus November) are unaccountable. Therefore, the analyses and findings presented here are tentative and subject to revision as dictated by continuing analysis.

The Denver results presented here are also tentative. They are gleaned for the most part from September 1978 on-board survey results of approximately 8000 riders. Data from a July 1978 2000-person on-board survey are used to supplement September figures in the estimation of off-peak ridership increases attributable to free fares. Other on-board surveys were being conducted in November 1978 and April 1979. Also, three rounds of telephone surveys are being used to identify rider reactions to the program over time and to follow public attitudes toward the program. Transportation supply and cost data are being collected on a monthly basis. In addition, Denver Regional Transportation District monthly and average weekday ridership estimates and information from staff interviews are used to describe free-fare impacts. As mentioned, the usefulness of the data will be diminished by changes in a number of transit system parameters, including ridership counting techniques, route structures, and bus kilometers of service offered.

TOTAL RIDERSHIP IMPACT

In both Denver and Trenton, increases in overall ridership have been strong and sustained at levels above what might have been predicted from previous

experience. Figure 1 presents a graphic picture of ridership change.

A comparison of before ridership estimates and four during counts indicates a 24 percent average monthly ridership increase in Trenton (542 000 riders to 672 000 riders). Seasonality differences and the inherent growth trend can account for about five percent of the increase. Therefore, the net ridership impact of the demonstration appears to be 19 percent.

In Denver it is also estimated that from 1977 to 1978 (using adjusted mean ridership estimates for February and August) average monthly ridership increased by about 49 percent from 2 667 600 to 3 973 300 riders. (Figures are adjusted for an estimated 5 percent overestimate in 1977 monthly ridership figures and an 8 percent underestimate in 1978.) However, it is likely that 15 percent of the increase from 1977 to 1978 is due to service expansion and secular growth. Therefore, it is estimated that the

Figure 1. Total monthly ridership trends. TRENTON

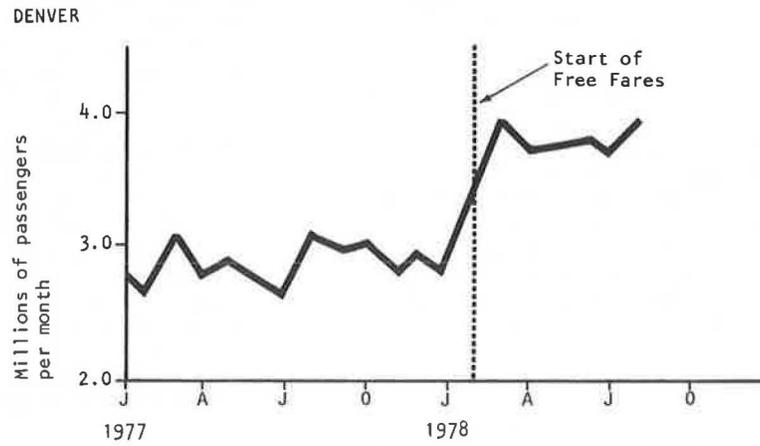
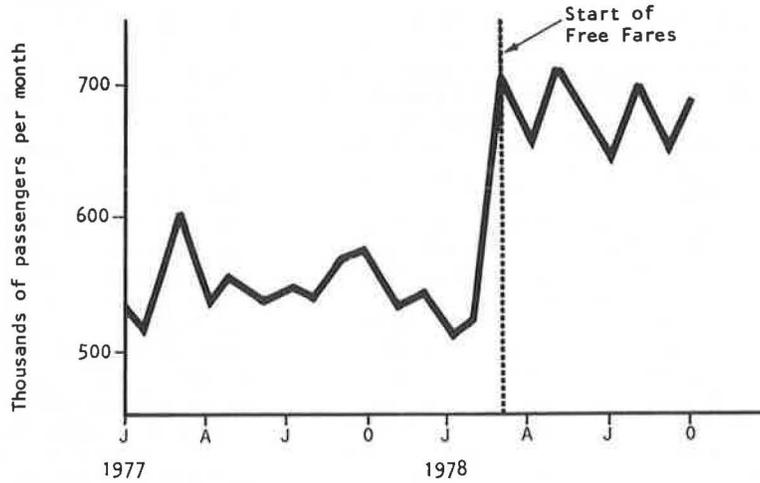
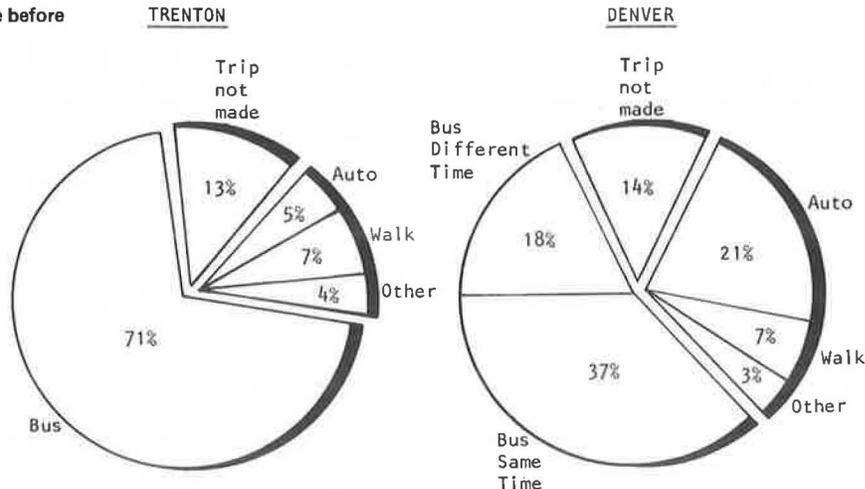


Figure 2. How trips were made before free fares.



net increase caused by free fares is about 34 percent.

EFFECTS ON OFF-PEAK RIDERSHIP

In Trenton, the estimated average weekday off-peak ridership increase from free fares appears to be about 45 percent. The magnitude of change in Denver's off-peak ridership from free fares is less exact at this stage in the data analysis. Average weekday off-peak increases are between 74 and 155 percent. This translates to between 41 000 and 61 000 new off-peak trips, which include trips switched from peak to off-peak because of free fares. The variation in estimates can be attributed to two differing estimates of average weekday pre-free-fare off-peak riders that come from different response patterns on two transit on-board surveys.

A comparison of the Trenton before and four during ridership counts adjusted for seasonality and secular growth indicates approximately a 45 percent increase in weekday off-peak ridership (7200 riders to 10 500 riders). It is not yet known what percentage of this increase is trips shifted from peak to off-peak.

Estimates of average weekday off-peak ridership in Denver are based on several assumptions. First, it is assumed that, like monthly ridership, weekday ridership underestimates actual ridership by 8 percent. This assumption is based on a comparative analysis of observed weekday patronage versus driver's use of fare-box counters. In addition, 1977-1978 secular growth is approximately 15 percent, as stated earlier. This assumption is based on a comparison of bus-kilometers. Finally, current average weekday off-peak ridership is about 70 percent of total weekday ridership, according to an all-day sample ridership count taken in September 1978.

OFF-PEAK TRAVEL BEHAVIOR CHANGES

As derived above, free fares appear to have increased Trenton off-peak travel by 45 percent, while in Denver estimated increases are from 74 to 155 percent, depending on the estimated pre-free-fare ridership. (A more meaningful range of percentages for Denver is that 39-57 percent of current off-peak trips are new bus trips plus bus trips switched from the peak period because of free fares.) The following paragraphs describe two of the characteristics of off-peak travel: automobile-to-bus mode shift and generation of new travel (latent demand). September on-board survey data are used to describe Denver traveler characteristics.

In Denver, 21 percent of current off-peak riders surveyed in September stated that the trip at hand was made by automobile before free fares, while in Trenton this percentage was only 5 percent (see Figure 2).

To determine what percentage of these trips were shifted to bus because of free fares, secular growth must be accounted for. Adjusting for this growth results in an estimated 21 300 weekday automobile trips switched to bus because of free fares in Denver and about 500 trips in Trenton. The number of automobile-switched trips in Denver represents 35 percent of the new off-peak bus trips, i.e., new bus trips plus bus trips shifted from peak period, attributable to free fares. For Trenton, about 17 percent of the off-peak trips not previously made by bus were trips formerly made by automobile.

The number of new trips made because of free fares appears to be significant in both Denver and Trenton. As shown in Figure 2, 13 percent of current off-peak riders surveyed in Trenton and 14 percent of the free-

fare off-peak riders in Denver identified the surveyed trips as trips not made before.

Adjusting for secular growth, it appears that in Denver 13 000 new trips were made because of free fares; this represents 21 percent of the new and peak-to-off-peak switched bus trips attributable to free fares. In Trenton, approximately 1300 trips, 45 percent of new bus trips caused by free fares, are trips not made before.

FREE-FARE USER CHARACTERISTICS

Some useful findings can be drawn from a comparison of characteristics of pre-free-fare trip makers versus those of the free-fare trip makers. A comparison of rider ages and trip purposes helps indicate whether a new market has been drawn to transit because of free fares.

Generally, the distribution of trips by purpose did not change with free fares, as shown in Figure 3. However, it appears that in both Denver and Trenton the percentage of discretionary trips increased. These trips, which form the "other" trip-purpose category, are mainly personal business trips and some joyriding trips. In Trenton, unlike Denver, the percentage of social and recreation trips dropped from 21 percent of pre-free-fare trips to 14 percent during free fare.

A comparison of the overall age distribution before and after the inception of free fares gives an indication of the way in which the benefits are distributed by age group. These distributions are shown in Figure 4.

In both Denver and Trenton, the percentage of youth (less than 16 years old) riders increased slightly with free fares, while the proportion of older riders dropped. Trenton-Denver differences in pre-free-fare and free-fare age distributions are most marked for the 17- to 24-year-old age group. In Denver this group took 26 percent of the pre-free-fare riders and increased this to 31 percent with free fares. For Trenton, both before and during free fares, the 17-24 age group is the most populous group. During free fares, the proportion of riders in this age group dropped slightly.

In response to comments about perceived increased youth ridership and increased harassment by youths in Trenton, the change in youth ridership by time of day was examined. Results showed that youth ridership understandably decreased as a share of ridership during school hours but tended to rise during the free-fare evening hours.

QUALITY OF SERVICE

Interviews with staff and drivers of both bus companies and a review of Trenton and Denver media indicate that there has been a decline in the quality of some aspects of transit service since free fares. In both demonstration projects, problems with vandalism and youth harassment, schedule reliability, and crowding have been noted.

Vandalism and Youth Harassment

In Trenton, perhaps the most surprising result of the project was a groundswell of driver and media reaction to an increase of rowdiness, vandalism, and harassment on the buses and in a suburban shopping mall served by the demonstration's free rides. All these difficulties were attributed to juveniles attracted to the buses and mall by the free fares; newspaper articles, county-sponsored open hearings, and irate letters to

the editor all called for action: increased security forces, reduced evening free-fare hours, or the denial of free-fare rights to certain groups of individuals.

To evaluate this problem, summaries of reported disruptive incidents for the past year and a half were collected from the transit operator, from the mall, from police, and from drivers. Moderate increases in the number of some kinds of incidents, for instance,

on-bus vandalism, can be discerned. In addition, the percentage of incidents reported in the free-fare period also increased for some type of difficulties, for instance, operator abuse. The incidence of such problems appeared to ease by summer.

In Denver, as in Trenton, the introduction of free fares created increased driver and patron harassment by youths and annoyance of patrons by drunks in the off-

Figure 3. Trip purposes.

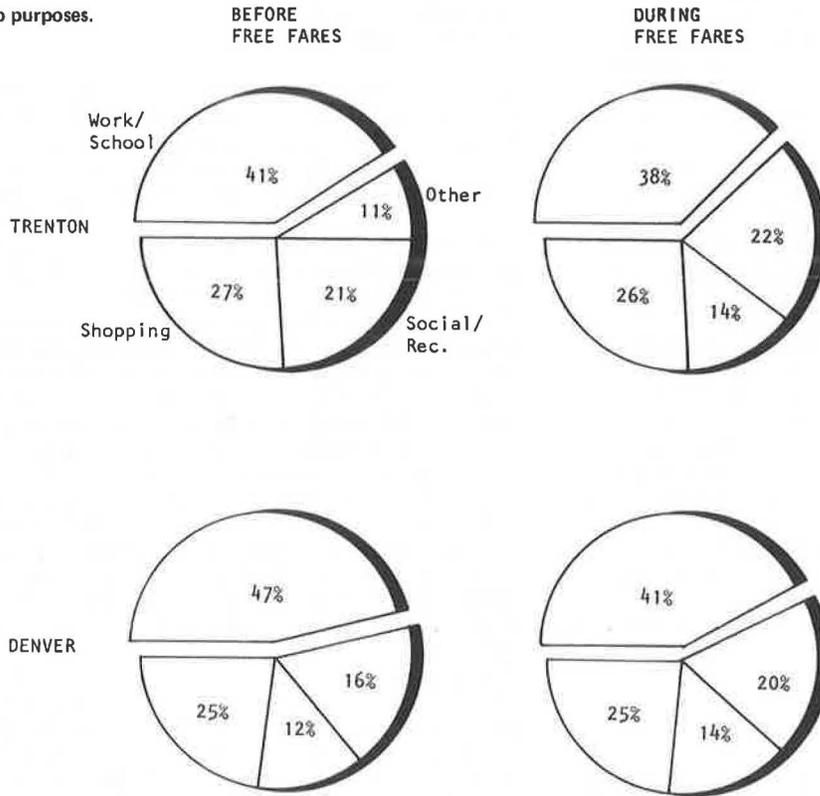
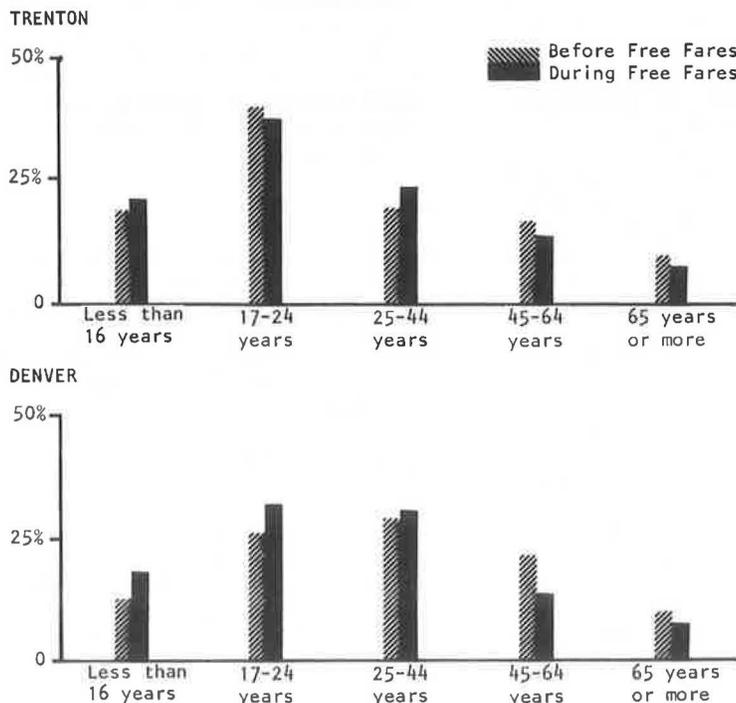


Figure 4. Rider ages.



peak hours. Increases in vandalism have been noted by RTD staff; however, incidents declined during summer. News articles, editorials, and interviews with RTD staff indicate that youths and drunks were causing problems with regular riders and drivers during the first few months. Nineteen percent of the riders surveyed in July responded that passenger politeness had declined since free fares.

Crowding

In Trenton, driver comments and load-factor counts taken near the central business district indicate that seat availability has been significantly reduced during the free-fare period. The most dramatic change occurred in the morning off-peak. The following shows before and during percentages of capacity-loaded buses based on corner-count observations.

Period	Percentage of Observed Buses At or Above Capacity	
	Before Free Fares	During Free Fares
6-10 a.m.	15	12
10 a.m.-2 p.m.	2	25 (free fares)
2-6 p.m.	16	19
6-10 p.m.	1	9 (free fares)

So far, there are three indicators that crowding on buses is a problem in Denver. News media have reported driver and rider complaints about crowding. Also, from January to March, the number of complaints about crowding to RTD increased dramatically. Thirty-four percent of surveyed bus riders (July 1978 survey) responded that seat availability was worse since free fares. Seat availability was checked as a problem more often than any other service quality listed on survey forms. Load-factor data are being collected, as a part of the evaluation, to permit more definitive findings.

Schedule Reliability

In both Denver and Trenton, there appears to be an increase in late bus arrivals during the off-peak. Comparison of a measure of schedule adherence indicates significant decreases in schedule adherence during free-fare periods in Trenton, as shown below.

Period	Average Delay per Scheduled Bus		
	Before Free Fares (min)	During Free Fares (min)	Percentage Change
6-10 a.m.	3.3	3.7	12
10 a.m.-2 p.m.	2.8	4.9 (free fares)	75
2-6 p.m.	5.0	5.7	14
6-10 p.m.	2.9	5.5 (free fares)	95

A survey of bus drivers provides additional evidence of schedule adherence problems. A majority of a sample of Mercer Metro drivers interviewed during the fall stated that free fares had negatively affected operating times and ability to maintain schedules or have layovers.

In Denver, crowding appears to be contributing to a reduction in schedule reliability. RTD staff members interviewed in June noted that, because of more frequent stopping, buses often ran late, particularly during the transition period between the afternoon peak and off-peak hours. Time checks are now being analyzed to determine the extent of the problem.

TRANSIT OPERATIONS

In both Denver and Trenton, the demonstrations appear to have increased fleet and driver requirements slightly. In addition, the programs have had a generally adverse effect on driver morale.

Fleet and Driver Requirements

In an April Denver RTD staff memo it was stated that passenger and running time checks indicated that additional midday service was necessary to eliminate passenger pass-ups and severe running-time problems that affected schedule reliability. A need for 13 extra weekday buses and 8 additional Saturday buses was shown. Additional service need was estimated at 40 bus-hours on weekdays and 56 bus-hours for Saturday; corresponding bus-kilometer increases were shown as 747 and 906 km (458 and 563 miles) for weekdays and Saturday, respectively. This amounts to an increase of about 1 percent in RTD's service.

Almost all of this required service has been added since April. All of the needed weekday buses have been added, and most of the Saturday requirements have been met. Trenton experienced minor increased fleet requirements early in its demonstration program. Trailer buses were added to serve a temporary increase in shopping-center trips.

Driver Morale

In both Denver and Trenton, driver morale has declined. News articles, comments from drivers and driver representatives, and RTD staff memos indicate that, since free fares began in Denver, driver morale has declined and complaints against drivers have increased.

Of the drivers sampled in Trenton, 92 percent said the free-fare program has made their jobs less enjoyable. Nearly all of the interviewed Mercer Metro drivers (95 percent) reported having received negative comments regarding the free-fare program; 89 percent said they frequently received negative comments.

Financial Impacts

As expected, revenue losses from free fares were substantial, but increases in operation costs appear to be insignificant in both Trenton and Denver.

Revenue Loss

RTD estimated that operating revenue loss resulting from Denver's free-fare program was of the order of \$3.7 million for 1978. This represents approximately a 37 percent decrease from RTD's estimate of 1978 operating revenues if normal fares had been charged based on a projection of 1977 trends. During 1977, revenue levels remained fairly stable at \$0.249 per passenger. January 1978 fare increases resulted in an average revenue of \$0.282 per passenger. With free fares, the average has dropped to \$0.122 per passenger, a 51 percent drop from January 1978.

For Trenton, the projected annual operating revenue loss due to free fares has been estimated at \$340 000. This is a 25 percent drop from Mercer Metro's estimate of annual revenues if regular fares had been charged. Current average revenue per passenger is estimated at \$0.135. Before free fares, this estimate was \$0.205; since free fares, average annual revenue per passenger has dropped by 44 percent.

Operating Costs

It appears that in Denver the demonstration resulted in a slight increase in transit operating costs; the additional costs for service to accommodate the increased free-fare riders were projected to total about \$250 000 for April-December 1978, or about \$28 000 per month. This amounts to an estimated increase of total operating costs of less than 1 percent. These slightly higher costs have resulted from (a) extra drivers and bus trippers deployed to improve schedule reliability and reduce crowding, (b) increased maintenance (mainly resulting from vandalism), and (c) increased public information needs.

Higher costs did result in Trenton when trailer buses were added to accommodate more trips to shopping centers, but no permanent service additions have been made because of free fares. Costs resulting from increased vandalism and additional wear and tear on buses have not yet been estimated.

CONCLUSIONS

Off-peak ridership gains from free fares are estimated at 45 percent for Trenton and 74-155 percent for Denver. Disaggregate data from both Trenton and Denver demonstrations will be analyzed to form estimates of elasticities for different market segments. However, in the absence of such data, a functional form relating the absolute amount of initial transit price to the percentage change in patronage caused by free fares was derived.

A parabolic curve that is a variation of Scheiner's (8) demand curve was formed. There are two assumptions associated with this curve that differ from Scheiner's. First, demand reacts differently depending on whether fares are increased or decreased; somewhat larger percentage changes are expected as fares are reduced. Second, ridership gain can exceed 100 percent. The equation of the parabolic curve is

$$y = kx^{\frac{1}{2}} \quad (1)$$

where

- y = percentage of off-peak patronage gain from free fares,
- k = a constant, and
- x = the average off-peak fare prior to free fares.

Applying the equation to estimated Trenton off-peak rider increases (55 percent) and the midpoint of the range for Denver (114 percent) results in elasticities of -0.42 for Trenton and -0.64 for Denver. This result indicates a greater response to free fares in Denver than in Trenton. This is likely to be due to the greater opportunity for potential riders to make use of free fares in Denver. RTD free-fare hours are longer than those in Trenton, and overall RTD service frequency is greater.

Results from both demonstrations do indicate support for the notion that, for a substantial percentage of riders in both cities, the movement to zero out-of-pocket costs is not equivalent to a movement to zero total perceived costs and that, while free fare induces large and sustainable ridership gains, the behavior of much of the population in making their modal choices is not significantly different at zero than it would be with any absolute fare change of an equal amount.

There is apparently no significant psychological "free-ride" behavioral change. There are two exceptions to this conclusion: parallel-route walk trips and trips made by youths (and presumably others with simi-

lar characteristics). The Trenton results summarized in this paper show that free transit attracts a large proportion of walkers; this result is also partially supported by the Denver results.

The trend of youthful riders is in itself an important consideration. Overall in both Denver and Trenton, the share of youth riders increased slightly. When the concentrations of young riders at particular times are examined, a clearer picture of their demand is obtained. In Trenton, young ridership understandably decreased as a share of ridership during school hours but tended to rise during those times when bus rides were an alternative for transportation to entertainment. In some cases bus rides were entertainment in and of themselves.

This leads to the conclusion that free transit attracts far more riders than might be expected in given subsets of the ridership. The theoretical reason for the discontinuous demand characteristics of these groups is that their nonmonetary costs are at or near zero, so that unlike many other riders the out-of-pocket cost of riding transit is a good proxy for the perceived cost.

Free fares also appear to cause some adverse changes in transportation supply. In both Trenton and Denver, crowding increased and schedule adherence was reduced. Incidents of rowdiness and vandalism also increased. But available documentation indicates that the increases in reported vandalism are not beyond what might be expected, given the ridership increases. Quite naturally, however, the situation of regular riders avoiding transit because of the perceived crowding and hassle is a distinct possibility.

Since most of these riders appear to make modal decisions based more on nonmonetary costs than on dollar costs, it seems that an increase in discomfort could offset the value of decreased fares. Perhaps the most negative conclusion of the study to date is that free fare has the potential to disrupt the typical social balance of a transit system; whether the future will show this to be a temporary condition is impossible to say.

One of the most severe impacts of free fares appears to be a drop in driver morale. Increased ridership has added to the responsibilities of drivers and affected their run times. In addition, drivers appear to be receiving the brunt of negative patron comments about the program and are having to deal with increased harassment and vandalism by youths on the buses.

As was expected, transportation costs were adversely affected. Revenue losses in both demonstrations are in the 30-40 percent range. But it is important to note that operations costs increased only slightly.

In conclusion, it should be reiterated that these results are interim; final project results should be available within a year.

REFERENCES

1. J.M. Elliott. No-Fare: Key to the Transit Jam. *American Federationist*, Vol. 79, No. 8, 1972, pp. 9-15.
2. J.I. Scheiner and G. Starling. The Political Economy of Free-Fare Transit. *Urban Affairs Quarterly*, Vol. 10, 1974, pp. 170-184.
3. L.M. Schneider. The Problem of Free Mass Transportation. *Proc., Transportation Research Forum*, Vol. 9 (supplemental papers), Richard B. Cross, Oxford, IN, 1968, pp. 23-30.
4. T.A. Domencich and G. Kraft. *Free Transit*. Heath, Lexington, MA, 1970.
5. L. Moses and H. Williamson. Value of Time, Choice of Mode, and the Subsidy Issue of Urban Transportation. *Journal of Political Economy*,

- Vol. 71, 1963, pp. 247-264.
6. P.B. Goodwin. Some Data on the Effects of Free Public Transport. *Transportation Planning and Technology*, Vol. 1, 1973, pp. 159-174.
 7. M.A. Kemp. Reduced Fare and Fare-Free Urban Transit Services—Some Case Studies. Urban Institute, Washington, DC, Rept. UI-1212-3, July 1974.
 8. J.I. Scheiner. The Patronage Effects of Free-Fare Transit. *Traffic Quarterly*, Vol. 29, 1975, pp. 19-27.
 9. R. Knight. Evaluation Plan for the Trenton Free-Fare Demonstration Project. Transportation Systems Center, U.S. Department of Transportation, Rept. DOT-TSC-UMTA-78-17, 1978.

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Operating Assistance for Public Transportation Systems: A Survey of State-Level Programs

Marlene Rodenbeck Politano, Northern Virginia Transportation Commission, Arlington
 Carol A. Keck, New York State Department of Transportation, Albany

A survey of several state-level programs of operating assistance for public transportation systems was undertaken early in 1978 by the New York State Department of Transportation as part of its annual evaluation of the impact and effectiveness of its statewide aid program. Only three states did not respond, but they were subsequently determined not to have such programs. This paper describes existing programs in terms of eligible operations, local sponsorship, relationship to Urban Mass Transportation Administration funding programs, ability to use funds for capital purposes, sources of program funds, and the scope of services assisted. Finally, it proposes a more in-depth review of the effectiveness of the programs designed to aid in policy development and implementation at both the state and the federal levels.

In recent years the role of the state in transit planning has expanded. A number of states have become involved in capital and technical assistance to local transit, and some of them now provide operating assistance to a variety of public transit services.

The New York State Department of Transportation (NYSDOT) was particularly interested in investigating other states' operating-assistance programs because of its own commitment in this area. New York's operating-assistance program was initiated in 1974 with the stated object of maintaining both fares and current levels of service.

In state fiscal year 1977/78, \$104.5 million of state funds were made available to transit operators for the provision of commuter rail, rapid rail, fixed-route bus, demand-responsive bus, and commuter ferry services. During 1978-1979 that amount was increased to \$110.6 million. NYSDOT annually evaluates the success of its program in meeting objectives as well as the broader social, transportation, and economic objectives of the state.

Operating and financial information is collected annually from all transit operators receiving state funds; this information is used to estimate future financial needs and to make recommendations for changes in the program to help better achieve its goal. As part of its information-gathering process and to provide comparative information for use in developing its recommendations, NYSDOT decided to investigate transit operating-

assistance programs administered by other states. None of the similar surveys conducted in recent years have focused on operating assistance. The recent growth of this type of program and approval of the Surface Transportation Act of 1978 have increased the importance of this activity.

METHODOLOGY

Copies of the 1977 Annual Report on Public Transportation Operating Assistance Programs in New York State (1) were distributed to appropriate officials in state departments of transportation or highways in the 49 other states in January 1978. Along with the report, these officials were sent a survey form requesting information on the existence of public transit operating-assistance programs in their states and asking a series of questions about the programs.

PREVIOUS RESEARCH ON STATE ASSISTANCE TO LOCAL TRANSIT

In 1975 three studies were conducted on state transit funding, all of which discussed capital and technical assistance as well as operating assistance. Bair and McKelvey (2) conducted a study for the Institute of Urban and Regional Research of the University of Iowa on current state practices in transit funding. They surveyed the 22 states with departments of transportation to identify state assistance to local transit in the areas of capital expenditures, technical studies, operating costs, demonstrations, planning, evaluation, and promotion. Carstens, Mercier, and Kannel (3) of Iowa State University conducted a study of the current status of state-level support for transit. They collected information from each state and looked at all types of financial assistance for local transit in 24 states. The third study of state expenditures for local transit, part of the investigation into 13 small city systems conducted by the Transportation Systems Center (4), also covered both capital and operating programs but focused on small cities, i.e., those with less than 200 000 people.

Of the 22 states that Bair and McKelvey surveyed, 9 used state funds to subsidize operating costs. The most common criterion for allocation of funds was the system's deficit, although system performance was used in several large states. The most common funding sources listed were similar to what the current New York State survey revealed: general revenues, general transportation funds, and gasoline taxes.

Carstens, Mercier, and Kannel found 14 states that provided operating assistance through four types of distribution procedures, purchase-of-service agreements, formula allocations, revenue-generating base of transit jurisdiction, and first-come, first-served allocation. Purchase-of-service agreements may be considered contracts with operators. Formula allocation refers to using a measure such as use, service, population, or population density to determine the amount of funding for which a system or area is eligible. Revenue-generating base of transit jurisdiction refers to those programs that allocate funds according to certain taxes (e.g., sales tax) or fees collected in the transit system's jurisdiction. The last type of distribution procedure (3) is the first-come, first-served allocation, which distributes funds as requests for assistance come in. None of the respondents to the New York State survey indicated using this method, although some states have a discretionary component in their allocation procedure.

The Urban Mass Transportation Administration (UMTA) study classified operating-assistance programs according to those states that match UMTA grants only and those states that provide aid regardless of federal funding. According to the UMTA study, two states (Indiana and Maryland) provided funds only as a match to UMTA funding. However, by the time the New York State study was done, Maryland had instituted an expanded operating-assistance program to include non-urban areas. Of the states that provided funds regardless of federal funding, 5 used a formula, 6 provided a set percentage of nonfederal share or of the deficit, and 2 provided aid in varying amounts. UMTA's findings on the success of state funds for operating assistance were similar to the responses in the New York survey; most states (10) used general revenues, 5 used highway funds, and 2 used other sources.

RESULTS OF NEW YORK STATE SURVEY

Administration

Programs offering operating assistance to local transit can be described in various ways. Four categories will be described here: operating assistance to transit service for the general public, assistance to specific geographic areas, assistance to specialized transportation services for the elderly and handicapped, and assistance based on locally generated tax revenues. Twenty-one states reported at least one operating-assistance program in these categories available to public transit providers in their areas. Specifically, 50 programs were identified. All of the programs discussed were created by state legislation, which specifies eligibility and allocation of funding as well as other rules or procedures to ensure accountability.

Nearly all of the states that provide operating assistance have at least one program to allocate funds to operators who provide transit service to the general public. Four states have legislation allocating assistance to specific geographical areas, usually through regional transit authorities or districts. This special legislation is generally directed to specific metropolitan

areas that are relatively very large compared to the other urban areas in the state; Chicago, Baltimore, Boston, New York, and Washington, D.C., are specific cases.

Each of these states (Illinois, Maryland, Massachusetts, and New York), however, also has general operating-assistance programs for which other areas of the state are eligible. In cases such as Delaware and Rhode Island, the state is so small that one or two authorities or transit districts serve the entire state.

Eight states have separate programs providing operating assistance to elderly and handicapped services, although a number of others include these groups under their general programs. All of the states that do have separate programs for the elderly and handicapped also have a general operating-assistance program.

Two states (Missouri and Washington) empower local governments to use certain tax revenues to support local transit service. The approach used in these two states should be distinguished from those programs that use tax revenues to support what is nevertheless a state-administered program. In fact, in Missouri the funding comes from the locality itself, not the state; state involvement is limited to legislation authorizing cities larger than 500 people and selected counties to approve a half-cent sales tax for transportation services. The Washington program permits several types of taxes to be levied by municipalities, counties, or "public transportation benefit areas" for the support of public transportation. The essential element in these programs is the great degree of local autonomy.

Allocation of Funds

The amount of annual state funds made available for operating-assistance programs varies greatly, from \$150 000 in Missouri to \$160 million in California. The total amount identified in the survey was for the most recent fiscal year (usually ending June 30, 1977). More than half of these funds are allocated by three states—California, Illinois, and New York—each of which provides over \$100 million in funds annually. The most generally used source of funding for operating assistance is general revenues (18 programs in 12 states). Several states provide funding from a separate transportation fund (8 programs in 3 states). Four states use sales tax and 2 states use gasoline tax as the principal revenue source of support for public transportation. Other sources of funding include turnpike tolls, motor vehicle registration fees, Title XX funding, and a state lottery.

In its tax-based program, Washington obtains funding from a motor vehicle excise tax, household and business tax, utility tax, motor fuel tax exemptions and refunds, as well as sales tax revenues. Many states use more than one source for funds for their public transit operating-assistance programs.

There are a number of ways in which funds for operating assistance are allocated. The four major bases are formula, financial needs, contracts with operators, and as a match to the UMTA Section 5 program.

Specific criteria for allocating funds are often identified by state programs. Four programs use a formula based on use (passengers) and three programs use service (vehicle-kilometers). Three use population, and one uses population density. Two programs for the elderly and handicapped use the population of these groups as the basis for allocation. Five programs use combinations of these criteria, and four fit into the "other" category.

The second set of mechanisms uses financial need as the principal allocation criterion. Most of these allocate funds on the basis of a portion of the deficit, although a few programs allocate on the basis of a portion of the costs. Six programs allocate funds on a discretionary basis or according to a specified legislative allocation, here presumed to represent interpretations of financial need.

The third basis for allocation is by contract with operators. There are nine programs in which these contracts are deficit based, three in which they are service based, and three in which they are both service and deficit based.

State operating-assistance funds are allocated as a match to the UMTA Section 5 program in 10 states. In states where no local match is required, the federal and state shares are generally split equally. In those areas where the state operating-assistance program serves as a match to Section 5 and a local match is required, the federal, state, and local share breakdown is usually 50, 25, and 25 percent, respectively.

About half (24) of the programs identified require some sort of local match for the state operating-assistance allocation. An equal match is usually required, but it may range from 10 to 70 percent. Some states express the required local match in terms of a percentage of cost or deficit. For example, in Michigan the required match represents up to 33 percent of costs. In New Jersey, at least 25 percent of the costs may be required of the county participating in the program. In Montana the local match in the program for urban and urbanized areas is up to 50 percent of the operating deficit, and in Ohio the local match is up to 25 percent of the deficit. In Iowa the local match is determined on a discretionary basis. There is also some actual or implied discretion on the part of the state in those programs in which a minimum or maximum match is indicated.

In nearly all cases the match is provided by the local government. In five states the match may also be provided by the operator, but in no case is a match required of the operator and not of the local government.

A number of states have programs that require no local match. They are generally special programs for the elderly and handicapped, a program specified for one metropolitan area, a rural program, or a program for modes other than local bus service. The states that require no local match at all are generally small (Connecticut, Delaware, Rhode Island).

A related issue is the matching of section 5 funds at the nonfederal level. In most states more than one source of matching funds is used. The most common source of matching funds is local government contributions or taxes. In 6 states regional financing mechanisms were used, and in 4 others operator contributions were cited as sources of matching funds. In 15 states the state operating-assistance programs provided the nonfederal matching funds.

In those states where the state program is not used as a match, the reason is generally that the state-provided operating assistance is targeted toward areas, modes, and services ineligible for section 5 funding. In the cases of Missouri and Washington, the state-authorized local tax revenues provide the section 5 match.

Eligibility Criteria

Twenty states with transit operating-assistance programs provide aid to urban areas (more than 50 000 people). Oregon provides assistance only to small urban areas. Indiana and Ohio provide funding only to

urban areas, as does Rhode Island (the entire state is considered urbanized).

Fifteen states also provide assistance to rural areas; in 6 of these states separate programs have been established for small urban or rural areas. The 9 others assist nonurbanized areas as part of their general operating-assistance programs.

Similar variations are also evident in the determination of which modes are eligible for assistance. All of the states with operating-aid programs offer assistance to local and commuter bus service. Twelve offer assistance to commuter rail, 10 to rapid transit, and 7 to passenger ferries; the smaller number of states offering assistance to these modes generally reflects the number of states in which these services are available.

The two modes that are variably eligible for funding are intercity bus and shared-ride taxi. Thirteen programs in 12 states provide assistance to intercity buses; 7 programs in 6 states provide assistance to shared-ride taxis. Most of these are programs intended for rural areas.

All of the states with programs are supporting services available to the general public. Most also support separate services for the elderly and handicapped, and seven provide assistance for separate services to young and low-income people. Five programs that were established specifically to assist specialized services were identified. However, in most cases specialized services received assistance through the same program that provides assistance to services for the general public.

Although all of the states surveyed give assistance to public operators, there is a wide variety among the states regarding the eligibility of private operators for state assistance. Only 2 states with programs give no assistance to private operators. On the other hand, 8 states give direct assistance to private operators, and 14 give assistance through local or state sponsorship.

A number of states with multiple programs provide assistance to private operators in some programs but not in others. For example, Maryland provides direct assistance to private commuter rail operators but requires a local sponsor for private operators in the programs that assist local and commuter bus service. Massachusetts gives direct assistance to two regional authorities but requires the other regional transit authorities to contract with private operators. Michigan provides assistance to both public and private local bus service through local sponsors; direct assistance is given to intercity rail services and passenger ferry operators. Two states (Missouri and Wisconsin) have separate operating-aid programs for private, nonprofit operators providing service to the elderly and handicapped.

Use of Funds for Capital

Twelve states indicated that they had programs in which funds could be used for capital as well as for operating expenses. In some cases it was revealed that the program was actually intended for any transit purpose; this is true for the tax-based programs in Missouri and Washington and for the rural assistance program in Montana. In other cases operating assistance may be used on a discretionary basis depending on local need or via a budget amendment. Indiana permits the use of operating assistance for capital when part of the UMTA section 5 allocation to an urban area is going to be used for a capital project. Massachusetts operating-assistance funds are used to pay a portion of the debt service for the transit authorities in the state. In Iowa

Table 1. Summary of state-level assistance to public transportation systems in 1977.

State	No. of Programs	Funding Level (\$000)	Areas Eligible ^a	Modes Eligible ^b	Services Eligible		Capital Purpose Eligibility
					Sector	Type	
California	1	160 000	All	All	Public and private	General and specific	All
Connecticut	1	21 156	U/SU	LB, CR, F	Public and private	General	None
Delaware	3	1 332	All	LB	Public	General and specific	Some
Illinois	3	141 535	U/SU	LB, CR, RT	Public and private	General	Some
Indiana	3	6 500	U/SU	LB, CR, RT	Public and private	General	All
Iowa	1	2 000	All	All but RT	Public and private	General and specific	All
Maryland	4	14 686	All	LB, CR, RT	Public and private	General and specific	Some
Massachusetts	3	92 644	All	All but SRT	Private	General and specific	All
Michigan	4	22 998	All	LB, IB, CR, F	Public and private	General and specific	None
Minnesota	3	14 850	All	LB, SRT, V	Public and private	General and specific	Some
Missouri	2	450	All	All	Public and private	General and specific	Some
Montana	2	150	All	All	Public and private	General and specific	Some
Nebraska	1	1 540	All	All	Public and private	General and specific	None
New Jersey	3	60 427	All	LB, IB, CR	Public and private	General and specific	None
New York	1	104 500	All	All but SRT	Public and private	General and specific	None
Ohio	1	10 400	U	LB, RT	Public and private	General and specific	All
Oregon	1	198	SU	LB, IB	Public and private	General and specific	None
Pennsylvania	2	88 900	All	All but F, SRT	Public and private	General	None
Rhode Island	3	2 724	U	LB, IB	Public and private	General and specific	None
Washington	5	39 045	All	LB	Public	General and specific	All
Wisconsin	3	5 400	All	LB, SRT	Public and private	General and specific	Some

^aAll = urbanized and small urban and rural; U = urbanized; SU = small urban.

^bLB = local and commuter bus; CR = commuter rail, F = passenger ferry; RT = rapid transit; IB = intercity bus; SRT = shared-ride taxi; V = vans; All = all of the above-mentioned modes.

an operator can use up to \$3000 of operating assistance for capital with no match required and can use up to 13.3 percent of its allocation to match federal capital assistance.

Special Programs

Elderly and Handicapped

There are two types of services for which states have developed special operating-aid programs: services for the elderly and handicapped and rural transit services. The surveys revealed that different states use a variety of programs to address these needs.

The following states have developed special programs to assist the elderly and handicapped: Delaware, Illinois, Missouri, New Jersey, Pennsylvania, Rhode Island, and Wisconsin. The programs in Illinois, New Jersey, Pennsylvania, and Rhode Island are used to subsidize reduced fares for the elderly and handicapped. Pennsylvania finances free transit for the elderly from the state-run lottery.

The other three states actually provide assistance for specialized transportation services for these population groups. The program in Delaware consists of a statewide authority that offers transit services to the elderly and handicapped. The program in Missouri is available to nonprofit operators only and is funded from the general fund and from Title XX of the Social Security Act. One of the criteria for allocation of funds in Missouri is the number of persons eligible for Title XX funding.

In Wisconsin the state provides assistance both to counties and to private nonprofit corporations for providing specialized services. The program providing funds for counties also uses the elderly and handicapped population as its basis for allocation.

In addition to those states providing assistance to the elderly and handicapped through specialized programs, nine states indicated that separate services for these population groups were assisted through a more general operating-assistance program.

Rural Areas

Maryland, Montana, Oregon, and Wisconsin had separate

programs of operating assistance for rural areas.

The state of Oregon gives operating assistance only to small urban areas (5000-50 000 people). The other states give money to both urban and nonurban areas under separate programs. In addition, 12 other states provide assistance to nonurban and/or rural areas as part of their general operating-assistance programs.

Many programs that do not specifically recognize the availability of UMTA section 5 funding are in fact intended only for modes and services ineligible for federal operating assistance. Three states have separate programs for rural and nonurban areas, and seven states have separate programs for transportation services for the elderly and handicapped. Michigan also has separate operating-assistance programs for intercity bus and rail passenger services.

SUMMARY AND CONCLUSION

Trends in Programs

The review of previous studies on state assistance programs shows that there has been steady growth in the number of states that have operating-assistance programs. In 1975 only 19 state programs were identified; this study identified 48 such programs. The states that have recently instituted programs have tended to be midwestern states of relatively smaller populations and fewer metropolitan areas than the larger, heavily urbanized states of the Northeast. Increased interest of states in providing assistance to rural areas and to elderly and handicapped services is also evident. The inclusion of small urban and rural areas in the list of eligible recipients for federal operating aid in the Surface Transportation Act should heighten activity in this area even more.

Table 1 summarizes some basic information concerning the 21 states identified as having operating-assistance programs for public transit systems. While the information is not provided on a program-by-program basis, it does allow one to identify, in a particular state, those areas, services, and modes eligible for state-level operating assistance.

In Table 1, the number of programs refers to those indicated on the survey form as being state administered, and funding refers to the total of all state funds allocated

to the programs listed on the survey form and generally represents allocations for that state's fiscal year ended in 1977. Eligible areas represent those for whom state funds would be made available under one or more of the programs reported. Public or private eligibility indicates the ownership and operation of services eligible for assistance under one or more of the programs cited but does not infer anything about matching ratios or required sponsorship. Similarly, only services available to the general public are eligible in the cases cited, but both specialized and general services are eligible for assistance under one or more programs in the states shown. Capital purpose indicates whether funds from all, some, or none of the operating-aid programs identified could be used for capital purposes but does not infer anything about conditions that may affect that availability.

General Conclusions

Some general conclusions that can be drawn from the survey results are

1. Most states with public-transit operating-aid programs are located in the northeastern section of the country, that is, the most densely populated states and the ones with the most extensive transportation systems;
2. The states with the largest populations (California, Illinois, New York, Massachusetts, and Pennsylvania) are also those with the largest state financial commitments to operating-assistance programs;
3. Those same states are also the principal locations of other-than-bus public transportation facilities (commuter rail, rapid transit, and light rail); and
4. The number of different programs offering operating aid to public transit systems largely reflects the variety of different modes eligible for funding in the state; this suggests the existence of modally oriented rather than comprehensive assistance programs.

A major influence on state operating-assistance programs has been the evolution of federal policy on operating assistance for transit systems. Clearly, much of the assistance provided has served as a portion of the nonfederal match for the UMTA section 5 program. The influence of section 5 is also evident in those programs that provide funds for services ineligible for section 5 funding—transit systems in nonurban areas and intercity bus operators—at the time of the survey.

Several states have responded to federal policies on special efforts for the elderly and handicapped by instituting operating-assistance programs for specialized services or reduced-fare programs for these population groups. An increase in the number of states assisting rural, small urban, and intercity operations can be expected because they have recently been included in the eligible categories for federal operating assistance.

Although this study and others have provided descriptive information on capital and operating-

assistance programs in various states, little is known about the relative success of these programs. Comparisons of the strategies pursued by the states of Washington and Missouri in their tax-based programs with the more common practice of allocating funds from general revenues to local areas based on legislatively determined distribution schemes would be particularly relevant for future policy development at both the state and the federal level.

It would be difficult to find conclusive evidence on which type of program is better, but some measurements of relative impacts on services, ridership, financial viability, and so forth could provide legislative and other decision makers with useful background. A number of states have collected and/or published operating data similar to those collected for the annual report on public transportation operating-assistance programs in New York State. Comparisons of these data, as well as an understanding of the varying local conditions among states and operators, offer the potential for assessing a wide variety of program alternatives that could meet local, state, and federal objectives selected as appropriate for public transportation.

Methods for evaluating and monitoring transit operations appear to vary widely among states. States seem to be very interested in performing this role, however, because nearly all respondents indicated some involvement in monitoring operating-assistance recipients.

How information is collected and used, and the extent to which the allocation of funds is influenced by the evaluation process, would be of interest to transportation planners and decision makers.

The institution of a consistent method and format for data collection through section 15 of the Urban Mass Transportation Act is only one phase in the development of evaluation techniques. Additional research could provide information on how those data could be used and how the system could be improved.

REFERENCES

1. Public Transportation Operating Assistance Programs in New York State—1977 Annual Report. New York State Department of Transportation, Albany, Jan. 1978.
2. B. O. Bair and D. J. McKelvey. Current State Practices in Transit Funding. Institute of Urban and Regional Research, Univ. of Iowa, Iowa City, 1975.
3. R. L. Carstens, C. R. Mercier, and E. J. Kannel. Current Status of State-Level Support for Transit. TRB, Transportation Research Record 589, 1976, pp. 14-19.
4. Small City Transit: Summary of State Aid Programs. Transportation Systems Center, Urban Mass Transportation Administration, 1976.

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Revenue and Ridership Changes in Ontario Cities Caused by Transit Fare Increases

J. J. Hajek, Ontario Ministry of Transportation and Communications,
Downsview

This report describes the development, accuracy, and application of a simple method for predicting changes in transit-system revenue (ridership) caused by an increase in fares. The method is based on an empirical cross-sectional model and on data obtained from 29 Ontario transit systems for which all necessary ridership, revenue, and vehicle kilometer data were available. Analysis covered the period of the first nine months after the fare increase. Results show that revenue change caused by a fare increase is predictable and is a function not only of the increase but also of the distance (service level) change, past ridership trends, city size, level of transit service, and time elapsed after the increase. A change in vehicle kilometers can be expected to have a greater effect on revenue than an equivalent percentage change in fares would. The effectiveness of a fare change in producing increased revenue apparently decreases with the time elapsed since the increase.

Rapidly increasing transit operating costs and deficits have induced a number of transit operators in Ontario to increase fares during the last two or three years. The effects of these recent increases were analyzed in view of the following two objectives: (a) providing transit operators with a simple method for estimation of revenue and ridership changes brought on by planned increases in transit fares and (b) providing transportation planners with basic empirical information on transit fare and service elasticities.

Results of these analyses are summarized in this report, which describes a simple method for predicting revenue (ridership) changes caused by changes in fares. It also attempts to separate and quantify the effects of additional variables that influence changes in revenue, such as past ridership trends, service level, employment, city size, time elapsed after the last fare increase, and time interval between the last two fare increases.

PREVIOUS STUDIES

The effect of transit fare increase on ridership has been a subject of numerous studies, most of which, however, have attempted to describe the effect of increased fares by using a two-variable relationship in the form of transit fare elasticity defined, for example, as shrinkage ratio:

$$\text{Ridership shrinkage ratio} = [(Ra/Rb) - 1] / [(Fa/Fb) - 1] \quad (1)$$

where

Ra = ridership after the fare change,
Rb = ridership before the fare change,
Fa = fare after the fare change, and
Fb = fare before the fare change.

The shrinkage-ratio concept has also been used in a recent Ontario transit fare elasticity study (1). This study analyzes effects of fare increases, implemented during 1975 and 1976 in 14 Ontario cities, for the first three months immediately following the increases. According to the study, the ridership shrinkage ratio

for large Ontario cities (more than 200 000 population) was about -0.20. In other words, considering Equation 1, a 10 percent increase in fares would result, during the first three months after the fare increase, in a 2 percent reduction in ridership. The shrinkage ratio for smaller cities was about -0.33, the same shrinkage ratio recommended previously by the so-called Simpson-Curtin formula (2).

MULTIPLE VARIABLE APPROACH

Changes in ridership are influenced not only by changes in fares but also by changes in a number of other factors or variables such as changes in level of service, number of people employed, city size, and length of time elapsed since the increase. The shrinkage ratio, being essentially a two-variable relationship, cannot systematically include the effects of all variables influencing the ridership change. To include additional potential variables and their interaction, a multivariable mathematical modeling approach was used.

DATA BASE

Selection of Systems

To eliminate bias, data for all 29 Ontario transit systems that satisfied basic data requirements of accuracy and completeness were included in the study. The systems are listed in Table 1, which also gives for each transit system the date of the fare increase evaluated in this study, average 1976 monthly ridership, average 1976 monthly vehicle kilometers, time elapsed since the previous fare change, adult cash fares before and after the fare increase, and percentage increase in adult cash fares.

Eight transit systems listed in Table 1 have not experienced a recent fare increase but were included in the analysis to increase the scope of generalization and to provide a measure of ridership change in the absence of fare increase. For three systems (Niagara Falls, Ottawa, Metro Toronto), two consecutive fare increases were included. This resulted in a total sample of 32 observations based on 29 transit systems.

The majority of ridership, revenue, and vehicle kilometer data were collected on a monthly basis and were then aggregated into three-month intervals. The aggregation permitted the inclusion of cities for which only quarterly data were available and helped to mitigate monthly data variation caused by such factors as weather conditions, number of work days per month, and accounting and recording procedures.

The three-month interval was also used to investigate the initial versus subsequent changes in ridership caused by the fare increase. The following four time periods were analyzed:

1. Months 0-3: First three months immediately after the fare increase,

2. Months 3-6: From three to six months after the fare increase,

3. Months 6-9: From six to nine months after the fare increase, and

4. Months 0-6: First six months following the fare increase.

Mathematical models predicting revenue and ridership changes were developed for all four time periods. However, only the models developed for the 0-6 time period are described in detail in this report, because

models for all four time periods are analogous and the number 4 models are deemed to be the most useful for forecasting purposes.

Data Description for Model Number 4

Data for the first six months following the fare increase are summarized in Table 2.

Table 1. Ridership and fare data.

No.	Municipality	Date of Fare Increase	Monthly Ridership	Monthly Vehicle Kilometers	Time Since Previous Change (years)	Adult Cash Fare (cents)		Adult Cash Fare Increase (%)
						Before	After	
1	Fort Frances	4/77	30 000	64 000	2.8	35	35	0.0
2	Port Hope	1/77	60 000	63 000	2.5	25	25	0.0
3	Thorold	5/77	20 000	84 000	1.2	25	35	40.0
4	Orillia	1/75	500 000	214 000	2.5	25	25	0.0
5	Newmarket	1/77	210 000	132 000	5.5	30	30	0.0
6	Stratford	3/76	640 000	473 000	3.5	25	30	20.0
7	Woodstock	8/76	510 000	435 000	8.0	20	30	20.0
8	Pickering	3/77	320 000	707 000	1.0	45	50	11.1
9	Barrie	3/76	520 000	410 000	2.5	25	40	60.0
10	Belleville	4/77	1 010 000	528 000	1.7	30	40	33.3
11	Chatham	6/75	760 000	446 000	10.0	30	30	0.0
12	Welland	3/76	750 000	707 000	2.3	25	35	40.0
13	North Bay	1/77	1 580 000	1 147 000	7.5	25	25	0.0
14	Sarnia	4/76	1 340 000	1 154 000	4.6	25	30	20.0
15	Peterborough	1/77	2 020 000	1 022 000	4.0	25	25	0.0
16	Guelph	8/75	3 100 000	1 173 000	4.0	25	35	40.0
17	Oakville	4/76	1 730 000	1 502 000	3.6	30	35	16.7
18	Niagara Falls	3/76	1 150 000	641 000	6.0	25	30	20.0
19	Niagara Falls	4/77	1 150 000	641 000	1.0	30	35	16.7
20	Brantford	3/77	2 130 000	1 205 000	6.7	25	30	20.0
21	Sault Sainte Marie	2/77	2 890 000	1 600 000	1.8	30	35	16.7
22	Oshawa	1/77	3 100 000	1 717 000	1.3	35	35	0.0
23	Saint Catharines	4/77	4 710 000	2 779 000	1.8	30	35	16.7
24	Kitchener-Waterloo	3/76	7 190 000	3 982 000	5.5	25	35	40.0
25	Windsor	3/76	6 480 000	3 410 000	4.0	35	40	14.3
26	London	3/76	3 530 000	7 073 000	5.0	30	40	33.3
27	Mississauga	4/77	7 430 000	6 128 000	0.9	50	55	10.0
28	Hamilton	3/76	24 150 000	12 281 000	6.9	30	40	33.3
29	Ottawa	3/76	50 920 000	28 101 000	5.3	30	40	33.3
30	Ottawa	3/77	50 920 000	28 101 000	1.0	40	50	25.0
31	Metro Toronto*	3/76	99 999 000	127 915 000	0.9	40	50	25.0
32	Metro Toronto*	1/77	99 999 000	127 915 000	0.8	50	55	10.0

*Actual 1976 monthly ridership was 29.2 million passengers.

Table 2. Data for model number 4.

No.	Municipality	Vehicle Kilometer Change (\$)	Average Fare Increase (\$)	ICI Change (\$)	ARF	Ridership Change (\$)	Revenue Change (\$)
2	Port Hope	-0.72	0.0	1.00	1.036	1.02	1.69
3	Thorold	-22.78	17.50	-2.09	1.095	-35.46	-24.16
4	Orillia	-0.65	0.0	-0.56	1.110	8.27	8.48
5	Newmarket	1.02	0.0	2.37	1.031	3.04	3.04
6	Stratford	6.46	26.54	5.95	1.048	1.69	27.99
7	Woodstock	3.31	33.33	5.56	1.432	3.60	38.14
8	Pickering	-2.88	22.46	0.52	1.227	-6.02	15.22
9	Barrie	61.94	57.62	4.58	1.297	14.71	80.64
10	Belleville	-4.95	25.12	0.73	0.829	-10.79	11.62
11	Chatham	1.24	0.0	4.06	1.135	-1.87	14.53
12	Welland	17.63	44.39	-1.01	1.441	3.33	49.22
13	North Bay	9.77	0.0	0.09	0.978	8.73	16.95
14	Sarnia	-5.94	39.50	5.52	1.247	1.70	41.93
15	Peterborough	4.19	0.0	-7.68	0.843	13.64	12.01
16	Guelph	10.50	25.10	-0.22	1.143	7.61	34.61
17	Oakville	0.01	26.57	1.56	1.200	-6.58	18.24
18	Niagara Falls	-9.34	37.15	0.09	1.100	-13.34	18.95
19	Niagara Falls	10.61	19.69	5.06	0.972	-1.93	17.29
20	Brantford	4.30	15.15	2.02	1.020	-2.41	12.33
21	Sault Sainte Marie	-0.62	42.25	-0.33	1.051	-16.54	18.77
22	Oshawa	-3.44	0.0	4.96	0.986	-0.84	0.69
23	Saint Catharines	0.14	13.19	-0.19	1.026	0.61	14.21
24	Kitchener-Waterloo	-5.96	43.88	2.69	1.049	-13.22	24.87
25	Windsor	-2.13	19.28	9.08	1.053	-3.89	14.52
26	London	0.05	41.83	1.14	1.014	-10.70	26.69
27	Mississauga	0.91	6.31	0.62	1.076	3.25	9.74
28	Hamilton	2.29	25.22	0.50	1.067	1.43	27.02
29	Ottawa	8.18	17.62	1.54	1.140	13.38	31.29
30	Ottawa	3.86	7.50	1.57	1.099	9.93	18.19
31	Metro Toronto	0.04	23.44	1.54	1.017	-3.34	19.28
32	Metro Toronto	-0.58	14.26	0.53	0.953	-2.17	11.77

Figure 1. Time periods used for number 4 models.

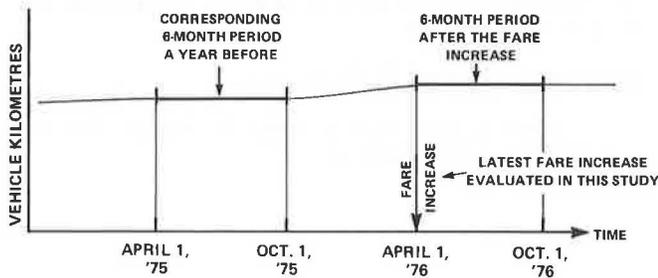
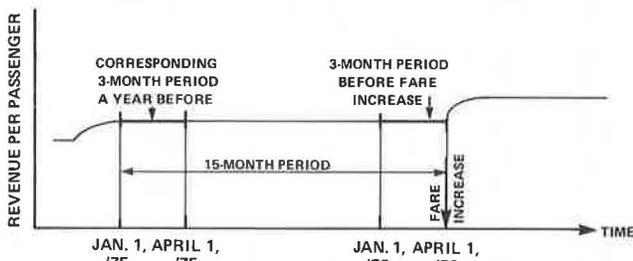


Figure 2. Time periods used for calculation of adjustment revenue factor.



Change in Vehicle Kilometers

The change in vehicle kilometers operated by a transit system while it provides regular passenger service during the first six months after the fare increase can be expressed as a percentage. The change is based on the vehicle kilometers operated during the corresponding six-month period a year before. The time periods used for the number 4 models are schematically shown in Figure 1. The average change in vehicle kilometers was about +3.0 percent.

Data unavailability made it impossible to distinguish where, when, and why the changes in vehicle kilometers occurred.

Average Fare Increase

Average fare increase is defined as the percentage increase in the average revenue per passenger during the first six months after the fare increase. The increase is related to the average revenue per passenger during the corresponding six-month period a year before. The average fare increase depends on the overall change in the transit fare structure and may not be equal to the increase in the adult cash fare. For this reason, average fare increase rather than adult cash fare increase was used in the model. The average increase, for the 24 observations of fare increase, was about 26 percent.

Change in Industrial Composite Index

Industrial Composite Index (ICI) is an employment index reported by Statistics Canada (3). It reflects change in employment for industrial and commercial establishments of 20 or more employees. As such, the ICI provides both a certain measure of general economic activity and a measure of population change. It is expressed as a percentage change in the ICI, unadjusted for seasonal variations, during the first six months after the fare increase, based on the ICI during the corresponding six-month period a year ago.

Unemployment rate may be a better measure of general economic activity; however, Statistics Canada (4) reports the unemployment rate only on a regional basis (Ontario is divided into 10 economic regions).

Adjustment Revenue Factor

The adjustment revenue factor (ARF) was calculated by dividing the total passenger revenue during the three months preceding the fare increase by the total passenger revenue during the corresponding three-month period a year before.

The time periods used for the calculation of ARF are schematically shown in Figure 2. ARF is designed to take into account past trends in ridership and may be considered a surrogate for many contributing but non-measurable variables. The ratio of revenues rather than a ratio of riderships was used in its calculation because the ridership is a secondary, derived variable usually estimated from the revenue.

The ridership estimate is based on the total value of received revenue (in terms of cash fares, tickets, and tokens) and assumed proportions of different fare groups (adults, children, students, senior citizens). The average ARF was about 1.09.

If the fares were actually increased during the time span for which ARF is being calculated, i.e., any time during the 15-month period preceding the last fare increase (see Figure 2), ARF would not reflect past trends in ridership. It would mainly reflect past trends in revenue. In this case, ARF should be calculated as a ridership ratio.

Ridership Change

Ridership change was defined as the percentage change in the number of revenue passengers carried by regular service during the first six months after the fare increase as compared to the number of revenue passengers carried during the corresponding six-month period a year before. The change in ridership ranged from an increase of 14.7 percent to a decrease of 35.5 percent (Table 2, column 7); average ridership decrease was about 1.1 percent.

Revenue Change

Revenue change was defined as the percentage change in revenue (from regular passenger service) during the first six months after the fare change based on revenue during the corresponding six-month period a year before. The average increase in revenue was about 18.5 percent.

DEVELOPMENT OF MODELS

A number of mathematical models empirically relating revenue and ridership changes to various independent variables were constructed and evaluated by using a least-squares technique. The following two models were chosen for their accuracy and simplicity.

$$\text{Revenue change} = -40.0 + 0.68 M + 0.41 F + 35.4 \text{ ARF} + 2.85 \log R - 5.8 S \quad (2)$$

$$\text{Ridership change} = -30.0 + 0.50 M - 0.42 F + 24.2 \text{ ARF} + 2.57 \log R - 4.8 S \quad (3)$$

where

M = change in vehicle kilometers (percent),
F = increase in average fare (percent),

ARF = adjustment revenue factor,
 R = average 1976 monthly transit ridership in passengers (maximum value is 10^7 passengers), and
 S = service level factor or $S = V/R$, where V is average 1976 monthly vehicle kilometers operated by the system and R is as defined above,

and where the revenue change is the percentage change in revenue during the first six months after the fare increase, and the ridership change is the percentage change in ridership during the first six months after the fare increase.

The average 1976 monthly ridership and vehicle kilometer data were used in the models because 1976 was the last year for which the data were available for all transit systems evaluated.

Assuming that the relationships in Equations 2 and 3 are valid for other transit systems and times, the model equations can be used for predicting revenue and ridership changes caused by increased fares and simultaneous increases in fares and service levels.

MODEL EVALUATION

Statistical Evaluation

The table below shows standard errors of estimate and multiple correlation coefficients for the two models.

Model	No. of Observations	Standard Error of Estimate (%)	Multiple Correlation Coefficient
Revenue change	32	3.95	0.978
Ridership change	32	4.01	0.931

The multiple correlation coefficient for the revenue-prediction model was 0.978, which indicates that about 96 percent (0.978^2) of the total variance in this variable was explained by the model. This is a relatively high percentage considering the amount of data aggregation and number of potentially significant factors not included in the model for lack of data or the absence of statistical significance. Examples of these are measures of economic activity, weather, comfort and convenience, advertising, and publicity.

The fact that 4 percent of the variance was not explained by the revenue-prediction model does not necessarily mean that all other variables not included in the revenue-prediction model account for only 4 percent of the change in transit revenues and are thus more or less insignificant in affecting transit revenues.

The selection of variables included in the model was not entirely predetermined and this, together with sample correlation and the inherent reliability, or rather unreliability, of multiple correlation coefficients (7) may have resulted in the overestimation of the multiple correlation coefficient of the sample.

All partial regression coefficients of the models were significant at the 0.01 probability level.

According to the table above, the accuracy of the revenue-change model was higher than the accuracy of the ridership-change model. This difference in the accuracy is also illustrated in Figures 3 and 4 (the numbers correspond to those in Table 1), which show plots of predicted versus observed values for the two models. The lower accuracy obtained for the ridership change model may have been caused by the procedure by which the ridership was derived from revenue and particularly by the changes in this proce-

dure with time. Consequently, whenever possible, priority should be given to the revenue-change model.

Sensitivity of Model Variables

This section contains a brief evaluation of the influence of model variables as predicted by the models. Emphasis is placed on the revenue-prediction model; the evaluation of the ridership model would be analogous.

Effect of Vehicle Kilometers

The change in vehicle kilometers was found to be the most significant variable and to have the highest correlation with revenue change. This result is in agreement with those of previous studies that service elasticity is generally larger than fare elasticity (1, 6, 7). The partial regression coefficient for the change in vehicle kilometers (0.68 in Equation 2) suggests that each 10 percent change in vehicle kilometers results in a 6.8 percent change in revenue during the first six months after the fare increase.

The model's effect of distance change is an average aggregated effect. Because data were unavailable, when (for example, peak period versus off-peak period or for weekday versus weekend), where (change in route alignment versus change in headways), and why (to improve level of service versus to meet capacity requirements) the change occurred were not distinguished.

Effect of Fare Increase

The fare increase was the second most significant variable. The partial regression coefficient for the average fare increase suggests that each 10 percent increase results in a 4.1 percent increase in revenues during the first six months after the fare increase. This corresponds to a revenue fare elasticity (or shrinkage ratio) of about -0.4.

The effect of fare increase is an aggregated effect that reflects only the average increase in the fare structure. However, different market segments (children, students, adults, senior citizens) may have quite different fare elasticities for the same fare increase. Moreover, in many cases, transit fares were not increased uniformly for all market segments.

Effect of ARF

ARF is intended to take into account past trends in ridership. This is necessary in order to estimate what the revenues would have been without the increase. ARF reflects ridership growth, unadjusted for weather variations, during the year preceding the fare change. According to the partial regression coefficient of 35.4, for each 1 percent change in revenue during the year preceding the fare change, we can expect a corresponding 0.35 percent change in revenue during the next six months.

Effect of Service-Level Factor and Ridership Size

Service-level factor (defined as the ratio of average monthly vehicle kilometers to average monthly ridership) and ridership have been included in the model to reflect the effects of these closely interrelated variables on fare elasticity.

1. Level of service: Transit riders are more sensitive to fare increases if the level of service is low. Level of service usually increases with an increase in city size.

2. Proportion of work trips: The fare elasticity is lower for work trips than for other trip purposes (8). The proportion of work trips usually increases with city size.

3. City size: City size is highly correlated with ridership size, a variable included in the model. Fare elasticity usually decreases with an increase in city size because of differences in level of service, propor-

Figure 3. Comparison of observed versus predicted change in revenue.

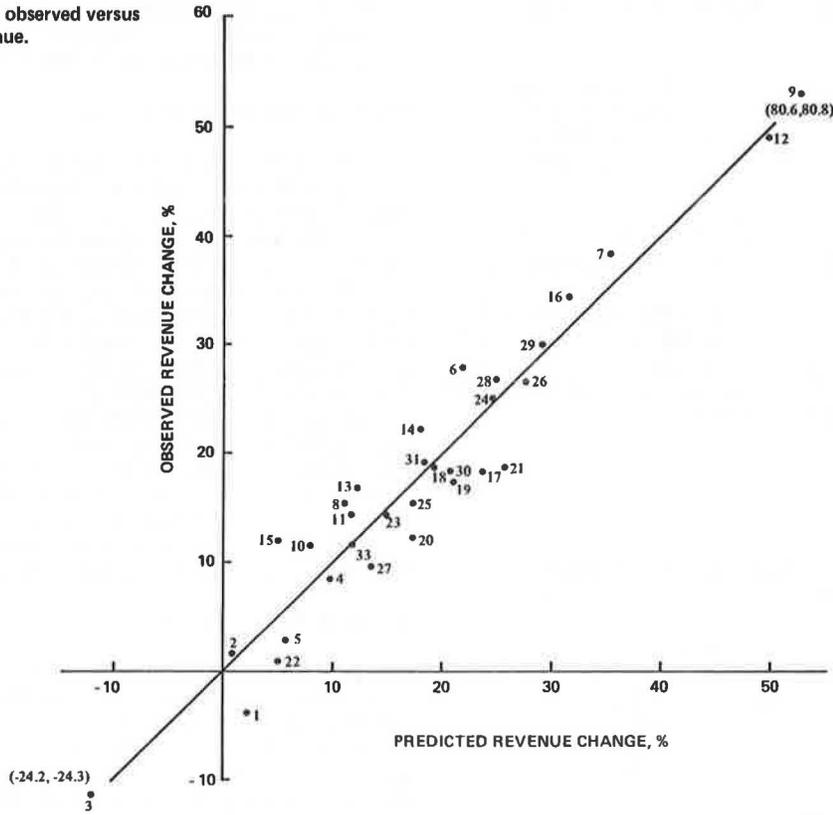


Figure 4. Comparison of observed versus predicted change in ridership.

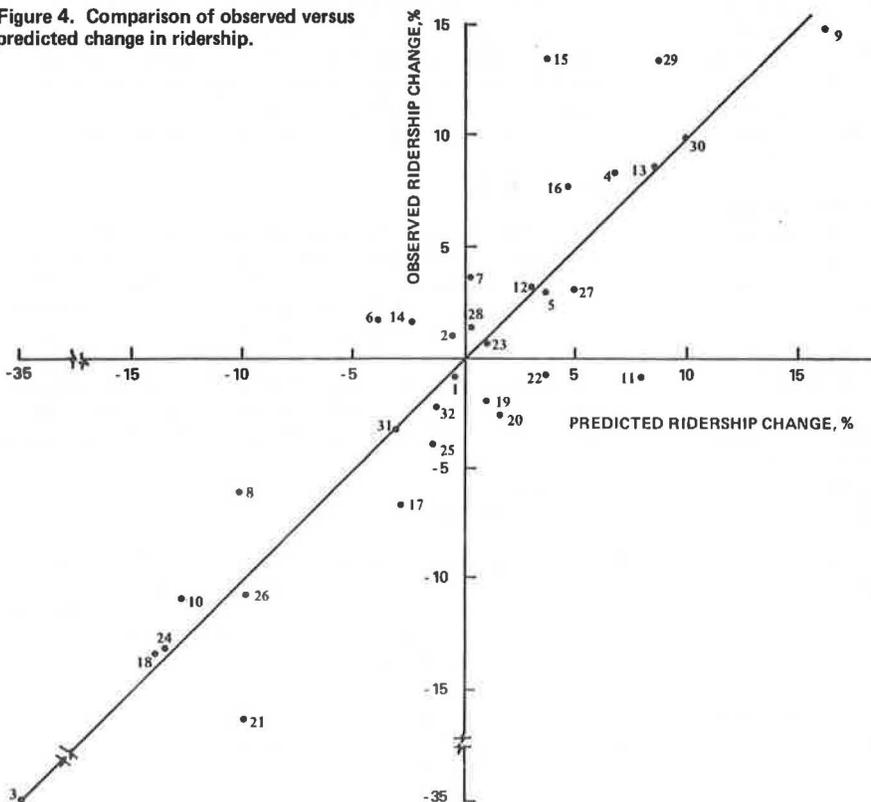


Figure 5. Definition of time intervals between and after fare increases.

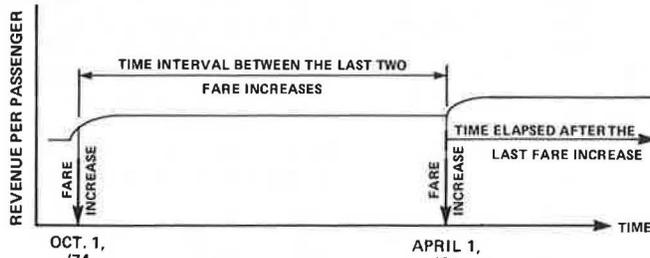


Table 3. Partial regression coefficients for average fare increase obtained for revenue-prediction models.

Time Period After Fare Increase (months)	Partial Regression Coefficient	Standard Error of Partial Regression Coefficient	t-Test	No. of Observations
0-3	0.452	0.0768	5.88	32
3-6	0.331	0.0789	4.20	32
6-9	0.203	0.1212	1.67	30

Table 4. Overall longer-term effects of fare increase.

Time Period After Fare Increase (months)	Average Fare Increase (%)	Average in Vehicle Kilometer Change (%)	Average Revenue Increase (%)	Average Ridership Change (%)	No. of Observations*
0-3	26.52	3.52	24.88	-1.33	24
3-6	25.50	2.72	20.19	-4.06	24
6-9	26.78	3.55	23.25	-2.32	21

*Only transit systems with fare increases were included.

tion of work trips, parking restrictions in downtown areas, and other factors.

The sign of the partial regression coefficient for the service-level factor indicates that its increase, usually associated with a reduction in city size, would result in a revenue reduction. The partial regression coefficient for ridership suggests that each 10-fold increase in ridership size results in an additional 2.85 percent increase in revenue change (all other variables being constant). One should note that variable ridership size is essentially used as a surrogate variable for "city population served by transit," which was not available.

EFFECT OF VARIABLES NOT INCLUDED IN MODELS

Time Interval Between the Last Two Fare Increases

The time interval between the last two fare increases was defined as years between the previous fare increase and the last fare increase (see Figure 5, where the numbers correspond to those in Table 1). The last increase is by definition the one evaluated in this study, and it was the latest fare increase for which all pertinent data were already available.

This variable, in its logarithmic form (logarithm of values in Table 1, column 6) was found to be statistically significant only at the 0.05 probability level and as such it was not included in the models. Results obtained for this variable indicated that the length of time between the last two fare increases has a beneficial (but not statistically reliable) effect on revenue. This is a quite logical effect considering that the fare increases were not deflated. Thus, a 30 percent fare increase after

five years since the previous fare increase may represent only a marginal real increase in fares if adjusted for inflation.

Change in Economic Activity

Because of the lack of better indicators, the change in general economic activity was measured by ICI. This index in its logarithmic form (logarithm of Table 2, column 5) was found to be statistically significant at about the 0.05 probability level for some models. Results suggest that the increase in ICI increases transit revenues, while the reduction in ICI has no effect on revenues. This is a preliminary observation; a better measure of economic activity is needed for a more authoritative conclusion.

Elapsed Time After Fare Increase

The influence of the length of time elapsed after the fare increase on revenue and ridership was analyzed with the help of three analogous revenue- and ridership-change models developed for the three consecutive time periods: (a) three months after the fare increase (0-3), (b) from three to six months after the fare increase (3-6), and (c) from six to nine months after the fare increase (6-9).

Partial regression coefficients for the variable fare change obtained for the three consecutive time periods after the fare increase are summarized in Table 3. Using the t-test, it may be shown that the difference between the partial regression coefficient obtained for the time period 0-3 (0.452) and the corresponding coefficient obtained for the time period 6-9 (0.203) is statistically significant. This indicates that the effect of fare increases on transit revenues changes with the length of time elapsed after the date of the fare increase.

The effectiveness of a fare change in producing increased revenue decreases with the time elapsed since the fare increase. For example, according to the models (see Table 3), while each 10 percent increase in fares resulted in a revenue increase of about 4.5 percent during the first three-month period (0-3 months), during the last three-month period (6-9 months) it resulted only in a revenue increase of about 2 percent. It appears that transit riders need some time before they can switch to other modes of transportation or eliminate certain unessential trips or both.

The overall average trends in revenue and ridership are illustrated in Table 4. According to the table, both revenue and ridership declined during the latter time periods in spite of the increase in vehicle kilometers.

Other model variables were not influenced by the elapsed time after the fare increase.

CONCLUSIONS

1. Revenue (or ridership) change caused by a fare increase is predictable and is a function of at least the following variables: fare change, distance change, past ridership trends, city size, level of transit service, and time elapsed since the fare increase. In addition to these basic variables, other marginal variables such as length of time elapsed between the last two fare increases and a change in general economic activity may be important.

2. No transit system studied suffered a loss of revenue from increased fares, with the exception of Thorold, where a 17 percent increase in average fares coincided with a 22 percent reduction in vehicle kilometers.

3. A given percentage change in vehicle kilometers

(change in level of service) has a greater effect on revenue (ridership) than an equivalent percentage change in fares.

4. The effectiveness of a fare increase in producing increased revenue decreases with the time elapsed since the increase. It appears that transit riders need some time after the fare increase before they can switch to other transportation modes or eliminate certain unessential trips or both.

5. An overall revenue increase may be a sufficient parameter for financial and budgetary purposes. However, in view of the role of public transit in today's society, we need a better understanding of the effect of transit fare increases on different socioeconomic and demographic groups.

6. The models are not suitable for estimation of revenue or ridership changes in the absence of a significant fare increase. An extrapolation of historical trends will probably yield better results. The models are also unsuitable for estimating revenue or ridership changes brought about by only a small change in vehicle kilometers. Better estimates of future revenue or ridership changes may be obtained by specific analysis of routes, time periods, and reasons for which the distance changes are planned.

7. For long-term use the models presented in this report should be checked and updated periodically.

REFERENCES

1. A. J. Ugge and P. M. Dalton. Urban Transit Fare

- Increase Effects on Ridership in Ontario Cities. Systems Research and Development Branch, Ontario Ministry of Transportation and Communications, Downsview, Internal Rept., Feb. 1977, pp. 1-22.
2. J. F. Curtin. Effects of Fares on Transit Riding. HRB, Highway Research Record 213, 1968, pp. 8-18.
3. Employment Earnings and Hours. Statistics Canada, Labour Division, Ottawa, Catalogue 72-002, Vol. 55, No. 10, Oct. 1977.
4. The Labour Force. Statistics Canada, Labour Division, Ottawa, Catalogue 71-001, Jan. 1978.
5. M. Ezekiel and K. A. Fox. Methods of Correlation and Regression Analysis. 3rd Ed. Wiley, New York, 1959, pp. 293-299.
6. R. L. Carstens. A Model for Estimating Transit Usage in Cities in Iowa. HRB, Highway Research Record 213, 1968, pp. 42-49.
7. Y. Chan and F. L. Ou. Tabulating Demand Elasticities for Urban Travel Forecasting. TRB, Transportation Research Record 673, 1978, pp. 40-46.
8. W. Lassow. Effect of the Fare Increase of July 1966 on the Number of Passengers Carried on the New York City Transit System. HRB, Highway Research Record 213, 1968, pp. 1-7.

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Abridgment

Who Pays the Highest and the Lowest Per-Kilometer Transit Fares

Wayne R. Ugolik, New York State Department of Transportation, Albany
Clark B. Leutze, State University of New York at Albany

Most U.S. transit systems charge a basic flat fare for bus trips within large zones surrounding urban centers, and additional incremental charges for longer intercity and intraurban bus trips. Naturally, under such fare structures, fares per kilometer for transit users vary greatly as trips differ in length. But, since such differences are often correlated with differences in rider characteristics, the issue of the equity of such fare structures has recently come into focus (1-3), particularly in light of transit-operating subsidies. The concept of distance-based fare structures has been proposed as a means to increase ridership and revenues while equalizing fares per kilometer across all transit users (4, 5). Therefore, the issue of fare equity needs to be considered by transportation planning professionals.

This paper takes a close look at fare equity, from the standpoint of the transit user, by investigating fares per kilometer paid by different groups of bus riders.

STUDY AREA

The research consisted of an examination of the ridership profile of the transit system operating in the capital district of Albany, New York, an area comprising three

medium-sized cities within a radius of about 16 km (10 miles)

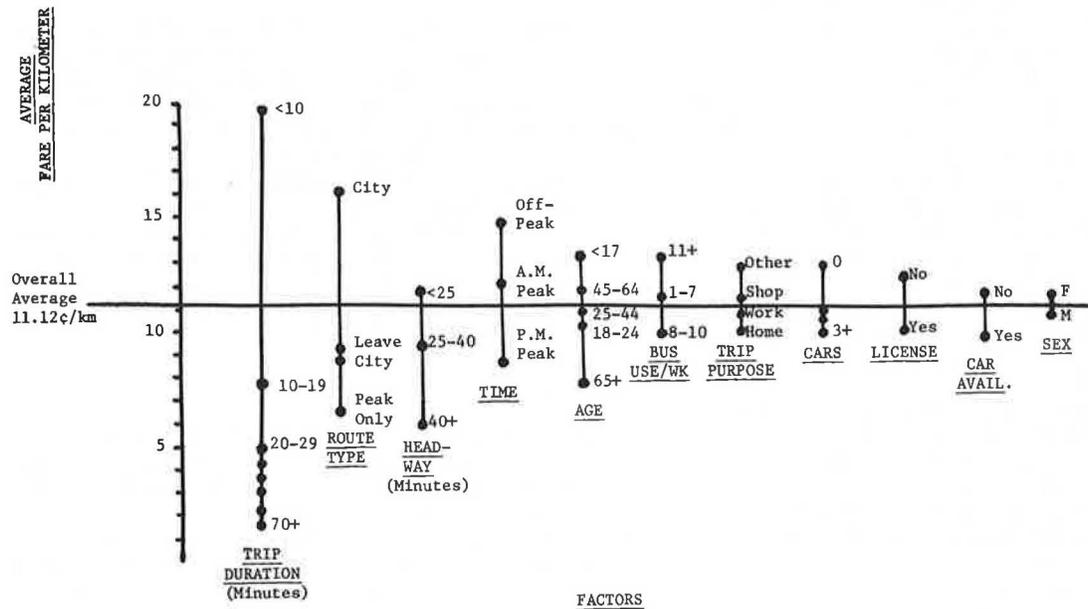
The fare structure is a basic flat rate. Riders within the urban centers pay 40 cents plus additional increments up to a maximum fare of 75 cents for intercity and intraurban bus trips. It should be noted that there are half-fare rates available to senior citizens and handicapped persons and special discount commuter and school passes.

The data base consisted of coded responses to questionnaires distributed during an on-board survey conducted in November 1975. More than 1100 questionnaires were analyzed; an average of 43 300 one-way trips are made daily on the system. Each questionnaire is related to one bus trip. Using information asked of the respondents concerning origin, destination, and fare paid, the fare per kilometer and the trip duration (in minutes) for each bus trip were calculated.

DIFFERENCES IN AVERAGE FARES PER KILOMETER

The average fare per kilometer for all riders in the sample was 11 cents/km (18 cents/mile) with a standard

Figure 1. Differences in average fares per kilometer.



deviation of nearly 9 cents/km (15 cents/mile). There is obviously a great deal of variation in fares per kilometer paid by different transit users. Some riders are getting a very good bargain; others are not. By analyzing the survey data on the average fares per kilometer for different classes of riders and types of trips, the study showed who these people are.

Figure 1 illustrates the differences in average fares per kilometer paid by different groups of riders. The groups determined by the factor trip duration show the greatest spread in average fares per kilometer. One-third of all riders traveled less than 10 min on the bus and averaged 20 cents/km (32 cents/mile). The next group, composed of riders who traveled between 10 and 20 min on the bus (42 percent of the sample), had an average fare per kilometer of only 8 cents (13 cents/mile).

Interestingly, about 10 percent of the riders traveled over 30 min on the bus and averaged less than 4 cents/km (7 cents/mile). These are the people traveling on intercity and intraurban bus routes. Comparison of their average fares per kilometer with those of people traveling less than 10 min on the bus shows clearly that basically flat-fare structures skew fares per kilometer in favor of the longer-distance traveler.

A look at average fares per kilometer on different types of bus routes indicates further that those who travel farther receive the greatest bargain. Indeed, riders traveling within the city centers (25 percent) pay an average fare per kilometer of 16 cents (26 cents/mile), which is more than 6 cents higher than that of the riders traveling on intercity routes (26 percent) or routes that leave the city limits (24 percent). Moreover, 7 percent of the sample rode on special peak-hour work-trip routes and averaged paying less than 7 cents/km (11 cents/mile).

In light of the fact that bus routes that reach into the suburbs have longer headways than inner city routes, it is of interest that on routes with headways of more than 40 min, fares per kilometer averaged 6 cents less than on routes with headways less than 25 min. This indicates that suburban riders receive a far better per-kilometer bargain than inner city riders, mainly because they must travel farther to reach centers of business and employment.

A study of the time the bus trips were made showed that midday off-peak riders (28 percent) averaged a fare per kilometer of over 13 cents (21 cents/mile), which is nearly 5 cents (8 cents/mile) higher than the average fare per kilometer paid by afternoon peak-hour riders. The latter group most likely comprises riders returning home from work. Interestingly, morning peak-hour riders paid an average fare per kilometer 1 cent above the overall average of 11 cents. This is due to the fact that, during the morning hours, some riders are using the bus for nonwork, personal business and school trip purposes, since work trips (37 percent) averaged 11 cents/km (17 cents/mile), while nonwork, nonshopping trips (24 percent) averaged 13 cents/km (21 cents/mile). All shopping trips (6 percent) averaged 11 cents/km (18 cents/mile).

Analysis of the ages of the bus riders showed that those under 18 years of age (15 percent) averaged the highest fare per kilometer, 17 cents (27 cents/mile). People over 65 (6 percent) averaged the lowest fare per kilometer, 8 cents (13 cents/mile), because they paid the special half-fares offered to the elderly. Discarding these extremes, it is noteworthy that, as age increases, average fare per kilometer tends to increase.

More interesting, however, is the fact that the study showed no appreciable difference between the average fare per kilometer paid by men and women. Indeed, even though women riders (68 percent) greatly outnumbered men riders, the average fare per kilometer for women was 11.3 cents (18 cents/mile), while that for men was 10.8 cents, a difference of only half a cent.

Intimately connected with bus use is the concept of need for the bus. Clearly, people who do not have cars available for use need the bus more than those who do have available cars. The riders who had cars available (21 percent) averaged a fare per kilometer of 9.6 cents (15.4 cents/mile); those without averaged 11.6 cents (18.6 cents/mile). Moreover, riders without valid driver's licenses (51 percent) averaged 12.2 cents/km (19.6 cents/mile), while those with them averaged only 10 cents/km (16.1 cents/mile).

Average fares per kilometer decrease with the number of cars in the rider's household. Indeed, 31 percent of all riders had no cars in their households and aver-

aged 13 cents/km (20 cents/mile), while 26 percent of the riders had two or more household cars and averaged less than 10.3 cents/km (16.5 cents/mile) for their bus trips.

A look at the factor average weekly bus use shows that riders who used the bus 8-10 times per week (40 percent) averaged only 10 cents/km (16 cents/mile), but those who used the bus 11 or more times per week (18 percent) averaged over 13 cents/km (21 cents/mile). The latter group is people who must regularly use the bus for most if not all of their transportation needs, whereas the former group is regular work-to-home commuters. Thus, there is strong and consistent evidence that people who need the bus most must pay the highest fares per kilometer.

The relationship between fare per kilometer and frequency of bus use has been studied in relation to the economics of demand (6). Results show that frequency of use is highly inelastic with respect to fare per kilometer, which implies that need plays a larger role than out-of-pocket cost in the process of deciding to use the bus. This, together with the results of this paper, suggests that the distribution of fares per kilometer is most unfair; those adversely affected are generally unable to use transit selectively and must use the bus as the only means of transportation available to them.

In addition to studying average fares per kilometer for different classes of transit users, a computerized data analysis scheme called automatic interaction detection (AID) was used to determine which factors explained the most variation in fares per kilometer (7). The results of this analysis were consistent with the picture of the variations in average fares per kilometer presented in Figure 1.

Indeed, the figure indicates large differences between the average fares per kilometer of groups of riders defined by trip duration, route type, and bus headway. These were the same factors that best explained the variation in fares per kilometer (57 percent explained); the factor trip duration explained the most variation (38 percent). None of the other factors proved effective in explaining the remaining variation. This is due to the interrelations among many of them; for example, the variation explained by work trips is explained by trips of longer duration, since work trips tend to be longer trips.

SUMMARY AND CONCLUSIONS

The research reported here showed that fares per kilometer vary greatly among different transit users and that, even when incremental fares are charged in addition to basic flat fares on longer intercity and intraurban routes, the fares per kilometer of bus trips tend to be inversely proportional to the length of bus trips.

Work-to-home trips cost less per kilometer than non-work-related trips; people without cars or unable to use cars pay higher fares per kilometer on the average than do those with cars available. The average fare per

kilometer of peak-hour riders is less than that of off-peak riders.

In addition, it was found that there was no appreciable difference in fares per kilometer paid by men versus women but that there is a tendency for fares per kilometer to rise as age increases from 18 to 65. Thus, current basically flat-fare systems tend to emphasize inequities already existing in society.

A priori, distance-based fare structures would equalize fares per kilometer across all groups of transit users. Basic research has shown that such fare structures can also maintain ridership and revenue levels (8). Further research into practical ways to implement such fare structures is needed. A preliminary study may be found in Natalizio (9).

REFERENCES

1. D. L. Weiss, D. T. Hartgen, and G. S. Cohen. Equity in New York State Transit Fares. Planning Research Unit, New York State Department of Transportation, Albany, Oct. 1975.
2. D. L. Weiss and E. P. Donnelly. Characteristics of New York State Transit Users. Planning Research Unit, New York State Department of Transportation, Albany, Aug. 1976.
3. D. L. Weiss and D. T. Hartgen. Revenue, Ridership, and Equity of Differential Time-of-Day Fares. Planning Research Unit, New York State Department of Transportation, Albany, April 1976.
4. Peat, Marwick, and Mitchell. Public Transportation Fare Policy. Urban Mass Transportation Administration, U.S. Department of Transportation, May 1977.
5. Financing New York City's 1976 Transit Deficit. Planning Division, New York State Department of Transportation, Albany, Staff Rept., June 1975.
6. W. R. Ugolik. Demand Elasticities of Per Mile Transit Fares. Planning Research Unit, New York State Department of Transportation, Albany, Feb. 1978.
7. J. A. Sonquist and J. N. Morgan. The Detection of Interaction Effects. Survey Research Center, Institute for Social Research, Univ. of Michigan, Ann Arbor, Monograph 35, 1970.
8. D. P. Blou, D. T. Hartgen, and L. Mohan. Distance-Based Transit Fares: Robin Hood or Sheriff of Nottingham? Planning Research Unit, New York State Department of Transportation, Albany, Aug. 1978.
9. F. Natalizio. Study of the Implementation Issues of a Distance-Based Fare for the Albany Transit System. School of Business, State Univ. of New York, Albany, May 1978.

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Forecasting Demand and Revenue for Transit Prepaid Pass and Fare Alternatives

Thomas E. Parody and Daniel Brand, Charles River Associates, Boston

This paper presents a relatively low-cost, easily implemented method for forecasting the demand and revenue impacts of alternative transit-fare prepayment (TFP) instruments and transit fares. In addition, alternative TFP strategies and their price implications are derived in some detail from basic TFP objectives. The forecasting technique focuses on computing price elasticities by individual market segments by using data from previous fare and service changes and then applying these results to forecast changes in the present transit system. The market segments are chosen to correspond with the issues being analyzed, thereby increasing the usefulness and accuracy of the procedure. To illustrate how the technique can be used to forecast the impacts of different monthly transit pass programs along with increases in transit fares, a case-study approach that uses local data from the Jacksonville, Florida, transit system was chosen. The data required in the analyses are typically available from most transit properties; therefore, the method is readily transferable to other areas.

This paper presents a method for forecasting ridership and revenue impacts of alternative transit-fare prepayment (TFP) instruments and transit fares. In addition, alternative TFP strategies and their price implications are derived in some detail from basic TFP objectives. The forecasting method uses demand elasticities derived from past changes in transit fare and supply for the system being studied. These elasticities are then used to project future patronage levels based on proposed changes in the TFP structure and fares on the present transit system.

In addition to being quickly and inexpensively implementable, the major advantage of this forecasting approach is its use of demand elasticities computed from prior changes in the same transit system rather than the more typical approach of transferring elasticities that have been observed elsewhere (either empirically or analytically through the use of models). This procedure greatly reduces the effect of numerous exogenous factors that vary from one locality to another and are normally not included in demand models or elasticity calculations. In particular, the approach automatically controls for the distribution of most socioeconomic variables (income, automobile ownership, etc.) and, to a large extent, many site-specific variables (geography, alternative transportation system characteristics, the particular structure of travel in the region, etc.) so that the same change in the transit system is being made and analyzed over different time periods.

To illustrate the method, a case-study approach is used with local data from the Jacksonville, Florida, Transportation Authority (JTA) transit system. As the data required are typically available from most transit properties, the approach is readily transferable to other areas.

Since 1970 the use of monthly transit passes by U.S. transit operators has been growing rapidly. A recent study of TFPs used by transit agencies in the United States has shown that, whereas only a few cities were using monthly passes as of 1970, 36 transit systems were using these passes in 1975 (1). Within the last year, monthly transit pass programs have begun in

Dallas, Columbus (Ohio), Chicago, Sacramento, Houston, Hartford, Detroit, and Ann Arbor (2).

Currently, JTA is in the process of implementing an employer-based monthly transit pass program as part of a demonstration funded by the Urban Mass Transportation Administration (UMTA) under a service and methods demonstration program. Because of the growing use of this type of fare payment system, it is useful to analyze procedures for forecasting the ridership and revenue responses that can be expected from implementing a TFP program.

OVERVIEW OF THE JTA TRANSIT SYSTEM

As a prelude to analyzing the impacts of alternative TFP and fare strategies, this section describes some of the relevant characteristics of the JTA transit system at the time this study was performed. (After the study, base transit fares in Jacksonville were raised by 10 cents and changes were made in TFP structure and pricing.)

On July 15, 1970, before public acquisition of the transit system, adult bus fares were raised by 5 cents, from 25 to 30 cents. The before-and-after data from this fare change will be used to derive the price elasticities required for the later analyses. After the system was publicly acquired at the end of 1972, base adult fares were reduced back to 25 cents, where they were at the time of this study (early 1978).

JTA currently sells an unlimited-use weekly pass for \$5.00. In addition to a contemplated change in the types of TFPs being sold, JTA is planning to increase the 25-cent base adult fare. The fact that this base fare is common both to the prior period for which elasticities are being calculated and to the present (or analysis) time period is an added advantage in the application of elasticities (particularly those computed on shrinkage ratios) because of their scale dependency (3). In addition, both periods involve a fare increase that entails breaking a single coin.

Although it is not well documented in the literature, some believe that any change in the fare structure requiring two or more coins will have an additional deleterious effect on demand over and above the effects of the fare change alone. If, in fact, breaking the quarter results in a larger than normal impact on demand, this effect will automatically be included in the elasticities computed.

To help understand the present patronage levels in Jacksonville, some knowledge of past changes in transit ridership statistics is useful. Figure 1 shows the trends in yearly ridership from 1962 to 1977. As can be observed, ridership was declining well before the 5-cent fare increase in 1970. Ridership started to increase in the period immediately after 1972 when the system started public operation, base adult fares were returned to 25 cents, and service was improved and expanded.

Figure 1. Trends in yearly ridership.

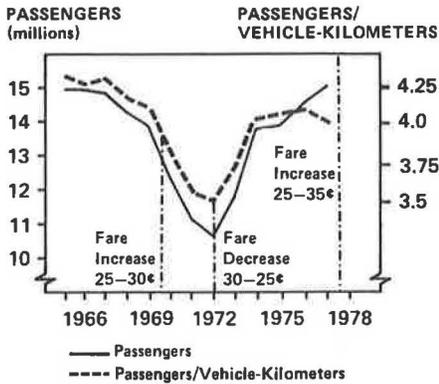
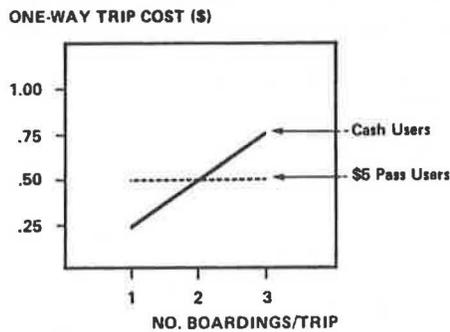


Figure 2. Fare structure.



As Figure 1 clearly shows, 1978 ridership returned to the levels enjoyed in the early 1960s.

DERIVATION OF TFP ALTERNATIVES

In the following sections, we shall identify the objectives of a TFP by using conditions in Jacksonville as an example. We shall then introduce and describe different types of passes designed to meet these objectives.

TFP Objectives in Jacksonville

A successful pass program must be attractive to both the user and the transit operator. Therefore, the following guidelines should be followed.

1. Under optimal conditions, a pass should be designed so that it is attractive to all users whether they transfer or not. This is particularly important in pricing the pass if many trips involve a separate transfer fare. If the pass is priced strictly on the basis of use by (paying) transfer passengers (e. g., at more than 20 round trips per month), then nontransferring riders will not find it attractive. Conversely, if an unlimited-use monthly pass is priced at less than 20 round trips per month, then the transit authority will be faced with a potential decrease in revenues from riders who previously paid for transfers but now use a pass. Solutions to the problem of appealing to two different user groups (transferring and nontransferring) for bus systems are presented below (passes 2 and 3).

2. TFPs should attempt to minimize both pass and coin-handling requirements. This suggests a monthly pass (versus weekly passes) and either no- or single-coin fares.

3. TFPs should allow individuals who must transfer

to do so at reduced cost, i. e., less than another full fare, and with minimal increases in administrative and distributional expenses to the transit operator (for instance, by not employing transfer slips).

4. The design of a pass should include recognition and minimization of potential abuse or fare cheating.

5. The pass should be sold both to the general public and at employment sites. That is, a pass that may be introduced and sold at employment locations should also be sold to the public at the regular transit sales outlets. This will reduce potential distortions in pass-purchasing behavior caused by a black market in passes bought originally only at employment sites.

6. Given that the average family income of bus riders is about \$9000 compared to \$15 250 for the resident Jacksonville population (4, 5), it is desirable to keep the initial front-end cost of the pass at a minimum. That is, the advantages of a TFP to low-income riders should be available to those who cannot put much money together at one time to purchase the pass. This suggests that the purchase price of the TFP should be only part of the entire fare cost.

TFP Alternatives

This section analyzes the current bus pass sold in Jacksonville and then introduces two other TFP alternatives. The discussion is presented from the viewpoint of users who ride the regular 25-cent bus routes. The special services such as express flyer and 75-cent beach routes in Jacksonville are not considered here. Transfers are not offered at a reduced price in Jacksonville.

Figure 2 is useful for illustrating the current Jacksonville fare structure. Plotted is total one-way daily bus-trip fare and number of bus boardings per one-way trip assuming travel on 25-cent bus lines. Notice that the \$5.00 weekly pass places an upper limit on the cost of regular trip making. That is, regardless of the number of transit-vehicle boardings required to complete a trip, the one-way trip cost to the user is typically limited to 50 cents, based on 20 round trips per month.

In terms of Figure 2, the following three passes will now be discussed and analyzed.

Pass 1. Existing weekly pass: The first type of pass to be considered is the existing unlimited, unrestricted weekly pass. This pass, priced at \$5.00, is represented on Figure 2 as the horizontal dotted line intersecting the y-axis at 50 cents.

Pass 2. The 15-cent pass (or permit): The 15-cent pass (or permit) would sell for \$6.00 a month (as compared to the present \$5.00/week pass). All peak-period rides with this pass cost 10 cents. Off-peak rides could either be free or cost 10 cents, to be determined at the discretion of the transit authority.

If 20 round trips are made each month, then the user is paying an initial, or front-end, price of 15 cents for each trip. However, the payment of 10 cents for the first boarding of a trip results in an actual fare of 25 cents; a one-way trip involving two boardings (i. e., a single transfer) would cost another 10 cents for a total fare of 35 cents. This can be compared to the current 50-cent price of a transfer trip. The pecuniary characteristics of this pass are illustrated in Figure 3.

Pass 3. The 25-cent line pass: A 25-cent line pass selling for \$10.00 a month would provide free travel on a specific bus line or sector of the city. Travel on all other lines (or in other sectors) would cost 10 cents with the pass. Off-peak rides are either free or cost 10 cents. As with the 15-cent pass, these are options to be con-

Figure 3. Characteristics of pass 2.

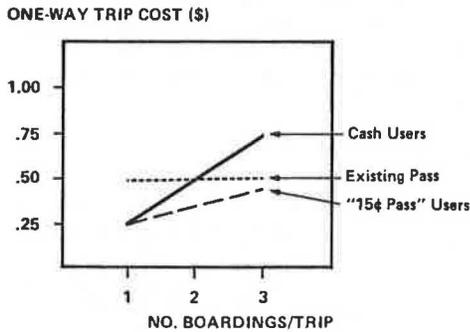
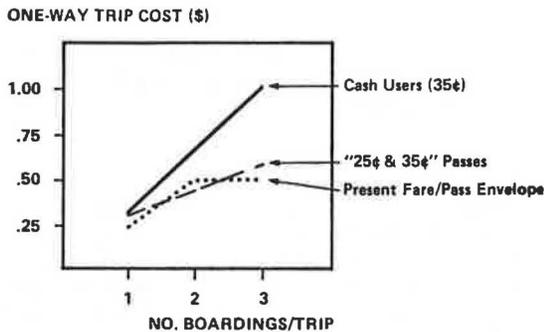


Figure 4. Fare integration after overall increase.



sidered. Assuming 20 round trips are taken per month with the line pass and all transfers are made to other lines, the graph of this pass is identical to that of the 15-cent pass shown above.

Discussion of Passes

An individual traveler would purchase the existing pass 1 only if he or she must transfer on a regular basis. Aside from its use on more costly lines, the effect of passes 2 or 3 (actually these could be labeled permits, but are called passes for simplicity) is to charge 25 cents for the first ride and 10 cents for each transfer, given the fares outlined above.

The second pass appeals to lower-income individuals, who tend to make more frequent transfers and who may not be able to afford a large outlay of funds for a pass at one time. Pass 3 appeals to the regular worker based in the central business district (CBD), i.e., the target individuals for a planned Jacksonville-UMTA joint TFP demonstration, who would like the convenience of a pass and the possible cost saving and can afford the higher initial price.

It is important to consider how these passes would be integrated with an overall fare increase. Assuming for this example that base fares were increased 10 cents, the price of the four passes would be \$7.00, \$10.00, and \$14.00, respectively. Figure 4 illustrates these passes under this assumption.

Note that the effect of the 15- and 25-cent passes, now renamed the 25- and 35-cent passes, in conjunction with a possible 10-cent fare increase, would be to reduce the cost of a two-ride trip (one transfer) for the lower-income travelers from 50 cents at present to 45 cents, with the above fare increase. This could be an important selling point in overcoming resistance to a fare increase from an equity point of view. Notice also that the first ride always costs 35 cents, ignoring other

possible TFP discounts.

Therefore, each pass appeals to its own separate market on the basis of the lump sum of money affordable, the appeal of no change-handling requirements, and the number of transfers required in daily trip making.

DERIVATION OF PRICE ELASTICITIES

In this section we shall derive the price elasticities, i.e., the percentage change in ridership resulting from a 1 percent change in fare, by using data associated with the July 1970 fare increase in Jacksonville.

These calculations are first performed by using average systemwide fare changes and total changes in ridership. Later, we shall window in on the data by computing price elasticities for selected market segments, including TFP users, to distinguish groups of users who may be more or less responsive to a change in the price and payment mechanism for transit.

Systemwide Analysis

As noted above, the base adult cash fare of 25 cents was increased by 5 cents to 30 cents in July 1970. However, average systemwide fares increased from 25 to 33 cents or by 26.9 percent (6). Below are the trends in systemwide ridership for the 12-month periods before and after the June 1970 fare increase.

End of 12-Month Period	No. of Riders	Ridership Change from Previous Year (%)
June 1968	14 686 571	-
June 1969	13 859 693	-5.6
June 1970	13 392 427	-3.4
June 1971	11 507 600	-14.1
June 1972	10 733 978	-6.7

To compute a fare elasticity from these data, we first determine the relative percentage change in ridership from the fare increase by taking the actual percentage change in ridership in the year following the fare increase and subtracting general secular changes by using the percentage change in ridership during the year before the fare increase. Using the shrinkage-ratio formula, fare elasticity (E_f) is computed as

$$E_f = \frac{\text{percentage change in ridership (relative)}}{\text{percentage change in fares}} \quad (1)$$

In this example, the change in ridership for the 12-month period immediately following the fare increase was -14.1 percent. However, the general secular change in ridership that was occurring in the year before the fare increase, -3.4 percent, is deducted from this figure, and results in a net or relative -10.7 percent change in ridership. An average systemwide fare increase from 26 to 33 cents, based on revenue and ridership figures, represents a 26.9 percent increase in fares. Thus, the resultant elasticity is computed as

$$E_f = -10.7/26.9 = -0.40 \quad (2)$$

If there were no other supply changes made during this period, the figure would represent a best estimate of systemwide elasticity. However, at the time of the fare increase, level of service as measured by bus

kilometers operated was also decreasing. Consequently, attributing all of the passenger reduction to changes in the fare level results in an overestimation of the above systemwide fare elasticity. Fortunately, a large share of the bus-kilometer impact has already been accounted for by taking into consideration past secular changes in ridership.

However, because bus kilometers were decreasing more rapidly during the period after the fare increase, it will be more accurate to compute a bus service or supply elasticity also by using the Jacksonville data. This may be done by using ridership changes associated with bus-kilometer decreases for a period (1968-1969) just before the fare increase. This bus-service elasticity can then be used to net out the additional effects of service reductions occurring simultaneously with the 1970 fare increase.

During the time period 1968 to 1969 there was a 1.06 percent decrease in ridership associated with a 1.88 percent decrease in bus kilometers. The 1.06 percent ridership decrease is the remainder after adjusting the (greater) rider decrease to net out the effect of slight increases in certain fare categories that also occurred in 1968 (6). From this information, a bus-kilometer elasticity can be computed as

$$E_s = \text{percentage ridership} / \text{percentage bus kilometers} \\ = -1.06 / -1.88 = +0.56 \quad (3)$$

For comparative purposes, a study (7) that examined a cross section of bus-service elasticities in 17 cities reported a service elasticity of about +0.7 for Jacksonville. Therefore, +0.56 appears to be a reasonable estimate of the current bus-kilometer elasticity for Jacksonville.

From JTA operating data, bus kilometers declined 2.52 percent in the 12 months following the fare increase, compared to a reduction of 1.66 percent in the year before, leaving only a -0.86 percent change in bus kilometers to be considered further. The additional ridership reduction due to this amount can be calculated as 0.56×-0.86 or -0.5 percent. Consequently, the previous fare elasticity should be reduced by this amount:

$$E_r = [-10.7 - (-0.5)] / 26.9 = -0.38 \quad (4)$$

This fare elasticity of -0.38 appears to be the best estimate of how systemwide ridership responded to the 1970 increase in fares, other quantifiable transit supply changes having been taken into account.

There is some evidence that the actual ridership loss may be even less today, however. First, this elasticity is based on an era in urban bus transit when bus service in general—comfort, cleanliness, reliability—was declining. The period could not be characterized as having a plant and facilities as new and modern as they are today. Also, the cost of alternative transportation (the automobile) was certainly less at that time compared to the present.

Furthermore, recent experience has shown that a fare increase coupled with an intensive marketing campaign tends to reduce loss of ridership (8). Therefore, the estimate of -0.38 for a systemwide fare elasticity appears to be an upper limit or most conservative estimate for Jacksonville under today's conditions. An ongoing study of the recent fare increase in Jacksonville is documenting actual changes in ridership.

The above analysis of fare and service elasticities was based on average systemwide statistics. In the following sections we shall present an analysis of fare elasticities computed for different market segments.

If elasticities can be determined for categories of travelers, it is possible to obtain more accurate predictions of ridership and revenue impacts as well as to obtain incidence information (which segments of the population are affected more severely than others by a fare increase).

Weekly TFP Users

As noted before, TFPs were being sold in Jacksonville in 1970. As part of the 1970 fare increase, the price of the pass was increased from \$4.95 to \$5.75, or 16.16 percent. Use of the weekly pass declined by 2.28 percent after the fare increase, compared to an increase of 4.1 percent in the year before the fare increase. Considering a 12-month secular trend as before, this results in a price elasticity of

$$E_r = [-2.28 - (4.1)] / 16.16 = -6.38 / 16.16 = -0.39 \quad (5)$$

If the average net bus-kilometer effect of -0.5 percent is included in the analysis, the fare elasticity for pass users is reduced to

$$E_r = [-6.38 - (-0.5)] / 16.16 = -0.36 \quad (6)$$

The sensitivity of pass users to changes in fares is observed to be somewhat less than that of the system as a whole. This is reasonable, because TFP users are more apt to use the system regularly for work trips, which have often been shown to be less sensitive to fare increases (9).

Adult Cash Users

As 57 percent of riders in 1970 were 25-cent cash-paying adults, they represent the largest single class of patrons. In the year following the fare increase, a decline of -9.7 percent was noted for this group of travelers, compared to a decline of only -2.9 percent in the year prior to the fare increase. The percentage increase in fare for these travelers was $5 \div 25$ or +20 percent. This, including the one-year secular trend, results in a shrinkage ratio of

$$E_r = [-9.7 - (-2.9)] / 20 = -6.8 / 20 = -0.34 \quad (7)$$

Including the systemwide bus-service elasticity of +0.56 and an approximate 0.5 percent ridership decrease from bus-service reductions results in a shrinkage ratio of

$$E_r = [-6.8 - (-0.5)] / 20 = -0.31 \quad (8)$$

The resultant adult cash-fare elasticity of -0.31 is less in terms of sensitivity than the systemwide fare elasticity of -0.38. This is as it should be, since, on a relative basis, more of the adult 25-cent trips represent peak-hour work trips. As noted before, these trips are generally less sensitive to fare increases. This fare elasticity is also important in helping to determine the impact of peak-hour fares.

Summary of Elasticity Analysis

An analysis of the 1970 Jacksonville fare increase indicates an average systemwide fare elasticity of -0.38. The price elasticity for pass users was very near that observed for the entire system. For adult cash trips, which take a disproportionately large share of the peak-hour work trips, a fare elasticity of -0.31 was determined.

CONSEQUENCES OF ALTERNATIVE JACKSONVILLE FARE INCREASES

The fare and bus-kilometer elasticities calculated in the previous section are used below to predict the ridership and revenue consequences of alternative fare and TFP changes. The following section briefly examines alternative fare increases, while the remainder of the paper concentrates on analyzing the consequences of different TFP options.

Fare Alternatives

The fare alternatives to be investigated consist of (a) an all-day uniform fare increase of 5 and 10 cents; and (b) a peak-period fare increase of 10 or 15 cents with no increase in off-peak fares. Both are examined under the assumption that bus kilometers, or supply, remain constant and, alternatively, are increased approximately 6 percent during the next fiscal year (10).

All-Day Fare Increase

If a current annual ridership of 15 200 000 is a base and a range in systemwide fare elasticity is -0.3 to -0.4 based on the above derivation, an average fare increase of 5 cents would reduce ridership by 6-8 percent ($5/25 \times 0.3$ or 0.4), while system revenue increased by about \$395 000 to \$486 000. Similarly, a 10-cent average systemwide fare increase would decrease patronage between 12 and 16 percent and increase revenue by \$670 000-880 000. This result assumes no change in bus kilometers.

If bus kilometers are increased by approximately 6 percent during the next fiscal year (10), the number of new patrons and additional revenue are estimated by using a bus-service elasticity of +0.7. This differs slightly from the bus-service elasticity of +0.56 calculated above for reasons beyond our purpose in this paper of illustrating the methodology described.

Thus, a 6 percent expansion in bus kilometers would increase ridership by 4.2 percent. Assuming 15.2 million annual riders, this results in approximately 638 400 new riders or \$159 600 in new revenue, given present fares. Similarly, increasing bus kilometers by 6 percent while increasing fares 5 cents on an average would increase revenue from \$174 000 to \$180 000.

For an average 10-cent fare increase, the additional revenue from increasing bus kilometers would range between \$187 200 and \$196 627. Consequently, the revised revenue forecasted for a 10-cent fare increase would be \$857 000-\$1 077 000.

Increasing Peak-Period Fares Only

The basic economic argument for higher peak-period fares is that much of the labor and capital costs required to operate the system are needed to accommodate the disproportionately large loads during the morning and evening rush hours. As a consequence, the marginal cost of providing transit service in the off-peak is low. Therefore, users should be charged less to travel at this time.

If peak-period pricing provides an incentive for some users to switch their travel to the off-peak or to not travel by transit and thereby flatten the peak, then savings in vehicle and labor costs may be possible.

For a systemwide fare-elasticity range of -0.3 to -0.4, assumed to be equivalent to a peak fare-elasticity range of -0.2 to -0.3, increasing only the peak-period (7-9 a. m. and 4-6 p. m.) fares by 10 cents will increase revenue by \$397 000-\$492 000. In addition, if bus

kilometers are increased by 6 percent, revenue will further increase by \$176 000-\$180 000 for a total increase of \$573 000-\$672 000. This is based on the observed peak to off-peak split of Jacksonville riders of 45 percent to 55 percent (6).

If average peak-period fares were increased to 40 cents and bus kilometers were held constant, fare-box revenues would increase \$534 000-\$698 000. A 6 percent bus-kilometer increase would increase these revenues by an additional \$182 000-\$189 000 for a total increase of \$716 000-\$887 000. Estimating the potential savings in operating costs that could accrue from switching of work-purpose transit trips from the peak period to the off-peak period (i.e., peak flattening) is beyond the scope of this paper.

Also, because of a very low time-of-day elasticity for nonwork trips, a negligible amount of discretionary or nonwork travel would be switched from peak period to the off-peak period (11).

The table below presents a summary of the ridership and revenue consequences for the alternatives discussed so far.

Alternative	Ridership Decrease (%)	Revenue Increase (\$000)
Fare increase with increase in bus kilometers		
5 cents all day	2-4	571-666
10 cents all day	8-12	857-1077
10 cents peak period only	0-2	573-672
15 cents peak period only	2-4	716-887
Fare increase without increase in bus kilometers		
5 cents all day	6-8	395-486
10 cents all day	12-16	670-880
10 cents peak period only	4-6	397-492
15 cents peak period only	6-8	534-698

CONSEQUENCES OF ALTERNATIVE TFPs FOR JACKSONVILLE

In the following sections, the TFP alternatives presented above will be analyzed with and without a potential fare increase to derive the revenue implications of the various TFPs.

Existing Weekly Pass 1 (No Fare Increase)

By using the following pass-user types, or market segments, and the existing pass prices in Jacksonville in 1978, the revenues from present weekly pass sales (pass 1) are provided (see the table below).

User Type	No. of Passes Sold	Weekly Price (\$)	Weekly Revenue (\$)
25-cent transfer	710	5.00	3550
Beach	404	5.00	2020
Flyer	200	5.00	1000
Senior citizen	338	2.50	845
Student	483	2.50	1208
Total	2135		8622.50

Introduction of Passes 2 and 3 Without Fare Increase

In this section we forecast the impact of introducing the 15- and 25-cent pass, assuming no increase in base fares. The flyer and beach pass are increased by \$10.00 and

Table 1. Revenue changes with passes 2 and 3 without fare increase.

User Type	New Total Monthly Fare (\$)	Present Total Monthly Fare (\$)	Fare Change (\$)	No. of Passes Sold	Monthly Revenue (\$)
25-cent transfer	14	21.67	-35	785	10 990
Beach	30	21.67	+38	358	10 740
Flyer	20	21.67	-7.7	205	4 100
Senior citizen	10	10.83	-7.7	346	3 460
Student	10	10.83	-7.7	494	4 940
Total					34 230

Table 2. Revenue changes with passes 2 and 3 with fare increase.

User Type	New Total Monthly Fare (\$)	Present Total Monthly Fare (\$)	Fare Change (\$)	No. of Passes Sold	Monthly Revenue (\$)
25-cent transfer	18	21.67	-16.9	746	13 428
Beach	42	21.67	+93.8	290	12 180
Flyer	28	21.67	+29.2	182	5 096
Senior citizen	14	10.83	+29.2	308	4 312
Student	14	10.83	+29.2	441	6 174
Total					41 190

\$20.00, respectively, to account for the fact that these two services actually have fares of 50 and 75 cents, respectively, in Jacksonville. The validity of pass 1 for these services is considered a loophole to be corrected. Thus, the cost of pass 3 for beach users will be 75 cents $\times 2 \times 20 = \$30.00/\text{month}$.

In making a forecast, the change in revenue per repriced pass and the change in pass sales from the price changes must be accounted for. That is, with regard to the latter, the number of transfer pass users will increase because trips with a transfer cost 35 cents for passes 2 and 3 versus 50 cents before (a 35 percent decrease), while the number of beach users will decrease (because of the perceived fare increase).

Table 1 can be used to determine the net change in pass revenue.

The fare-change column is based on comparing the new monthly pass cost in each category with what is currently charged (computed on a monthly basis). The number of passes sold by type is computed from the current number of passes sold (shown in the previous table) by using an average price elasticity of -0.3.

The analysis indicates that there is only a net \$37 610, or 8 percent, loss in pass revenue, even though transferring passengers are receiving substantial fare reductions under the new TFPs (35 cents versus 50 cents). The additional revenue is generated by repricing the special transit services (flyer and beach runs). Adult cash-paying users are still charged 25 cents for transferring.

Revenue losses that do occur are attributable to the fact that the new passes are priced on the basis of four weeks to the month (20 round trips per month). Thus, when multiplying by 12 months to obtain a yearly figure, only a 48-week year is being used, versus a 52-week year with the current passes.

This, in itself, is a built-in reduction of 7.7 percent in the price of a pass and, consequently, revenues as shown in Table 1. It should be noted that pricing TFPs at 20 round trips per month or more or less than this number is a matter of policy. The consequences of such policy alternatives can be analyzed by the methods shown here.

Introduction of Passes 2 and 3 with a Fare Increase

Assuming a systemwide all-day fare increase of 10 cents, from 25 to 35 cents and an equal corresponding increase in the price of passes 2 and 3, the pass revenue shown in Table 2 would be generated.

The \$494 280 yearly revenue from passes 2 and 3 represents an increase of \$45 910 over what the current passes generate under the existing fare system. This is equivalent to a 10 percent increase in revenue from passes based on an overall 40 percent increase in fare (from 25 to 35 cents).

The table below presents in summary format the revenue consequences of the TFP alternatives analyzed above.

Alternative	Yearly Revenue (%)	Change in Revenue from Pass 1	
		\$/Year	%
Pass 1 (existing \$5.00 pass)	448 370	0	0
Passes 2 and 3 (current fares)	410 760	-37 610	-8.4
Passes 2 and 3 (35-cent base fare)	494 280	+45 910	+10.2

TFPs 2 and 3 are particularly attractive options when accompanied by a general overall fare increase, because most of the objectives associated with introducing a TFP, both in general and with respect to Jacksonville, are attained. These include appealing to different market segments (transferring and nontransferring passengers, and low-income riders not able to front large amounts of money), minimizing coin handling, and making off-peak use of the system more attractive.

CONCLUSIONS

By using relatively simple techniques that are easily applied and appropriate for many analyses of this type, this paper has presented a method that can be used to forecast the ridership and revenue consequences of alternative fare and TFP strategies.

The technique focuses on computing demand (fare and, if necessary, service) elasticities for individual market segments commensurate with the issues at hand, and on using these results in a straightforward manner to forecast changes in the existing transit system. Using elasticities derived in this way eliminates the substantial problems and uncertainties associated with transferring elasticities computed elsewhere.

Choosing additional market segments, which are bounded only by the available data, may improve the usefulness and accuracy of the results. For example, ridership changes on specific routes or corridors as a result of past fare and service changes may be used to analyze market segments served by those routes or served by specific types of services of interest such as rail, low-frequency bus, and express bus. Alternatively, the approach presented in this paper may be viewed as a screening of alternatives to be followed up with more expensive, more elaborate, and possibly more accurate models.

Finally, it may be hypothesized that the cumulative effect of many years of inflation may reduce the effect on ridership of a given percentage increase in fares over some constant or slowly rising, relatively low historical fare level. That is, fares and fare increases may contribute less to the overall travel-choice decision

as inflation increases the current dollar value of time and other attributes of transit service. The extent to which this is the case is the subject of an ongoing study of a 10-cent fare increase in Jacksonville.

ACKNOWLEDGMENT

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The opinions and conclusions expressed in the paper are ours and do not necessarily reflect the views or policy of the Transportation Systems Center or the Jacksonville Transportation Authority.

REFERENCES

1. W. R. Hershey and others. Transit Fare Prepayment. Urban Mass Transportation Administration, Aug. 1976.
2. Business, Government Rally Behind New Chicago Pass. Passenger Transport, Dec. 16, 1977, p. 10.
3. C. Difiglio. Transit Fare and Ridership: A Review. Technical Notes, Highway Users Federation for Safety and Mobility, Washington, DC, Dec. 1974.
4. R. Kendall. A Bus Passenger Profile: A Public Opinion Survey of Jacksonville Transportation Authority Bus Users. Univ. of Florida, Gainesville, 1977.
5. Preliminary Summary Results of Transit On-Board Survey. Jacksonville Area Planning Board, July 14, 1977.
6. Charles River Associates. Jacksonville Fare and TFP Study. Transportation Systems Center, Boston, 1978.
7. J. Hayden Boyd and G. R. Nelson. Demand for Urban Bus Transit: Two Studies of Fare and Service Elasticities. Institute for Defense Analysis, Washington, DC, 1973.
8. B. Morris. Marketing... A Tale of Two Cities. Mass Transit, Vol. 5, No. 2, Feb. 1978, pp. 6-11.
9. T. Domencich, G. Kraft, and J.-P. Valette. Estimation of Urban Passenger Travel Behavior: An Economic Demand Model. HRB, Highway Research Record 238, 1968, pp. 64-78.
10. Jacksonville Area Transit Development Program—Annual Update. Jacksonville Transportation Authority, Summer 1977.
11. T. E. Parody. Technique for Determining Travel Choices for a Model of Nonwork Travel. TRB, Transportation Research Record 673, 1978, pp. 47-52.

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Abridgment

Feasibility of Combining Public Transit and School Bus System Services in Dade County, Florida

Michael J. Cooperman and Joseph A. Martin, Jr., Cresap, McCormick and Paget, Inc., Washington, D.C.
Fred J. Silverman, Dade County Office of Transportation Administration, Miami

The concept of a public transit system's providing school transportation services is an issue of major interest to many communities. Where a community already has two large transit operations—a general public transit operation and a school transit operation—there is a possibility that cost or service efficiencies or both can be achieved by using these services jointly. Several cities, such as Buffalo, Atlanta, and Toledo, have joint-use arrangements by which public school students are transported on the public transit system rather than by school buses.

An issue here is whether joint use would be appropriate for Dade County, Florida, which includes the city of Miami as well as other urban, suburban, and rural areas. Four alternatives for joint use of transit services were examined:

1. Home-to-school and return transportation of public school students by the public transit system, known as the Metropolitan Transit Agency (MTA),
2. Field-trip transportation of public school students by the MTA,
3. After-school transportation of public school students by the MTA, and
4. Maintenance of school-board buses by the MTA.

BACKGROUND

School-Board Transportation Services

Florida school boards are required by state statute to provide transportation services to students. They must provide home-to-school and return transportation for all public school students who live 3 km (2

miles) or more from school; home-to-school and return transportation for many types of exceptional students such as the physically handicapped, regardless of how far from school they live; and school-to-school transportation for students participating in vocational and special education programs.

The Dade County school board meets these responsibilities by owning and operating a fleet of 448 vehicles. The board's transportation department provides these services to about 38 300 students per day, out of a total school enrollment of about 230 000 students. In addition, and beyond the minimum legal requirements, the transportation department provides these supplemental services:

1. Transportation for about 2600 students (mostly in kindergarten, first grade, and second grade) who live within the legal limit but near enough to school bus routes that have extra seats available;
2. Transportation for almost all school field trips, involving about 14 000 vehicle trips/year, and
3. Up to 30 after-school runs from selected junior and senior high schools.

Thus, the school board provides all of the services required by statute, plus significant supplemental services. Outside contractors are used only for occasional field trips.

Of the transportation department's pupil transportation budget for the 1977-1978 school year, \$5.6 million, the primary expenditure, was driver compensation. The state of Florida, through the Florida Education Financing Program (FEFP), currently reimburses the school board with about \$2.7 million for pupil transportation; the allocation is based on a formula that considers number of students transported and vehicle distance traveled.

The school board fleet operates over 393 designated routes and makes about 1150 runs each morning and afternoon. Most of the vehicles hold 66 passengers; 96 vehicles are lift-equipped to accommodate handicapped students. The average cost per student is \$146/year, which breaks down to about 81 cents/day and 40 cents/trip. These average costs vary significantly between the regular school runs and the special runs for exceptional students. The regular school runs, about 69 percent of all runs and 91 percent of all students transported, have an estimated cost per student trip of 31 cents; the special runs, about 31 percent of all runs and only 9 percent of all students transported, have an estimated cost per student trip of \$1.35.

For the 1977-1978 school year, vehicle distance traveled totaled approximately 9.2 million km (5.7 million miles). In terms of operating costs, basic home-to-school and school-to-home transportation service is provided at a cost of about \$0.63/km (\$0.98/mile).

Public Transit Services

MTA, the authorized public carrier for Dade County, owns and operates a fleet of 550 buses. Each month, the buses carry approximately 5.6 million passengers over about 2.9 million km (1.8 million miles). Routes are laid out in a grid system and tend to be concentrated in the central business district and other commercial areas. As many as 425 buses are committed for peak-hour transit service. The cost of providing service is approximately \$1.05/km (\$1.70/mile). Based on the number of passengers carried, the average cost per passenger trip is 55 cents. The MTA also runs a limited charter service within the constraints of the regulations of the U.S. Department of Transportation's Urban Mass

Transportation Administration (UMTA).

MTA's operating budget for fiscal year 1977/78 was \$39.2 million; driver compensation accounted for 55 percent of this total. The capital budget for fiscal 1977/78 was \$21.5 million. At present, MTA operates buses only, but it will become a rail-bus operator when the county rapid rail system, scheduled to open in 1983, is completed. By 1982, MTA plans to have over 900 buses.

HOME-TO-SCHOOL TRANSPORTATION OF PUBLIC SCHOOL STUDENTS

The study recommended that the school board continue to use its own vehicles and drivers for the home-to-school transportation of students. This recommendation was based on five factors.

First, Florida state laws require that the level of service provided be sufficient to ensure all students a seat on a vehicle. It is the responsibility of the school board to provide the seats; exceptions are allowed only in emergencies. This requirement is most important. While state law requires seats on vehicles for students, federal regulations prohibit reserving seats on MTA vehicles for students. Thus, guaranteeing each student a seat on an MTA vehicle would necessitate adding inordinate further capacity to the MTA system.

By contrast, Florida's seating requirement, which is intended to improve student safety, is not a law in a number of other states that provide joint use. In these other states, students stand on the vehicle as a matter of course. However, even if this law were to be relaxed in Florida, it is not clear that joint use would be enhanced. If standees were allowed, the school board could obtain significant economic benefits by placing more students on its own vehicles, which would reduce the number of school buses needed and the associated operating costs.

Second, school bus transportation is far less expensive than MTA transportation. For the six months ending March 1978, MTA had a total operating cost of \$1.05/km (\$1.70/mile), as compared with \$0.63/km (\$0.98/mile) for the school board. The difference is attributable to MTA's higher vehicle operating costs and higher driver compensation. MTA vehicles cost \$0.47/km (\$0.76/mile) to operate, as compared with \$0.29/km (\$0.46/mile) for school board vehicles. MTA drivers are paid an average of \$6.88/h, as compared with \$5.80/h for school board drivers. Thus with differences of 65 percent in vehicle operating costs and 19 percent in hourly driver compensation, a direct one-for-one substitution of MTA vehicles and drivers for school board vehicles and drivers would not be cost effective; school board costs would increase by about 40 percent, or \$2 million, each year without an improvement in service.

Similarly, major expansion of MTA service specifically to meet student needs also would be disadvantageous. Based on the figures cited above, the cost of transporting students would be reduced only if more than 1.4 school buses could be eliminated for each additional MTA bus that had to be placed in service.

School buses carry an average load of 47 students. To replace 1.4 school buses would require that 66 students be transported by the MTA. This, in turn, would require all the seats (53) on the one bus added during the morning peak period plus another 13 seats on an MTA vehicle already in service. (The demand for 13 seats is an average; the demand can be as high as 20 on certain days.) This availability of seats does not now exist and, barring an extreme drop in level of demand by the general public, is not expected to exist in the foreseeable future.

Third, the present labor contract of MTA, which would be difficult to change, guarantees drivers at least a 40-h week. School board transportation, however, requires only a 20- to 25-h week, and school board drivers work with a 20-h guarantee. Thus, using MTA drivers for the school peak could necessitate higher wage rates, plus compensation for drivers for time when they are not needed.

Fourth, while federal regulations require that MTA vehicles have an open-door policy, i.e., that they be available to all types of passengers, Florida law currently disallows state financial support for students transported on open-door vehicles. This support is important; it currently funds about 48 percent of the county's total costs for mandated pupil transportation services. If there were no other difficulties with the concept of joint use of services, this is one area in which statutory change should be sought.

Fifth, MTA's current routes are designed to meet the needs of the general public and would be of limited value to students. Bus routes on major roads are typically long and direct with a minimum of stops. By contrast, school service involves short runs of many stops, primarily in residential neighborhoods, followed by a closed-door run to the school. Given MTA's current routes, many or most students would have to transfer at least once during each trip, and students' walking distances from home to bus stop would also increase. The inherent differences between the two transit services limit the route and schedule integration that can occur.

OTHER JOINT-USE ALTERNATIVES

The alternative of having MTA rather than the school board provide field-trip transportation for class trips, athletic team trips, and band and chorus trips should not be pursued. Under federal restrictions, which are not likely to be changed in the foreseeable future, MTA is only allowed to provide this type of service to the school board at a charter rate. MTA charter rates are almost 100 percent above the corresponding rates and actual costs of the school board; thus, MTA service would not be economical. Moreover, the school board has demon-

strated responsiveness and good performance in providing field-trip services.

The alternative of having MTA provide some after-school service, such as transporting late-staying students along designated routes, represents a meaningful opportunity for joint use as long as the students can be accommodated through regularly scheduled service. Students are an attractive market for MTA. Federal regulations would allow MTA to provide service as a part of its regular schedule, and there are no state restrictions in this area.

The alternative of having MTA provide maintenance services for school board vehicles should not be pursued. Federal rules and regulations sharply restrict use of MTA's equipment and facilities for school bus purposes. In addition, MTA lacks the present and planned capacity for servicing school board vehicles. Finally, the school board has demonstrated responsiveness and good performance in its maintenance operations, and its operations are of sufficient size to achieve efficiencies.

SUMMARY

There are very limited opportunities for joint utilization of transit services in Dade County. The home-to-school transportation of students should continue to be provided by the school board's transportation unit, primarily because of (a) the inability of MTA to guarantee seats for students on its vehicles, (b) the significantly lower operating costs of the school board's vehicles, and (c) the more flexible labor contract of the school board in terms of guaranteed hours for drivers.

The school board should also continue to provide field-trip transportation for students, primarily because its cost is significantly lower than the charter rates of MTA.

MTA maintenance of school board vehicles is not feasible under federal regulations, nor is it desirable. MTA provision of after-school service for students, however, should be explored.

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Abridgment

Assisting Small Transit Operators in California

H. W. Griffin and R. R. Trimble, Management Assistance Branch, California
Department of Transportation, Sacramento

The California Department of Transportation (Caltrans) recently conducted a series of 10 workshops with transit operators throughout the state. The workshops were held to (a) identify the needs of small transit operators, (b) determine the existing expertise of transit operators and others associated with transit (universities, consultants, etc.), and (c) discuss the role Caltrans should play in a transit management assistance program.

This paper describes the workshop process and presents the workshop results.

BACKGROUND

Transit in California has followed the national historical pattern. In 1950 there were 30 transit operators providing scheduled fixed-route service in the state; 21 were private companies. By 1970 there were still about 30 transit companies, but only 3 were privately owned. In 1971 a statewide transit-assistance program was established through the Mills-Alquist-Deddeh Act of 1971, better known as the Transportation Development Act.

There are now 84 transit operators in California receiving such funds.

The 84 operations provide a variety of services, such as fixed route, demand responsive, and route deviation, and are managed through a variety of institutional arrangements.

PROCESS

The 10 workshops held in late 1977 and early 1978 were conducted by Caltrans staff from the transit management assistance branch in Sacramento. Many transportation consultants and university representatives, 84 public and private operators, and 43 representatives of city and county governments, transportation commissions, and regional transportation planning agencies attended the workshops. The problems and needs identified were written down on large sheets of paper in front of the group. This usually generated additional discussion and additional needs, which varied according to several factors, five of which are given below.

1. Age of the transit system: The operator's needs tended to vary with the system age.
 - a. New operators' most immediate needs tend to be such things as information regarding transit laws and regulations, vehicle specifications, the availability and sources for funding, system planning, and insurance.
 - b. The needs of operators whose systems are between one and three years old seem to be in the areas of scheduling and run cutting, preventive maintenance, accounting, grant assistance, and insurance.
 - c. The needs of operators who have been operating longer than three years are focused on such items as grant assistance, accounting, driver training, and marketing.
 - d. It was apparent that, even considering the system age differences as noted, there is a core of information needs common to the majority of operators and that some cyclic needs, such as driver attrition, vehicle aging, route changes, and system expansion, are related to operational characteristics of the system.
2. Local political atmosphere: This was mentioned on several occasions as being a hindrance to achieving previously adopted transit goals because of diminishing or unreliable financial support.
3. Type of transit organization: There are several types of organizations. This accounts for the somewhat different attitudes and perceived needs of the responsible agencies.
 - a. Transit districts are legislatively formed and, because of the complicated process, do not at present include small transit operators.
 - b. Municipal operators (cities and counties) are allowed by the state constitution to provide transit service to their citizens.
 - c. Some cities and counties have elected to contract for transit service with private transportation suppliers.
 - d. Private nonprofit organizations are usually human service agencies that provide service to special clients.
 - e. Private operators are taxi or bus companies.
 - f. The needs of the operators vary depending on the roles they play in the overall transportation system and its operation.
4. Location of the transit system.
 - a. Proximity to larger operators: In many cases, large operators were able and willing to give small operators the extensive information and, in some cases, physical assistance they required.
 - b. Interest and ability of local transportation planning agencies: The degree of existing active assistance depends to some degree on the size, staffing, and will-

ingness of the regional transportation planning agencies as well as the Caltrans district.

5. Membership in transit associations: Three professional operator organizations are available for California transit operators to join. These are

- a. American Public Transit Association (APTA), a national organization with headquarters in Washington, D.C.;
- b. California Association of Publicly Owned Transit Systems (CAPOTS), a California organization viewed in the past as primarily serving operations larger than 50 vehicles; and
- c. Western Public Transit Association (WPTA), a Southern California group consisting of small operators in that area primarily concerned with financial problems and issues.

RESULTS

The needs mentioned most frequently are summarized below.

Accounting systems—The federally required uniform accounting requirement (FARE) and the State Uniform System of Accounts and Records for Transit Operators are of major concern to small operators.

Grantsmanship—Many small operators said they had problems with obtaining federal and state funds because of their lack of experience and expertise in preparing project proposals and completing the required forms.

Marketing—Small operators generally are in need of assistance in learning how to develop marketing programs and need assistance specifically in the areas of market segmentation and system promotion.

Management, planning, and technical assistance—The need for management, planning, and technical assistance was universally expressed by small operators.

Scheduling and run cutting—Scheduling and run cutting for transit systems have traditionally been done by an experienced old hand. Many small operators simply do not have the knowledge or experience required to do the effective run cutting needed to make their systems operate in an optimum manner.

Information resource and information workshops—Many small operators expressed their need for an information center to act as a resource for transit operators.

Insurance—Steadily rising insurance costs are a major concern of small transit operators.

Equipment maintenance—Many small operators, particularly those most distant from larger operators, have critical needs in the area of equipment maintenance, especially when it involves diesel mechanics.

Vehicle and equipment specifications and acquisition—Due in part to the rapid turnover in small transit vehicle suppliers and changing specifications, vehicle acquisition is often a tedious matter.

Driver training—Small operators in most cases do not have access to driver training courses.

Management and supervision training and diesel mechanic training—Most small operators do not normally have access to supervision training courses and training courses for diesel mechanics, which are conducted for large organizations or taught at trade schools and colleges.

Ongoing system evaluation—Several operators expressed a need for objective evaluations or performance audits of their systems so that they could improve their operations.

Transportation Development Act information—Many operators feel that they do not fully understand or cannot keep pace with changing regulations.

Methods of assistance—The workshops were used as

a forum to discuss the best methods of providing assistance to operators. Five methods were considered.

First, on-site methods were discussed, as was assistance provided to individual operators on location by one or more persons who have specialized expertise. Then area workshops, or groups of operators brought together to share knowledge on topics of mutual interest, were suggested. The need for information pertinent to the operation of transit properties that is distributed on a regular (newsletter) or intermittent (special reports) basis was expressed. Audiovisual presentations can also present information on specific topics in a structured manner. And there is a need for university and college or night school courses.

It is not surprising that the consensus at each workshop was that the on-site method is the most preferred method for providing assistance. The other four methods did have appeal for specific problems or situations. In most cases, formal instruction programs at the university and college level were judged to be too broad in scope for transit operator's purposes.

The inventory process also elicited a surprising number of potential assistance sources. Several large operators, consultants, colleges, taxicab operators, and the Institute of Transportation Studies at the University of California at Irvine all indicated a willingness to be considered as possible assistance resources.

CALIFORNIA'S TRANSIT MANAGEMENT ASSISTANCE IMPLEMENTATION PROGRAM

California's first-year transit management assistance program will consist of six elements that fall into two general categories. These six elements are in addition to existing Caltrans transit planning assistance, information sharing, research, and training programs. The first category, statewide management assistance, revolves around the dissemination of information. The three specific elements of this category are

1. Central transit information center: A central transit information center will be established by Cal-

trans, Division of Mass Transportation (DMT), to serve as an information resource for small operators in urban and rural areas;

2. Newsletter: A newsletter will be published by Caltrans-DMT on a bimonthly basis and will be directed to small operators with emphasis on state and federal legislation, innovative activities and programs of small operators in California and elsewhere, scheduled workshops and seminars, APTA-CAPOTS activities, technical developments, etc.;

3. Workshops: Twice yearly in two locations in the state, two three-day workshops will be conducted on subjects such as grantsmanship, regulations, FARE, insurance, legal issues, joint purchasing arrangements, transit goals, financial management, productivity techniques, scheduling, marketing, maintenance, etc.

The second category, local management assistance, is directed toward providing assistance to individual operators and toward developing programs on specific topics. There are three specific elements in the first-year program for this category:

1. On-site assistance: An exchange program between transit operators and Caltrans will be initiated (travel expenses subsidized) to provide on-site assistance in areas such as diesel mechanics, preventive maintenance, scheduling, and run cutting. The function of the exchange will be to encourage Caltrans or large-operator employees to travel to small operations and provide direct on-site assistance.

2. Marketing presentation: A slide and tape presentation will be developed on marketing small transit systems. This presentation will include an educational element as well as a basic promotional package.

3. Driver training program: A basic driver training program will be prepared for transit operators to use and supplement with material they prepare to suit their particular needs or situations.

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Abridgment

Light Rail Transit and Bus Integration in Edmonton

J. J. Bakker, Department of Civil Engineering, University of Alberta, Edmonton

Edmonton's light rail transit (LRT) started operation on April 23, 1978, to serve the northeast sector of the city. This sector of Edmonton, the area east of 97 Street and north of the North Saskatchewan River, has several major traffic barriers. The population in 1977 of 120 280 was expected to increase to 175 000 by 1985, according to the city's general plan. The transportation options considered were the following:

1. A northeast freeway option: The transit component would require 70 buses in the peaks, including express services for the corridor;

2. An all-bus option: This would require use of 150 buses in the peaks, including express services through the central area of Edmonton; and

3. An integrated bus-LRT option: This would call for 75 buses in the peaks to serve mainly as feeders and cross-city services, together with 14 LRT cars on the northeast line.

The revised 1974 estimates, allowing for capital and operating subsidies from the provincial government and for a constant deficit, showed the following annual costs to the city in 1978: \$9.7 million for the freeway option,

\$1.1 million for the all-bus system, and \$0.2 million (gain) for the integrated bus-LRT. Every year at budget time these estimates were updated. Inflation and an increased deficit notwithstanding, the relative attractiveness of the integrated bus-LRT option remained the same.

An integrated bus-LRT option means that the LRT line is part of the transit network but uses a different technology.

THE BASIC BUS SYSTEM

The bus system developed in Edmonton is based on the timed-transfer concept developed over a number of years. Regular transfer locations are created in the city, and buses meet at the same minutes past the hour to provide regular and reliable connections between routes.

Bus services from these transit centers are generally feeder bus routes serving residential areas, radial routes to the city center, crosstown routes to other centers, and express routes to major destinations such as the city center, university, or government center. The express routes may operate during daytime (6:00 a.m. to 7:00 p.m.) or in the peak hours only and may be an extension of a feeder route.

Bus route changes that are proposed for any sector of the city therefore do have constraints placed on them. The midday schedule module in Edmonton is a bus every 30 min, which means that the travel time of a feeder route must fit within that 28-min period and that the travel time between transfer locations should not exceed 13 min (allowing 2 min for transfer and recovery time).

The midday frequency of LRT service is a train every 10 min. Maintaining the 30-min module along the LRT would mean an imbalanced loading pattern. The midday module along the LRT was therefore changed to 20 min with a pairing of routes.

PUBLIC INPUT

The marketing and development section of Edmonton Transit takes a two-stage approach to public input. In the first stage, the deficiencies, determined from a census, are noted, and the timed-transfer concept is explained. The public is then asked for input on deficiencies as they see them, on routes they desire, and also on roads on which bus routes can or cannot be located.

By breaking up the meeting into smaller groups, each with a resource person and a recording secretary, all input is available in detailed minutes. The staff can then sit down and work out two alternative networks for the sector, and try to cater to the existing patronage as well as to attract additional riders. These two plans are then taken to a second public meeting, and one plan (sometimes with modifications) is recommended to the city council for approval. Citizens who disagree can still go to council and protest (1).

1972 ROUTE CHANGES

In 1972 the public input pointed up a need for connecting the various neighborhoods with the regional shopping centers. In addition, it was found that the university and the government center were destinations that were inadequately served.

By establishing one timed-transfer location next to one regional shopping center (Northgate), the times past the hour could be fixed for the various routes that parallel the railway tracks in an east-west direction before they turn to go north-south through one of the track crossings.

1978 CHANGES

The introduction of LRT meant that bus routes in the residential areas could stay where they were but that the express portions could be eliminated along the Fort Road and the routes diverted to the nearest LRT station. The downtown express routes along 97 Street, from west and northwest of 97 Street were maintained.

The university bus, via downtown on 82 Street, was also maintained but with a reduced peak-hour frequency. A feeder bus to the Coliseum station was also added. All other routes that operated as loops were broken into routes terminating at the Belvedere or the Coliseum station.

Local service between LRT stations was introduced by extending a crosstown route (no. 11). The LRT services give a midday frequency of a two-car train every 10 min, a peak-hour frequency of a two-car train every 5 min, and a late evening and Sunday service of a train every 15 min. During special events a 7.5-min frequency is run, using three-car trains.

In the peak hours the number of buses passing 97 Street at the Canadian National (CN) tracks was reduced from 34 to 22, while at 82 Street at 112 Avenue the number was reduced from 48 to 22. The seating capacity of the LRT that replaced the bus service is 1536 seats/h (12×128 seats). The LRT does, however, produce time savings and gives more generous standing room of 3888 spaces. The before-and-after comparison is therefore (a) a reduction in buses of 1824 seated transit capacity and 2736 full transit capacity and (b) an increase in LRT of 1536 seated transit capacity and 5424 full transit capacity.

The local bus routings were given a 50 percent increase in service. Midday the service was changed from 30 to 20 min and in the peak hours from 15 to 10 min.

The actual total bus requirements were reduced from 91 to 78 buses in the peak hours and from 49 to 44 at midday. The original estimated bus requirement of 75 buses (bus-LRT proposal) was based on maintaining the same level of service with growth. With the 50 percent increase in level of service, the ultimate bus requirement of the integrated bus-LRT option will now exceed 75. It is also expected that LRT will be extended to Clareview, which will reduce bus requirements between 137 Avenue and Belvedere. However, this extension will also require additional LRT units.

DESIGN OF BUS-LRT STATIONS

Edmonton's northeast LRT line is 7.2 km long, of which 1.6 km is in a subway in downtown Edmonton. There are two downtown subway stations in use, while a shell for a third station is being built just east of 97 Street. The two stations, Central and Churchill, are of standard design with a central platform, a full mezzanine floor, and several exits from the mezzanine to the street system above. Bus-LRT transfers involve walking to the nearest bus stop.

The surface portion has three stations, two of which are important timed-transfer stations, Belvedere and Coliseum. The design of these two stations differs in that Belvedere is a temporary terminal of the line. There are proposals to extend the line to Clareview. Passengers have to cross the LRT and CN tracks at grade and then walk to the bus station, which is laid out in the form of a U with a central island; this minimizes bus-pedestrian conflicts.

Belvedere station also has a park-and-ride lot for 320 cars. After one month this lot filled daily and is also popular for shoppers on Saturday and patrons going to football games at the Stadium.

Figure 1. Average 1978 weekday patronage.

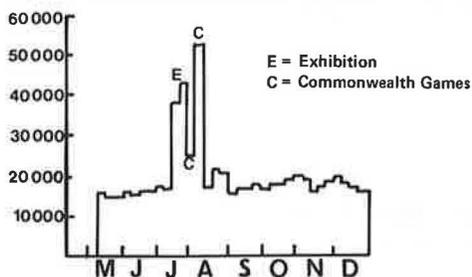
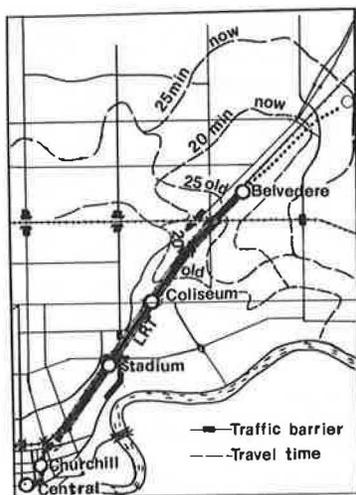


Figure 2. Traffic barriers and travel time savings.



The Stadium station has only one crosstown route that connects at the present time.

PATRONAGE CHANGES

The introduction of LRT changed the travel pattern of many transit passengers. The patronage along 97 Street was reduced by 4000 passengers/day; the bus patronage along 82 Street was reduced by 9900/day. After one month LRT was carrying about 17 000 passengers/day.

Figure 1 gives some figures regarding LRT patronage between May and December (months indicated by letters). However, since the opening there have been several occasions when LRT patronage increased. The annual Klondike Days and Exhibition increased patronage between July 19 and July 29, 1978. From August 4 to 13 the Commonwealth Games were being held in Edmonton and again normal patronage patterns were distorted. In reality it is too early to draw conclusions because of a number of other factors such as the fare increase on April 1, 1978 (from 35 to 40 cents), and the reduction in gasoline tax of 10 cents per imperial gallon on April 1, 1978, in Alberta.

Notwithstanding these systemwide deterrents to transit, an average month, June 1978, showed that overall patronage had increased by 1 percent compared to June 1977. Only time will tell the real impact of Edmonton's LRT line. In July 1978 patronage was 9 percent more than that of July 1977. Patronage on the LRT increased to about 46 000 per day during Klondike Days; the Exhibition grounds are of course directly accessible from the Coliseum station. The maximum load was an estimated 61 400 on parade day.

On an average day the daily patronage on LRT is about

17 000, of which about 2350 travel in the peak hour in the peak direction. With 1536 seats available in the peak hour on the LRT, a third of the patrons have to stand. Before LRT the daily patronage on 97 Street and 82 Street together was 25 000. On an average day in June it was 17 000 on LRT and 11 100 on the remaining bus system. The maximum daily load during the Commonwealth Games was 69 000.

TRAVEL TIME

As can be expected, LRT will reduce travel time the most for the outlying areas that are reasonably close to a station. The travel contour map in Figure 2 was prepared from midday schedule times. The travel times with LRT make an allowance of 4 min for transfer time. The equal travel time via LRT-bus and bus via 97 Street is just west of 82 Street.

The northeast areas of Clareview had a travel time saving of about 8 min as a result of LRT. The area of Abbottsfield had no time savings at all. It is not surprising, therefore, that the latter has generated the most complaints, since they now must travel via Coliseum station. This is particularly true for trips that go beyond downtown and involve a second transfer.

The immediate area of the Coliseum had a time saving of 9 min and Belvedere of 11 min. The public is likely to respond to these time savings, but the experience in Edmonton is that it usually takes time before significant mode shifts occur.

CONCLUSIONS

The integrated LRT-bus system has proved able to handle the existing transit patronage and has attracted additional riders, notwithstanding the introduction of transfers. The conversion from express buses to feeder buses-LRT has been accepted as an attractive alternative.

The LRT-bus system has also shown its worth during special events at the Coliseum, Exhibition grounds, and Stadium. However, a system capable of carrying 5400 people an hour in one direction cannot be expected to fill a stadium of 46 000 people.

The disadvantage of the LRT system is that it does not serve two major trip destinations, namely the government center and the university. Passengers to these destinations are required to make a second transfer. A complete valid solution probably requires a more complete system.

ACKNOWLEDGMENT

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REFERENCES

1. L. Lawrence. The Marketing of LRT and the Integration with E. T. S. Bus Routes. Proc., LRT Case History Conference, Faculty of Extension, Univ. of Alberta, Edmonton, 1978.
2. D. L. MacDonald and J. J. Bakker. Edmonton's Northeast Light-Rail Rapid Transit Line. TRB Special Rept. 182, 1978, pp. 23-27.
3. J. J. Bakker and T. D. Clement. Transit Trends in Edmonton. Paper presented at Road and Transport Association of Canada, Edmonton, Sept. 1974.

Providing Coordinated Transit Services by Using a Transit-Functional Classification

Robert M. Winick, Maryland-National Capital Park and Planning Commission, Silver Spring
Colin H. Alter, Washington Metropolitan Area Transit Authority, Washington, D.C.

This paper describes a planning concept used in providing coordinated bus and rail service to a suburban county of the Washington, D.C., metropolitan area. This concept, which is that of a functional classification of transit services, is analogous to that long in use for highways. Four transit service classes are defined: transitway, regional, collector, and community. Like the highway classification, the transit classification has universal applicability to all metropolitan areas, although it is more easily illustrated in large areas. The transit-functional classification concept, used by Montgomery County, Maryland, as a network planning tool, was found to be particularly useful in planning a comprehensive restructuring of county bus services that provide coordinated services to the first part of Washington's Metrorail system extending into the suburbs. The county planning department has also used the transit-functional classification concept as a policy-planning tool in carrying out a fiscal impact analysis for a growth policy study and in transit financial planning and intergovernmental responsibilities for transit operations.

Over the years many authors have expressed their views on categorizing the numerous transit submodes in operation or on some planner's drawing board. It seems as though each planner or transit operator had developed a personal working definition to group and distinguish forms of transit service.

This paper first considers various classifications of transit and generalized concepts of functional classification. It then gives a specific conceptual definition of a functional classification of transit services. We felt that use of this transit-functional classification can bring the attention of transportation planners and political decision makers into focus so they can better address ways to improve transit services.

To illustrate the utility of the transit-functional classification, the paper describes how it has been used by transportation planners and decision makers in Montgomery County, Maryland, a rapidly urbanizing suburban county of the Washington, D.C., metropolitan area. One application was as a network-planning tool used to restructure bus services to the first of seven suburban segments of Washington's Metrorail system. A second application was as a policy-planning tool used as a component of a fiscal impact analysis of future growth. The paper also shows the utility of the transit-functional classification in addressing other policy-planning issues.

CONCEPT OF FUNCTIONAL CLASSIFICATION

To understand the concept of a functional classification for transit, we shall first examine it in relation to its traditional use in highway and regional systems planning. The generalized concept for both major urban transportation modes is then presented. The reason for using such a classification is that it provides a powerful transportation planning tool applicable to activities such as transit financial planning and policy matters and to assisting decision makers in determining which level of government should be responsible for implementing particular transit services.

Highway-Functional Classification

As discussed in many transportation engineering and planning texts, highway systems have long been classified according to their administrative, planning, and design purposes (1-3). While the terminology has varied from report to report and study to study, urban roadway classifications generally contain four components: expressways, arterials, collectors, and local roads.

Different criteria have also been used to classify different types of roads. As shown in the table below, the two main criteria in general use are (a) the degree to which the roadway serves through movements exclusively and (b) the degree to which it provides access to land abutting the roadway.

Highway- Functional Classification	Classification Factors	
	Through Movement	Land Access
Expressway	High	-
Arterial	↓	Low
Collector	Low	↑
Local street	-	High

Additional criteria such as typical trip length, spacing between similarly classed roadways, land-use areas linked by the different types of roadways, and traffic volumes on the roadways have also been used.

Such highway-functional classification schemes have been of value to transportation planners for many reasons. For instance, it has often been observed that, while those facilities primarily serving travel—the expressways—may only represent 5 or 10 percent of the roadway kilometers in a particular urban area, they may carry 40 to 50 percent of the vehicles.

These classifications have been used as a rationale by transportation officials and policymakers for planning urban transportation investment as well as setting specific priorities for funding, operation, and maintenance.

There is also a general correspondence between the classes of roadways and the level of government responsible for the construction and operation of them. Thus, by using the concept of highway-functional classification, transportation planners have been better able to bridge the gap between planning and implementation by the various levels of government. In addition, other planners have relied on such a classification to facilitate their work. For instance, many land-use plans and zoning ordinances use such classifications to help designate those areas that should have a particular type or intensity of land use.

Classification of Transit Modes

Many authors have classified different types of transit primarily according to the subtransit mode. For example, the Lea Transit Compendium (4) has identified six general transit classes as follows: (a) moving way,

Table 1. Vuchic's classification of transit modes.

Right-of-Way Category	Technology		
	Rail Guided	Rubber-Tire Guided and Other Modes	Highway
Fully controlled	Regional, rapid transit, light rail	Rapid transit, monorail, people movers, personal rapid transit	Bus on busway only
Partially controlled	Light rail	Dual-mode systems	Bus partially on busway
Surface street	Streetcar	Trolley bus	Surface bus

(b) light guideway, (c) personal rapid, (d) light rail, (e) heavy rail, and (f) roadway systems.

In their recent study, *Public Transportation and Land Use Policy*, Pushkarev and Zupan (5) define eight modes of public transportation. They indicate that "the different modes of public transportation are distinguished most visibly by the hardware they use, but more importantly by the type of service they provide and by the manner in which they operate." The eight modes they examine are taxicab, dial-a-bus, local bus, express bus, light rail, light guideway transit, standard rapid transit, and commuter rail.

Classifications such as these seem to have a common trend, which, as previously pointed out by Vuchic (6), appears to be to categorize a particular transit mode according to its type of technology. To address the question of transit mode classification, Vuchic has suggested a method based on the three characteristics as shown in Table 1: right-of-way, technology, and type of operation.

In retrospect, this research has basically adopted the right-of-way and type-of-operation dimensions and re-defined their underlying characteristics. It should be pointed out that many of these classifications recognize that each transit mode has a range of suitability when it is functioning as the line-haul portion in a given demand context.

In their report on *Bus Use of Highways*, Levinson, Adams, and Hoey (7) not only speak of various transit modes as local bus, express bus, and rail rapid transit, but also give a bus-priority topology based on the criteria of corridor intensity and central business district (CBD) intensity. Perloff and Connell (8) speak of primary and subsidiary elements of transportation systems. The primary elements of the transportation system exist to provide transregional access and indicate that connecting various areas of the metropolitan region is the main rationale for the system. Associated with this primary system is auxiliary or secondary service that may provide back-up or feeder service to the primary routes. On the other hand, they define a subsidiary system as one whose "operations [are] limited to a particular group or location, or both, and therefore, its focus is not on generalized access but on penetrating to personal service demand levels."

Ward and Paulhus (9) identify four types of metropolitan travel according to the relative intensity of each end of the trip, i.e., whether they are in low- or high-density areas. They indicate "that total urban systems should be made up of multiple elements operating cooperatively, each tailored to the characteristics of a neighborhood or area it serves." They further indicate that "regional transit systems will consist of 1) a regional express bus or rail guideway network fed by 2) a public collection/distribution system, 3) high density circulation service provided where appropriate, with 4) accommodation to the usually dominant mode, auto."

One common thread through these last three classification schemes seems to be greater emphasis on the type of service provided to the transit user as well as on the type of area being served.

Generalized Concept of Functional Classification

It is proposed here that there is a generalized concept of functional classification that is applicable to both major transportation modes, highways and transit. From an urban planning perspective, the two key classification factors that functionally distinguish between components of transportation systems are the degree to which the transportation serves person movement and the degree to which the transportation serves land access.

In the first, we are primarily concerned with the degree to which the facility is serving regional, longer-distance travel generally in terms of line-haul capacity. In the second, we are concerned with the degree of access, because for some facilities people cannot reach their destinations off the transportation right-of-way unless they first get off at a transfer facility. As shown in the table below, this results in a classification for transit analogous to the one used for highways.

Transportation Mode		Classification Factors	
Highway	Transit	Through Movement	Land Access
Expressway	Transitway	High	-
Arterial	Regional	↓	Low
Collector	Collector	Low	↑
Local street	Community	-	High

This generalized concept could also be extended to bike-way and pedestrian systems, but we leave that task to other researchers.

Description of the Classes of Transit Service

In most large metropolitan areas, four distinct classes of transit service can be found. We define them as transitway, regional, collector, and community-class transit services. These classes are categorized according to their principal functions of serving people movement and land access.

Transitway Service

Transitway service, which is analogous to expressway-class roadways, primarily serves the through movement of people within an urban area and has access points limited to transit stations and terminals. It only serves people movement and does not provide direct access to land. Transitway service generally has exclusive or grade-separated right-of-way, although it is sometimes shared with other vehicles, such as commuter rail and freight trains that use the same track or a busway available to carpools.

Several transit technology modes fall within this service class, including commuter or regional rail, rapid or heavy rail transit, light rail transit in an exclusive or protected right-of-way, automated guideway transit, busway transit, and even waterborne transit operations.

Regional Transit Service

Regional transit service is analogous to arterial-class roadways. It primarily serves generally continuous movement throughout the urban area and secondarily provides direct access to activities on the land but has

no separate stations or terminals.

This class of service is most generally characterized by standard-size or high-capacity buses that travel on major arterial highways and follow a traditionally radially oriented route structure. While such service is usually characterized as having frequent stops, this class also includes express transit service, which is analogous to access-controlled arterial roadways. This service class also includes the transit technology mode of the traditional trolley or streetcar service.

Collector Transit Service

Collector service is analogous to collector-class roadways. It primarily serves access to activities on the land but also allows for through movement that frequently involves a transfer to complete the journey. Such services have traditionally been characterized as branch service off of main transit routes or crosstown services. Its main purpose has been to penetrate residential neighborhoods to bring transit service within walking distance of a greater number of potential patrons and to connect major activity centers in nonradial patterns.

Community Transit Service

Community service is analogous to local-street-class roadways. It primarily serves client-group or geographic subportions of a region, generally on a town, ward, or neighborhood scale. It provides a very high level of access to them but generally does not enable any through movement to other portions of the region without first transferring to one or more other class of transit service.

Such a transit service is generally characterized by the use of small buses or vans that operate either on a fixed route or on a demand-responsive basis.

Distinguishing Among Transit Service Classes

It may not always be a simple task to clearly identify a particular transit service as falling into one class or another. Even among highway and transportation planners preparing or updating a highway-functional classification for a particular urban area there is often disagreement about which class is most appropriate for a particular roadway. Likewise, we have found that, in attempting to define and apply such a transit functional classification, disagreement is bound to arise over which class best fits a particular transit service.

It is hoped that the conceptual definition given above and modified by experience over the coming years will enable many transportation planners to develop their own working operational definitions to supplement these conceptual ones. However, the reader should be cautioned against making simple generalizations, such as relating technology to class; e.g., all services operated by small buses are not community services.

USING THE TRANSIT-FUNCTIONAL CLASSIFICATION TO PROVIDE COORDINATED TRANSIT SERVICES

Most metropolitan areas have multiple operators of public transit service—from conventional fixed-route to fixed-schedule operation to paratransit of various kinds. It is emphasized that what distinguishes these services from one another is a functional classification, not ownership, technology, or size of vehicle. Whenever there are different types of services offered, it has

rarely been a conscious choice based on a hierarchy of service. Rather, it has simply been that an area has decided that one or all kinds of service will not meet the needs of the people.

Coordinated Services in Toronto

A prime example of a conscious application of such a concept has been the coordination of bus and rail services in Toronto, where the Toronto Transportation Commission (TTC) has established a policy that buses and streetcars will feed into the subway. There has also been a determination not to provide regional-class service that duplicates the transitway service. Although it is possible to travel along the Yonge Street corridor by bus, parallel bus routes are structured and operated to act as either collectors to the rail or as community service.

Similar policy has also been applied to coordinate classes of service at terminal stations in Toronto. For example, at the Finch station on the Yonge Street route, located in the borough of North York, there are two major bus terminals: one for collector services operated by TTC itself and the other for regional bus routes operated by Grey Coach, GO Transit buses, and community services of various municipalities north of metropolitan Toronto.

The subway is clearly acting as transitway service for that portion of the metropolitan area. Grey Coach and GO Transit buses act as regional service because they serve communities far beyond what would be the normal service area of an on-line station. The municipal operations, while they may operate on some of the same access roads as the other two, are considered community-class services because their primary purpose is to provide penetration into nearby communities above and beyond the levels of the collector service that is provided in accordance with the regional standards of TTC or GO Transit.

Montgomery County, Maryland: A Case Study

We want to now focus on how this concept has been applied in Montgomery County, Maryland, a major suburban jurisdiction northwest of the District of Columbia. There, the extension of the Metrorail system into the county has been generally viewed as an opportunity to reduce public dependency on the automobile for trips to major regional activity centers.

Before Metrorail opened, the county decided to experiment with providing community-oriented services by using small buses. The first service on fixed routes was started in April 1975 in the most densely populated part of the county, Silver Spring. This area was also selected because it was scheduled to be the first area in the county to receive Metrorail service.

The object of this modest experiment was to evaluate public response to a low-fare (25 cents) operation that provided a high level of transit penetration into the neighborhoods and connected the major suburban commercial office area of Silver Spring. Public response was excellent; ridership grew to nearly 4000 weekday users. As an indicator that it was truly functioning as a community-class service, it had relatively high mid-day use, and work trips only accounted for about 40 percent of the ridership.

In the summer of 1975, staff of the planning department prepared a detailed projection of future transit operating costs as a component of a fiscal analysis for county growth policy studies. The concept of a functional classification of transit services was developed

at that time to address planning issues of

1. Expected mode of access to the rail system,
2. Providing transit access to the employment and retail centers in the county, and
3. Appropriate level of government to provide these projected transit services.

Part of that effort was the development of a sketch network showing the extent and integration of the various classes of service once the basic transitway service began to operate in two of the major radial corridors in the county. Metrorail has not been viewed as replacing all radially oriented, regional service in the county. This is because there are a number of major activity centers either not located along the rail system or located so that circumferential bus access is more direct than radial rail service. In addition, regional access must be maintained for trips beyond the rail or in important corridors where rail does not operate. In each of these examples, ridership projections showed considerable demand for line-haul transit service. Hence, a regional bus network complementary to Metrorail transitway service was designed for the county.

The street system of the county is not based on a grid pattern; there are relatively few through streets between neighborhoods, and streets within neighborhoods have numerous cul-de-sacs. Further, the county's experiments with community bus service are showing that the best way to serve these neighborhoods is by small buses that make several short trips on appropriate collector and local streets. There are many medium- and high-density neighborhoods clustered in the vicinity of the rail lines that need such service.

For this community-class operation, it is expected that the vehicles would not be making line-haul trips. Rather, they would augment the collector routes that will be traveling along these arterials and would feed either the regional bus or rail systems.

When these two complementary bus networks were completed, it became obvious that there was need for a third set of routes that had different service characteristics. First, service needed to be provided between activity centers within the county, including major concentrations of high-density housing. A second need was to provide transit to activity centers on roads that parallel the rail system but not closely enough for rail users to walk to rail stations. A third need, to provide service to activity centers between the two rail lines, was important because the two rail lines generally parallel each other in the county.

No clear-cut division of function, regional movement, or local access seemed paramount; rather, a blend of functions seemed necessary.

While the third network shared attributes with both of the other bus networks, it was clearly distinct from them. Its major role seemed to be that of collecting passengers, and, for purposes of identification, it was called the collector network.

Detailed transit network planning for the bus-rail coordination was begun in the summer of 1976 by using this transit-functional classification as an organizing concept. The county department of transportation, the operators of the ride-on minibus system, began their efforts later that fall and were joined only a few months after that by Metrorail. It became evident that all three agencies could readily agree on what the regional service and the community service should be but could not concur on the collector service.

The county council made a policy choice to use the county-operated services for all of the collector-class service in the vicinity of the Metrorail station. The

council adopted the other elements for funding when the Glenmont Line to an interim terminal was opened at Silver Spring in February 1978.

It is also of interest to give some more details regarding the planning of coordinated bus and rail services for rail operations to Silver Spring. Certain basic principles were emphasized at the beginning of the process by the planning staff.

1. The identified functional classification of transit would provide the basic format for structuring the bus-rail coordination.

2. For economic reasons, there would be a 100 per cent turnback of bus routes oriented toward the Washington central business district at the Silver Spring Metrorail station.

3. Ridership along the major corridor (Georgia Avenue) was sufficiently heavy in the north beyond Silver Spring to establish express-bus operations as a regional-class service.

4. Existing park-and-ride facilities would be retained.

5. Some of the savings accrued by not needing to operate the buses all the way into downtown Washington would be retained for extending existing Metrobus routes, creating new routes, and decreasing headways for re-regional- and collector-bus-class services.

6. Because of the incremental growth of the bus system over the years, there was no meaningful pattern of bus route names and numbers, and consequently there was the opportunity to establish more efficient and effective branching from the passengers' perspective; in addition, service improvements were combined with an almost complete route renaming and renumbering.

7. Lightly used Metrobus operations that had been functioning as collectors or branches of regional service generally terminating at the Silver Spring bus terminal would be discontinued.

8. There would be an accompanying major increase in ride-on operations that would provide greatly expanded community-class service to a larger area and also some collector service within the immediate service area of the Silver Spring Metrorail station.

9. All these changes were to occur on one date, two weeks after the opening of the Metrorail station. This was done with the realization that there would be a large amount of confusion, since people would not only be facing new bus service, but also encountering the rail operation, perhaps for the first time. It was believed that, once what was expected to be a short period of confusion was resolved, it would be easier for the transit-operating agencies to communicate travel options to patrons. This proved to be the case.

USING THE TRANSIT-FUNCTIONAL CLASSIFICATION FOR POLICY PLANNING

In addition to assisting in network planning for bus-rail coordination, the transit-functional classification concept is also useful as a policy-planning tool. Its utility in two policy-planning areas—transit financial planning and intergovernmental responsibilities for transit operations—is discussed below. There are other policy-planning applications that could be considered.

Transit Financial Planning

A major policy consideration facing all levels of government is one of how to fund transit service. It is proposed that the concept of a transit-functional classification be used in establishing fare policies for setting different

operating ratios for different classes of transit service. Transitway and regional-class transit services, especially for work-trip purposes, have definite value to each individual transit user. Consequently, there should be a user charge. However, those classes of service also definitely possess a component of public or social good that justifies public financing. It is our opinion that, for these classes of transit service, the user benefits are greater than the social benefits. Therefore, the operating ratio (the percentage of the transit costs paid by the user) for those service classes should be on the order of two-thirds to three-quarters of the cost of providing the service.

Generally, transitway and regional-class operations tend to be more productive in terms of riders per dollar. For any given fare structure it can be expected that this greater productivity could allow a lower level of subsidy compared to other classes of service. At the same time, the user is likely to perceive a higher value from transitway and regional-class services. For example, it is generally known that users of higher-quality express service will pay a premium fare for those services, a fare they would be unwilling to pay for conventional, multistop regional bus service.

At the other end of the spectrum of the transit-functional classification, community-class services, there is a much greater benefit to society in providing an enhanced mobility or fine-grained accessibility throughout the area served. However, there is still always some value to the users of the service. Consequently, there appears to be sufficient justification for this class of service having a policy operating ratio more on the order of one-fourth to one-third.

Collector-class transit services have a dual and roughly equal function of providing for movement throughout the region and serving activity on the land. The value to the user is not as great as that of regional class service in that there are frequently inconveniences to them such as transfers and circuitous routing. Consequently, it is recommended that this class of service should have a policy operating ratio of about one-half.

Such a policy-planning perspective has been used by the Montgomery County planning board in carrying out fiscal impact analyses of future county growth. Although there is not yet a complete or reliable system of cost and revenue analyses of routes, the different components of the transit system are apparently following this policy. For example, the ride-on services had an operating ratio of 27 percent in fiscal 1977/78, while the collector and regional bus services had a combined ratio of approximately 55 percent for the region.

Intergovernmental Issue: "Balkanization" of Transit?

For a long time there has been federal funding of highways based on perceived national priority as well as on a functional classification. Similarly, state highway departments generally also take financial responsibility for higher-class roadways and leave local governments the responsibility of providing more local access to streets within their boundaries. These differing needs have fostered a multitude of highway and road departments, each funded to meet the needs of its constituency.

It is suggested that there is a similar situation in urban public transportation, particularly in the larger urban areas. Establishing uniform standards of service for all components of a multijurisdictional metropolitan area is generally very difficult. The usual stereotype is that the suburban jurisdictions demand high-quality service oriented toward commuter operations but put little emphasis on midday or night service. The central core

city is usually interested in frequent service at all times because of greater perceived social, environmental, or community benefit.

Beyond this stereotype, however, there are segments of the community that are perceived to have greater public transportation needs than other segments. The regional transit operator, for a number of reasons, is either unable or unwilling to provide these supplementary services. There is also the question of the ability of a regional operator to respond to highly localized needs. There must be consideration of the costs of providing the service in light of federally imposed standards: wage rates, labor protection clause, delays and perceived difficulties in receiving federal funding, handicapped mobility requirements, affirmative-action reporting requirements, etc. There is also the growing tendency to believe that bigger is not necessarily better, that the concentration of all public transit services into one huge operation may not, in fact, be more economical, that the economies of scale for the administrative functions are less than the major increase in cost of management overhead, decreased personal responsibility for quality operation in the lower management and operating ranks, and the decreased responsiveness to segments of a community.

Numerous experiments in this nation have been done to provide transit service in a community by sources other than the regional transit operation. One of the better known is the Knoxville brokerage-concept demonstration. In connection with that program, it has been pointed out that a significant proportion of high-occupancy vehicles are not owned by the Knoxville transit operator. In another example, numerous transit operators serve northern New Jersey communities by providing a connection to Manhattan at the Port Authority bus terminals. Reference is again made to the Toronto situation, where there are a number of transit operators feeding into the Finch station, or into various GO Train service along the lakeshore route.

One conclusion is that multiple ownership of transit operations per se in an area does not necessarily produce adverse conditions for the public.

However, we want to emphasize that "balkanization" does occur where multiple owners do not cooperate to produce the most cost-efficient or cost-effective operation. Looking again at the northern New Jersey example, the problem is not the multitude of bus operators, who provide the regional- or collector-class service, and the various operators of transitway-class services of the commuter and urban rail systems. A similar situation exists in the San Francisco Bay Area, where there would appear to be a need for improved coordination between the operators of regional-class bus services and the transitway class service of the rapid transit system.

Balkanization can even occur in the same ownership, as illustrated by the inability of the Washington Metro to completely integrate bus operations with the rail service in the northeast portion of the District of Columbia. Another example is New York State's Metropolitan Transportation Authority's problems of integrating the operations in Nassau County (which they own) with the Long Island Railroad (which they also own).

The difference between these various situations is that these latter cases of balkanization are examples of multiple operators, in the same corridor, of the same class of service. The former cases of coordinated services illustrate multiple classes of service that are operating to complement each other, regardless of the number of operators. The important conclusion for planning is that the classes of service have been coordinated within those communities. That is the key: coordination between classes of service. It allows each

class to do the job that it does the best and then to interface with each other to provide better transit service to the users and to the communities.

CONCLUSION

This paper has described a concept: a transportation planning tool of a functional classification of transit services. The concept has been applied and worked in a complex real-world test of providing coordinated transit services. It has worked because it makes technical, economic, and political sense. It has enabled implementation of a well-integrated transit system not only from the perspective of the operators but also from that of governmental officials, the general public, and, probably most importantly, the users.

REFERENCES

1. L. J. Pignataro. *Traffic Engineering, Theory and Practice*. Prentice-Hall, Englewood Cliffs, NJ, 1973.
2. R. L. Creighton. *Urban Transportation Planning*. Univ. of Illinois Press, Urbana, 1970.
3. E. M. Hall. *Let's Speak a Common Language!* Traffic Engineering, Vol. 38, No. 12, Sept. 1968, pp. 11-15.
4. N. D. Lea Transportation Research Corporation. *Reference Guide*. Lea Transit Compendium, Vol. 2, No. 1, 1975.
5. B. S. Pushkarev and J. M. Zupan. *Public Transportation and Land Use Policy*. Indiana Univ. Press, Bloomington, 1977.
6. V. R. Vuchic. *Comparative Analysis and Selection of Transit Modes*. TRB, Transportation Research Record 559, 1976, pp. 51-62.
7. H. S. Levinson, C. L. Adams, and W. F. Hoey. *Bus Use of Highways: Planning and Design Guidelines*. TRB, NCHRP Rept. 155, 1975.
8. H. S. Perloff and K. M. Connell. *Subsidiary Transportation: Its Role in Regional Planning*. Journal of the American Institute of Planners, Vol. 41, No. 3, May 1975, pp. 170-183.
9. J. D. Ward and N. G. Paulhus, Jr. *Suburbanization and Its Implications for Urban Transportation Systems*. Office of Research and Development Policy, U.S. Department of Transportation, Rept. DOT-TST-74-8, April 1974.

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Institutional and Political Considerations of BART and Bus Coordination in the San Francisco Bay Area

Franceen Lyons, Metropolitan Transportation Commission, Berkeley, California

The experience of the San Francisco Bay Area with discussions and negotiations regarding coordinating bus and Bay Area Rapid Transit (BART) should be of interest to other metropolitan areas currently operating or constructing new rapid transit systems. While the technical aspects of implementing such service, for example, mutual fare-collection systems and realignments of routes and schedules, tend to be the more frequent subject of discussion among transportation professionals, the subtler political and institutional aspects of consideration negotiations can be the deciding factors leading to implementation or, conversely, to the continuation of duplicated transit service and inadequate feeder-bus service to rail transit stations. The service-coordination issue, then, calls for politically acceptable and institutionally feasible responses as well as technical studies. The Metropolitan Transportation Commission, a regional transportation planning agency for the San Francisco Bay Area, armed with the authority to allocate local and federal discretionary transportation funds, has established a framework that acknowledges the political and institutional constraints to BART-bus coordination and facilitates negotiations among the transit operators. While a resolution to the service-coordination issue is still off in the future, the Bay Area experience thus far has implications for other regions faced with similar transit problems.

In view of the continuing need for efficient public transit service in metropolitan areas that have both bus and some form of rail mode and the current construction of rapid rail systems, the issue of Bay Area Rapid Transit (BART) and bus coordination in the San Francisco Bay Area is a timely subject for discussion. While the technical aspects of implementing such coordinated ser-

vice are more frequently discussed by transportation professionals, the subtler political and institutional aspects of interoperator service-coordination agreements are often overlooked. In actuality, to play down the politics of interoperator cooperation may often result in nonnegotiable positions among the individual rail and bus agencies and, ultimately, in the continuation of duplicated transit service and inadequate feeder-bus service to rail transit stations.

This paper will emphasize the process of service-coordination planning among the BART district, San Francisco Municipal Railway (Muni), and the Alameda-Contra Costa County Transit district (AC), and later the Metropolitan Transportation Commission, since the early stages of BART development. Specific recommendations for the more technical aspects of coordination will not be discussed as much as the political and institutional context in which interoperator negotiations took place.

The object of this paper is to point out the political and institutional aspects of coordination negotiations, not to make recommendations for either the Bay Area or other regions faced with the same bus-rail coordination issues.

TRANSIT OPERATORS

The following descriptions of the major public transit operators in the three BART counties is provided as background.

BART

The BART district was created by an act of the California state legislature in July 1957. After years of planning and engineering design, a proposal for a three-county rapid rail transit system was approved by the voters in November 1962, who also passed the \$792 million general-obligation bond issued to finance the construction of the system.

The initial 114-km (71-mile) system began operations in segments in 1972. The last segment, the Transbay Tube, was opened in 1974.

BART serves the counties of Alameda, Contra Costa, and San Francisco with 34 stations, one of which is located in Daly City in northern San Mateo County. Daily weekday ridership in 1978 averaged 143 000 trips. Control of the district is vested in an elected board of nine directors, who represent the three counties in the BART district. BART levies district property taxes to pay bonded indebtedness from construction and a small portion of operating (administrative) costs. Since late 1977, BART has a permanent subsidy for operations from its share of a half-cent sales tax in the three-county district.

AC

AC, the major bus operator in the East Bay, is a public agency created by the state legislature in 1956. It became an operating entity in 1960, when it acquired the assets of the privately owned Key System Transit Lines. AC Transit provides two kinds of bus service: (a) directly to the areas in the district, the cities west of the Berkeley and San Leandro Hills, and (b) by contract to other cities in portions of Alameda and Contra Costa Counties outside of the AC district.

In its district service, all 18 BART stations on the Richmond and Fremont lines and one station each on the Concord and Daly City lines are served by AC. In addition to local and express buses in the East Bay, AC operates extensive bus routes across the San Francisco-Oakland Bay Bridge to the Transbay Bus Terminal on the eastern edge of downtown San Francisco.

AC operates several kinds of contract bus service in areas of central Contra Costa County, east of the Berkeley Hills, which are also served by the Concord BART line. Some cities contract with AC for local service, which includes connections with BART at the Concord, Pleasant Hill, Walnut Creek, Lafayette, and Orinda BART stations. Under contract to the BART district, AC also operates BART Express Bus service to and from portions of the BART district beyond the immediate service of BART stations.

In 1960, the last year of Key System operations, AC Transit had a total patronage of 45 million. By 1970 the patronage was 52 million, and by 1977, five years after BART began phasing in operations, the patronage was 61 million.

The district is governed by a board of directors, seven elected members serving four-year staggered terms. The AC Transit district was the first public transit agency in the nation to be given the power to levy a property tax. The tax rate began at 3 cents/\$100 of assessed valuation in 1960 and was approximately 45 cents/\$100 in fiscal year 1977/78. For that year the property tax assessment brought in revenues of more

than \$21.4 million. However, with the passage of Proposition 13 in June 1978, the tax revenues for the current fiscal year will net only 35 percent of the preceding year's revenues. The difference is being made up with state surplus funds and state Transportation Development Act monies for this year. No long-term funding source has yet been committed to AC for this deficit.

MUNI

MUNI is a passenger transportation utility owned by the city and county of San Francisco and administered as a unit of the city government by the public utilities commission. MUNI operates a diverse fleet of motor buses, trolley buses, streetcars, and cable cars within the city. This service area includes nine BART stations, four of which are in the downtown area. MUNI'S average weekday ridership exceeds 400 000 trips.

MUNI is governed by a five-member public utilities commission appointed by the mayor. Major policy decisions regarding the system—level of fares and rerouting of lines—are subject to approval by the city's board of supervisors. MUNI is largely subsidized by San Francisco's general fund and therefore must compete with other city agencies for revenues.

EARLY ATTEMPTS AT SERVICE COORDINATION

In its original concept, BART was envisioned as a comprehensive regional transportation system providing service between the major employment centers and residential areas of the three BART counties (Figure 1). BART was designed to compete with the automobile in terms of travel times, passenger cost, and passenger comfort. However, in BART's planning, insufficient attention was given to how necessary corollary feeder-bus services were going to be provided. In reality, for BART to be an effective public transit operator, some degree of coordination with AC and MUNI is necessary.

The need for coordination of bus and rail transit services was stated as early as 1956 by the BART commission's engineering consultant. In the report on preliminary plans for regional rapid transit in the Bay Area, the consultant noted (1, p. 77) that

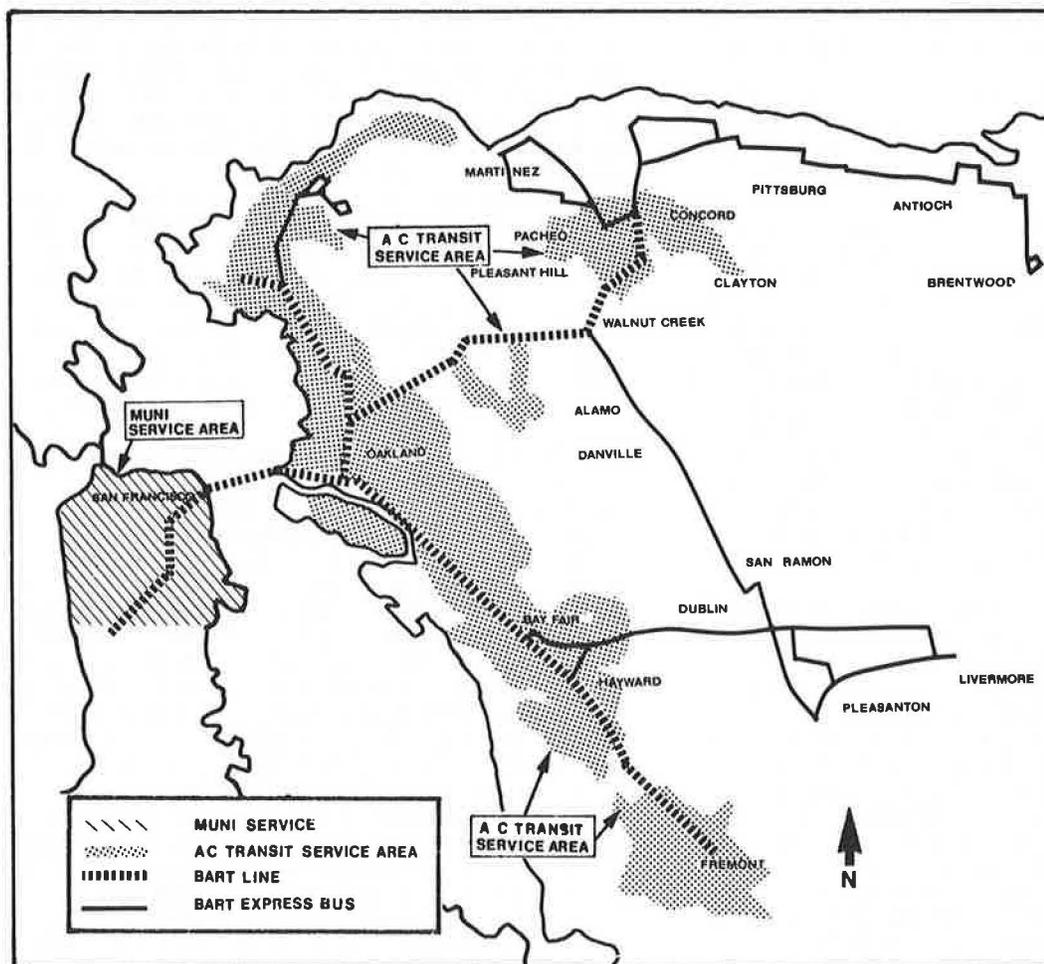
We cannot overemphasize the importance of effective coordination and integration of the rapid transit system with the vast networks of existing surface lines, both local and interurban, in the Bay Area. A coordinated system of surface transit and rapid transit essentially provides two important advantages: traffic is fed into the rapid transit system, which acts as the backbone of public transportation, and unnecessary surface transit competition is effectively channeled into the rapid transit operation. The success of the rapid transit system in the Bay Area will depend upon establishing desirable relationships between the surface and rapid transit lines.

No administrative or institutional process was recommended, however, to facilitate this interoperator integration. BART's consultant seemed to adopt the attitude that integration would occur somehow automatically because it was necessary for BART's success:

We have assumed, therefore, that substantially all existing interurban transit operations serving the Bay Area would, upon the inception of rapid transit service, be redirected and integrated with the new system.

With no regional or even local forum available to begin discussions on this issue in BART's planning phase, the groundwork for inevitable conflicts between BART and AC and MUNI was established.

Figure 1. BART, MUNI, and AC Transit service areas.



BART and AC Relations in the 1950s

BART-AC relations were amicable during the planning phases of these two systems during the middle and late 1950s; the BART board supported AC's 1959 bond election for new capital equipment and acquisition of the Key System. Earlier, AC had proposed continuing the operation of the Key System trains on the lower deck of the Bay Bridge. The toll bridge authority, however, wanted this service eliminated so that this deck could be converted to eastbound rubber-tired-vehicle use. The state public utilities commission also objected to continuation of Key System trains on the bridge. Consequently, the AC board gave up the idea and voted for buses systemwide.

In August 1959, the AC board approved their consultant's Public Transit Plan (2, pp. 20-21), which went before the voters that November. This plan, with the board's support, implied that AC would cease transbay operations once BART began service in this corridor.

Since the Key System now operates most of the transbay buses between the East Bay and San Francisco, the [AC] District must logically assume the obligation of continuing this essential transbay service. This service must be maintained during the six to seven year, or perhaps, longer period required for the Bay Area Rapid Transit District to plan, finance, construct, and place in operation an improved transbay connection. Eventually, however, the District may be relieved of this responsibility so as to limit its functions entirely to the problem of adequate transit within Alameda and Contra Costa Counties ... no part of the equipment purchased with the capital recommended in this report would be duplicated

or wasted when the Bay Area Rapid Transit District would start its operation.

By 1965, however, the AC board had reconsidered this earlier claim and passed a resolution stating that "transbay service should continue to be performed so long as public convenience and necessity actually require them." Throughout this period BART and its engineering consultants and many Bay Area elected officials had expected AC to cede most of its transbay service to BART. But after 1965 AC never again re-inforced this expectation.

The Northern California Transit Demonstration Project

Efforts at transit coordination began in 1963 after the passage of the BART bond issue. An informal joint committee was organized by the operations staffs of BART and AC, and, soon after, MUNI officials joined the session. By 1964, the group had developed a work program and applied for federal funding when it appeared that the complexity of issues warranted outside assistance. The result of this proposal was the Northern California Transit Demonstration Project (NCTDP), a consultant's study of BART-bus coordination issues conducted from 1965 to 1967.

NCTDP was designed to be a comprehensive study of all potential issues among the three major transit operators. It was to develop recommendations on a coordi-

nated route network for tying local transit and BART operations into an integrated system, a modernization program for MUNI, passenger transfer procedures, and a mutual fare system proposal to facilitate passenger transfers.

In the introduction to the 1967 NCTDP report, the need for coordination was stressed again as necessary for BART's success. Two sets of coordination problems were analyzed. The first was the impact of BART on existing transit operations of AC, MUNI, and Greyhound. Alternatives to these systems were defined as necessary for operation and maintenance of the balance of services "beyond the influence of rapid transit." Second, interfaces between BART and the established surface transit networks were recommended. Foremost was the operation of feeder services to and from BART. Included were questions of joint fares, collection and handling of fares, transfers of passengers, sharing of revenues, and scheduling. While significant changes in MUNI's and AC's services, routes, and transfers to coordinate with BART were recommended, the NCTDP report lacked an implementation plan. Instead, the final report proposed that the three operators form an inter-agency compact to undertake a more detailed coordination study.

By 1971, that is, before BART began operations, none of the NCTDP's recommendations had been implemented by MUNI or AC. In 1969, San Francisco voters had rejected a bond issue to upgrade MUNI as recommended by NCTDP. This bond issue would have implemented a massive switch from streetcars and electric buses to diesels. Strong neighborhood opposition to this proposal was the death knell for the NCTDP plans in the city. Also, both MUNI and AC, based on what they considered to be the faulty analysis of the study, resisted any change in their service levels or policies.

In mid-1971, joint exercise-of-powers agreements were concluded among AC, BART, and Metropolitan Transportation Commission (MTC) and MUNI, BART, and MTC to again develop recommendations for executing and improving the coordination of transit in the three BART counties. These agreements led to two more federally funded studies—the AC Transit-BART Service Coordination Project and the MUNI-BART Coordinated Transit Planning Project—which were sponsored by MTC and conducted in 1972 and 1974, respectively. Both studies were overseen by boards of control that included representatives from each operator (either AC or MUNI), BART, and MTC. The general service recommendations of these coordination studies included elimination of or reduction in routes paralleling BART, particularly AC's transbay service, which was often seen as in direct competition with BART in this essential corridor, and rerouting of local bus service to serve BART stations.

In spite of these comprehensive studies and joint meetings among operators, few recommendations for major service and route changes to coordinate with BART were implemented by either MUNI or AC. Proposed route additions or adjustments to serve BART were generally adopted, whereas proposed reductions in routes and service levels paralleling BART were not. Certain characteristics of the coordination process were the primary cause of this outcome and will be discussed separately for the BART-MUNI and BART-AC cases.

BART-AC Coordination Project

Overall, the coordination process has resulted in the reduction of some AC service rather than in the elimination of competing lines. In the East Bay local service

area, many existing lines were rerouted as BART phased in service, new bus lines were added, and service frequencies increased to improve feeder service to BART. Also, under contract to BART, AC Transit operates five new BART express bus routes to and from parts of the BART district. On only a small number of lines has parallel AC service been reduced, and only one line has been eliminated altogether because of patronage losses to BART.

In the transbay corridor, service has been cut back because of BART operations but not severely. AC's transbay service operates as a local collector in the East Bay neighborhoods, and the bus then runs express across the Bay Bridge. Even where these bus lines parallel BART, they continue to provide a more convenient, no-transfer, and often faster journey than BART for many transit riders. Total scheduled bus kilometers on AC transbay runs had been reduced by only about 15 percent in the year after BART transbay service began; on the lines experiencing the greatest reduction in bus patronage, headways have been increased from 5 to 10 min in the peak period (3).

NCTDP recommended modifications and abandonments of 30 of AC Transit's routes. Obviously, to date, the actual changes in AC service are minor in comparison. Regarding transbay service, however, it should be noted that BART's capacity in this corridor and general service reliability have not yet reached levels originally anticipated when AC service reductions were recommended. In 1974, before the start of BART transbay service, the BART Board, realizing fewer cars would be available for service than expected, quieted its demands that AC reduce its service to San Francisco.

To begin to understand this lack of implementation of coordination-study recommendations, it is necessary to describe the political and institutional environment in which the coordination process was attempted.

AC has basically always maintained a favorable public image as a transit agency in the Bay Area, while BART's image has certainly been more controversial and generally not as popular. AC established a good record of transit operations in its brief tenure before coordination discussions began with BART, which, at that time, was still an unknown to the public eye.

Coordination discussions also coincided with media reports on BART's money shortages and construction delays. In this light, public opinion in the East Bay not unnaturally sided with AC Transit. Patrons were familiar with the kind of service AC provided, its convenience to neighborhoods, and its costs. BART, on the other hand, was encountering skepticism as to its projections of service levels and travel costs. Also, as a new regional system, BART did not have the same strong local constituency that AC Transit did.

The board of control for NCTDP—representatives of MUNI, BART, and AC—had served strictly in an overseer's capacity, not as a forum for compromise. In fact, the disclaimer at the beginning of the NCTDP report indicates that none of the report's recommendations had the approval of the board of control.

After the report, between 1967 and 1970, BART and AC held 37 meetings or joint sessions on service policy that failed to produce an agreement between the agencies. When BART received the preliminary proposal for AC route changes in 1969, few of BART's preferences, as shown in NCTDP, were met. BART believed that AC should cut back parallel and competing service on transbay routes and reroute these and other lines to feed BART stations. AC, meanwhile, maintained that transbay service should not be cut back, as noted previously. Financial considerations regarding reduction of transbay service were also uppermost in AC Transit's thoughts;

in 1965, transbay was the only break-even portion of AC Transit's operations.

AC and BART then held widely divergent and often nonnegotiable positions on service policy. AC Transit's general manager viewed NCTDP service-change recommendations as "points of departure" for discussions with BART, rather than final recommendations (4). This position was due to the general feeling of AC staff that the NCTDP projections of BART's ability to attract ridership, especially from buses, were overestimated. The AC Transit board in 1971 adhered to the stance that lines paralleling BART should not be abandoned until AC patrons had the opportunity to make a choice between modes once BART began operations.

BART, conversely, preferred NCTDP's recommendations on routing and frequencies, stating that these changes were crucial to the viability of BART as a regional rapid transit system. BART felt that AC, as a technologically flexible system, could and should change routes to maximize use of BART. Being a fixed system, BART was dependent on AC to flesh out its skeletal system, yet AC remained intransigent in its position. BART's dependence on feeder-bus access then became AC's bargaining strength (5), particularly since BART reduced the number of parking spaces available at stations by half due to construction budget constraints.

BART-MUNI Coordination Project

MUNI has improved feeder service to BART by rerouting and increasing service on several lines. But, generally, service paralleling BART has not been downgraded to the extent recommended by NCTDP, in spite of the loss of MUNI riders on these lines. The majority of service recommendations resulting from early coordination studies required that MUNI reduce or totally eliminate parallel service in the BART corridor; feeder service was a minor issue compared to AC's situation. However, largely because of public protest against proposed service reductions in the affected San Francisco neighborhoods, no MUNI line has been discontinued as a result of BART.

Coordination with BART was a low-priority issue for MUNI, whose planners and management felt their system's first priority was to serve trips within San Francisco. MUNI staff felt that few trips would originate on MUNI and end up on BART to the central business district or points in the West Bay. MUNI delivered good service paralleling BART, and public pressure was on MUNI's side to maintain these lines. In spite of San Francisco's decision to not have parking lots at BART stations in the city, there was no local public pressure on MUNI feeder service.

MUNI also had few staff resources available in its planning or engineering departments to work on coordination issues. The need for extensive coordination on the design and construction of the MUNI Metro subway, built one level above BART along Market Street, only served to increase the complexity of BART-MUNI interactions and to deplete available MUNI staff resources.

In November 1969, the San Francisco electorate defeated Proposition B, which would have upgraded the MUNI system according to NCTDP recommendations. The defeat of this proposal for an expanded and modernized rapid transit system in the city indicated that most residents preferred the local MUNI system, which serves local travel needs well, to rapid transit or a combination of feeder-bus service and rapid transit.

The process of implementing any change in MUNI service is also more time-consuming and cumbersome than for most transit systems. San Francisco's city charter requires the approval of the board of super-

visors and the public utilities commission for any MUNI route abandonment. The courts have broadened this interpretation by including any reduction in service within the definition of "service abandonment," thus taking these operating decisions from MUNI management's purview and placing them in the political process. Hearings must be held by the board of supervisors for each proposed change in service. Any evidence of public protest or opposition usually results in the proposed service changes being dropped from consideration. As has been said of this process, "[San Francisco] city government is so muscle-bound because of the obsolete charter that the best transit manager in the country would have been frustrated" (6).

Continuing Attempts to Coordinate Service

The issues of BART-related fare- and transfer-policy changes for MUNI and AC were discussed in the same forum as service policy. To date, BART has had little effect on the fare policies of AC or MUNI. BART's lowest fares, for intra-urban trips, were kept down to be competitive with AC and MUNI. AC did raise their fares in 1978 after the passage of Proposition 13 so that transbay bus fares are approximately the same as average BART transbay fares.

Interim intersystem transfer arrangements have been in existence for AC since BART began East Bay service in 1972 and since MUNI and BART negotiated transfer policies within two years of BART service in the West Bay. It should be noted that BART's fare-collection equipment was not designed to facilitate transfer procedures between systems.

The NCTDP had made recommendations on transfer mechanisms, although their recommended system of two-way transfers was not generally acceptable to AC and MUNI. It was thought to be too complex to be easily understood by the public and would have been handled by bus drivers, thus slowing the boarding process. However, both local transit agencies realized a need to compromise with BART, and the cost-sharing aspect of the purchase of transfer equipment and the exchange of money among operators necessitated a working out of an agreement.

A BART patron boarding an AC bus gets a free bus ticket at a BART station that is good for a trip away from the station; full fare is paid for the bus ride to BART. The cost of the trip discount is paid now with federal Section 5 funds allocated to AC by MTC. BART's early preference was for transfer tickets to be issued by bus drivers and that one-way riders not be given this discount. AC's plan prevailed, however, although improvements to this transfer system are currently being discussed.

MUNI shared many of AC's reservations about the NCTDP-proposed transfer mechanisms. MUNI's dilemma was further compounded when in 1974 they instituted a monthly "fast pass" that cannot be recognized by BART fare-collection equipment. MUNI did adopt a two-way transfer system where paired "from" and "to" MUNI tickets are sold in BART stations for the cost of one MUNI fare. This two-part transfer is of value only to the regular BART rider who does not purchase a fast pass. Like AC, MUNI pays the cost of this system through Section 5 funds. As in the AC situation, MUNI's transfer scheme with BART is considered an interim solution.

Summary

The process of implementing coordinated bus and rapid

rail service is complicated by both technical and political problems. However, the NCTDP and the 1972 AC and 1974 MUNI coordination studies viewed the coordination issue as a technical problem and failed to recognize the political and institutional context in which these issues had to be resolved. Some of the problems not considered included public interests and vested constituencies, fear of change, and simple inertia on the part of the operators. These obstacles to resolution of coordination agreements and ultimate implementation were underestimated in early attempts at resolution of coordinated transit operations in the BART counties.

Adding to these problems was the absence of a real forum for negotiation. No incentives for bargaining and compromise were present in early coordination meetings. No third party was available in the 1960s to play the role of mediator and to provide some incentive for operators to reach a resolution of their differences. This vacuum of authority is where the Metropolitan Transportation Commission (MTC) entered.

CREATION OF THE METROPOLITAN TRANSPORTATION COMMISSION

The final report of NCTDP proposed that the three major operators, AC, BART, and MUNI, form an interagency compact to undertake a more detailed coordination study. Commenting on the NCTDP results, the Bay Area Transportation Study Commission (BATSC), MTC's predecessor, said that "present institutional arrangements are not sufficient for resolution of the issues." BATSC saw the need for the intervention of a regional level of policy-making because local interests (AC and MUNI) were often in conflict with regional (BART) interests.

The state legislation establishing MTC in 1970 instructed the commission to expend some effort to "insure adequate feeder service to public multi-county transit systems." The Transportation Development Act (TDA) of 1971 provided a new source of local funding for transit and also instructed those agencies allocating the act's funds, such as MTC, to set "maximum coordination of public transportation services, fares, (and) transfer privileges" as a priority in allocating TDA monies.

MTC's planning and programming responsibilities have provided opportunities for interaction with the transit-operating agencies. MTC's responsibilities include

1. Review and approval of transit operators' claims for the act's funds (TDA legislation instructs MTC to "approve those claims which will not result in the undesirable duplication of public transportation services, and which will provide for a coordinated public transportation system in the region"),
2. Review and approval of applications for federal and state grants,
3. Sponsorship of formal planning studies related to transit service coordination, and
4. Adoption and updating of a five-year plan of program and project priorities and development of capital improvement programs.

MTC appears to be the appropriate institutional structure for improving coordination among transit operators, particularly through the bargaining power it has in allocating discretionary funds, such as TDA and federal Section 5 monies.

MTC is making some efforts to set standards for operators' performance but has not yet tied funding in with these standards. However, MTC has no direct

regulatory powers. Although some regulatory authority was proposed in early drafts of the MTC legislation, opposition by Bay Area transit operators resulted in the deletion of these provisions.

The Metropolitan Transit Association

Aside from sponsoring the two interoperator coordination studies in the early 1970s, MTC also took steps to organize the transit operators in the Bay Area to facilitate the coordination process. In late 1972, the MTC commissioners proposed a Metropolitan Transportation Federation, modeled on a plan in Hamburg (Germany), where transit properties pooled revenues and coordinated service to move from perennial deficits to a slim profit.

A consultant was hired by MTC to develop a consumer-oriented coordination and promotion strategy. Much of the marketing strategy that was developed was incorporated into MTC's first Regional Transportation Plan (RTP) in 1973 as a diluted version of the Hamburg plan called the Metropolitan Transit Association (MTA).

MTA was described in RTP as a "cooperative federation of transit operators to propose, plan, keep the Commission advised and help implement certain programs of coordination in transit operations." MTA was to include representatives of MTC, the California Department of Transportation, and the policy boards of all the major carriers, both private and public, to act as an advisory body to the commission. Coordination of transit routes and schedules, research and marketing, fare structures, ticketing, and transfer and fare collection procedures among Bay Area operators was a high priority for MTA. However, implementation procedures for MTA's recommendations were limited in the RTP: "The recommendations of MTA would be encouraged by the yearly updating of MTC's RTP and by MTC's control over transit aid funds."

MTA never really got off the ground after RTP was adopted. In the meantime, an informal organization of transit operators, the Bay Area Transit Association (BATA), drew up a series of joint-powers agreements for eventual discussions of coordinated purchasing, service policies, etc. In early 1975, BART's first elected board of directors (the board had previously been appointed by county supervisors) voted against the participation of BART's acting general manager in BATA. Without the involvement of the major regional transit operator, and apparently lacking a strong push from MTC, BATA, like the MTA, never formally met in the mid-1970s, and coordination of services and other aspects of operations among the three major operators in the BART district remained elusive.

Current MTC Role

As constituted by the state legislature, MTC did not have a definitive mission, just broadly stated goals and objectives for the planning and operations of transportation facilities and transit modes in the Bay Area. MTC defined its mission more specifically in its own Regional Transportation Plan (RTP), which must be updated annually.

In the process of establishing the regional plan and financing priorities, MTC had to consult with the implementing agencies in the region. Therefore, the RTP became a product of consensus and collaboration with these agencies rather than a product purely of MTC's own regional perspective on how the various modes of transportation should interface, plan capital improvements, finance services, etc. (7, p. 5). RTP, first written in 1973, then established the process of decision making by MTC, which appears to be more suited

to the role of arbiter in the interoperator service-coordination issue. Although having the potential for substantial management control over the transit operators through the allocation of Transportation Development Act monies and other local and federal operating subsidies, by the mid-1970s MTC had not actually flexed this muscle to influence the cooperation of the three major transit operators in settling the BART-bus service-coordination problem.

However, more currently, although Bay Area transit operators have evidenced ridership gains, fare-box revenues constitute a decreasing portion of total operating revenues. Aside from federal subsidies, new local sources of revenue had to be secured for Bay Area operators. BART had been receiving 0.5 percent of the increased local sales tax since 1969 to cover construction shortfalls; in 1974, this legislation was amended to temporarily extend the sales tax for BART's operating expenditures. In 1976, MTC unsuccessfully attempted to gain control from BART of these sales tax revenues. As a compromise, the state legislature mandated both MTC and the state legislative analyst to develop a long-term financing solution for BART, which ultimately included consideration of the increasing unfunded deficits of MUNI and AC Transit.

A result of MTC's Transit Financing Study was Assembly bill 1107, enacted in September 1977. This legislation provides a permanent base of funding for BART's operation by allocating 75 percent of the half-cent sales tax to BART and the remaining 25 percent to BART, AC, and MUNI for "Improvements in the level of transit services beyond that provided on or before January 1, 1978, on the basis of regional priorities" established by MTC. These latter discretionary funds, however, cannot be allocated to an operator unless it is a member of the MTC-established Transit Operator Coordinating Council (TOCC).

TOCC, which was mandated by bill 1107 and organized in February 1978, is composed of the general managers of the six major public transit operators in the Bay Area and the executive director of MTC. TOCC builds on the existence of the Regional Transit Association (RTA), which was created in March 1977 by the same six operators partly as a defensive maneuver against the threat of an MTC-led association (the subsequent TOCC). RTA, which has no MTC representation, has joint working committees in the areas of service and fares, procurement, public information, management systems, maintenance, operations, legal services, personnel, training, and affirmative action. One of the RTA's objectives is to try to settle major issues among the top management of the transit operators without having to involve MTC in the decision-making process. RTA has had some success but primarily in areas of mutual benefit such as procurement and public information; the high-conflict issues that are more difficult to resolve still exist. RTA and TOCC have separate agendas but generally meet together; MTC provides some staff support for TOCC.

Given the financial problems of the three major transit operators in the BART district, aggravated by the passage of Proposition 13 in June 1978, which limits property tax assessments, the discretionary funds allocated by MTC on the basis of compliance with regional transit objectives are then of increasing importance to the transit operators for maintenance of, at least, existing services. TOCC and RTA now have this additional financial incentive to work out service coordination, with some direction by MTC.

It is too early to predict what the outcome of these stepped-up efforts will be, but proposals for coordinated fare structures and transfer mechanisms are currently

being evaluated and service-level changes will be considered in the near future. MTC, given the appropriate tools and political climate, is becoming a stronger force in mandating the coordination of transit services to best serve transit riders and taxpayers in the San Francisco Bay Area with the limited public resources currently available.

CONCLUSION AND POLICY IMPLICATIONS

The problem of BART-bus service coordination is only partly a technical one: The technical know-how is available to solve this perceived "problem" of duplicated service, as in the transbay corridor, and inadequate bus service to BART stations. The service-coordination issue is primarily an institutional problem of negotiation and implementation. Continuing technical and consulting studies of an advisory nature only tend to prolong the decision-making process by rehashing the same issues and failing to produce politically acceptable mechanisms of execution.

The Bay Area, with its strong political fragmentation and diversity of transit operators and their constituencies, represents a unique example of institutional constraints that have hampered the long-term objective of achieving cost-effective and efficient coordination of transit services.

There are a number of policy implications that can be deduced from the Bay Area experience of attempting to coordinate the transit services of two existing local public transit operators with a new regional rapid rail transit operator.

1. Organizational structure: A loose, cooperative organization of independent operators with potentially competing services will have little incentive among themselves to agree to a regional cost-effective approach to providing comprehensive regional transit service. A single regional authority like MTC can probably provide the best incentives for service coordination if given sufficient legislative mandates, such as MTC's authority to allocate discretionary funds to support regional objectives for transit.

2. Rapid rail transit system design: Coordination issues should be addressed early in the planning and design phases of rapid rail system development. One basic issue in system design is the purchase of fare-collection equipment that is flexible enough to implement a transfer system to buses and therefore does not constitute a barrier to service coordination.

3. Transit service policy coordination: Planning studies have to go beyond the first level of analysis and the listing of recommendations and service options to examination of potential incentives to achieve the optimum coordination of transit service. Items for consideration include ways to compensate transit agencies during coordination trials and option of bus service under contract to the rapid rail transit agency to provide feeder service.

4. Role of regional authority: Coordination discussions among a number of operators are best handled by a separate, regional agency maintaining operations by the transit operators. By setting regional priorities and trade-offs, broad policy changes can be provided through a variety of mechanisms, such as overall system planning, including approval of capital improvement proposals and service levels, and monitoring of operator performance and efficiency coupled with allocating discretionary funds.

While the resolution to transit service coordination

is not yet at hand, the process for reaching a politically acceptable and workable solution has been set in motion by MTC, armed with its authority to allocate discretionary funds for transit, with the cooperation of the transit agencies. With clearly defined objectives and the public interest well in mind, the goal of BART-bus service coordination may be within reach of the San Francisco Bay Area.

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REFERENCES

1. Regional Rapid Transit: A Report to the San Francisco Bay Area Rapid Transit Commission, 1953-

1955. Parsons, Brinckerhoff, Hall and MacDonald, New York, 1956.
2. DeLeuw, Cather and Company. Report to the Alameda-Contra Costa Transit District on a Public Transit Plan for Special Service District Number One. San Francisco, Aug. 1959.
3. Peat, Marwick, Mitchell and Co. BART Impacts on Highway Traffic and Transit Ridership. Metropolitan Transportation Commission, Berkeley, CA, May 1977; U.S. Department of Transportation, technical memorandum DOT-BIP-TM-20-3-76.
4. Booz-Allen and Hamilton, Inc. The Impact of BART on Local Transit Service and Financial Policy. Metropolitan Transportation Commission, Berkeley, CA, Sept. 1977; U.S. Department of Transportation, working paper DOT-BIP-WP-42-8-77.
5. S. Zwerling. Mass Transit and the Politics of Technology. Praeger, New York, 1974.
6. B. Dorais. Transit Trauma. San Francisco, Vol. 9, No. 9, Sept. 1967, p. 33.
7. D. W. Jones, Jr. Transportation in the Bay Area: A Challenge to Institutional Reform. Public Affairs Report (Bull. of the Institute of Governmental Studies, Univ. of California, Berkeley), Vol. 19, No. 2, April 1978.

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Abridgment

Dade County's Experience with Urban Station Simulation (USS) Procedures

Ronald L. Rardin, Gunter P. Sharp, Joseph C. Corradino, and Charles C. Schimpeler, Schimpeler-Corradino Associates, Miami

One of the most important considerations in the design of rapid transit stations is the delay that passengers passing through the station will encounter. It is important that service facilities in the station (turnstiles, escalators, stairways, etc.) have sufficient capacity to process the maximum number of passengers arriving or departing at any given time. Sufficient capacity is mandatory to assure the safety of passengers. Further, ridership tends to increase as the delays passengers experience are reduced.

Urban Station Simulation (USS) is a transit station simulation computer program developed by the Urban Mass Transportation Administration (UMTA) to analyze the capacities of stations. Station planners provide as input to the program the geometric configuration of a proposed station and the proposed capacities of the various service facilities in the station. The USS program then simulates the movements of individual passengers through the station and records statistics on how they are distributed along alternate routes and on the delays they encounter in waiting lines (or queues) that develop at various points.

By reviewing USS reports of such statistics, the plan-

ner can evaluate the capabilities of a proposed station design before resources invested are in detailed design and construction. Capacity problems can be identified and dealt with during the early stages of design. Details of the capabilities of USS have been presented elsewhere (1).

As part of its analysis of transit stations in the Metropolitan Dade County Transportation Improvement Program, the Kaiser Transit Group (KTG) has applied the USS program to designs for the proposed Douglas Road, South Miami, and Dadeland North stations in the southern (Dixie Highway) corridor of the stage 1 Dade County Rapid Transit System. Figure 1 shows the USS model of one of the Douglas Road station configurations that was analyzed.

Links (pedestrian paths) and nodes (decision and delay points) of the model are superimposed on floor plans of the lower (concourse) and upper (platform) levels. Passengers boarding trains originate as walkers (zone 1), drivers who have used the park-and-ride (zone 2) or kiss-and-ride (zone 3) facilities, or transferring riders on one of the several bus lines serving the station (zones 6-10). They enter the station through turnstiles (nodes

Figure 1. Sample station layout and USS network.

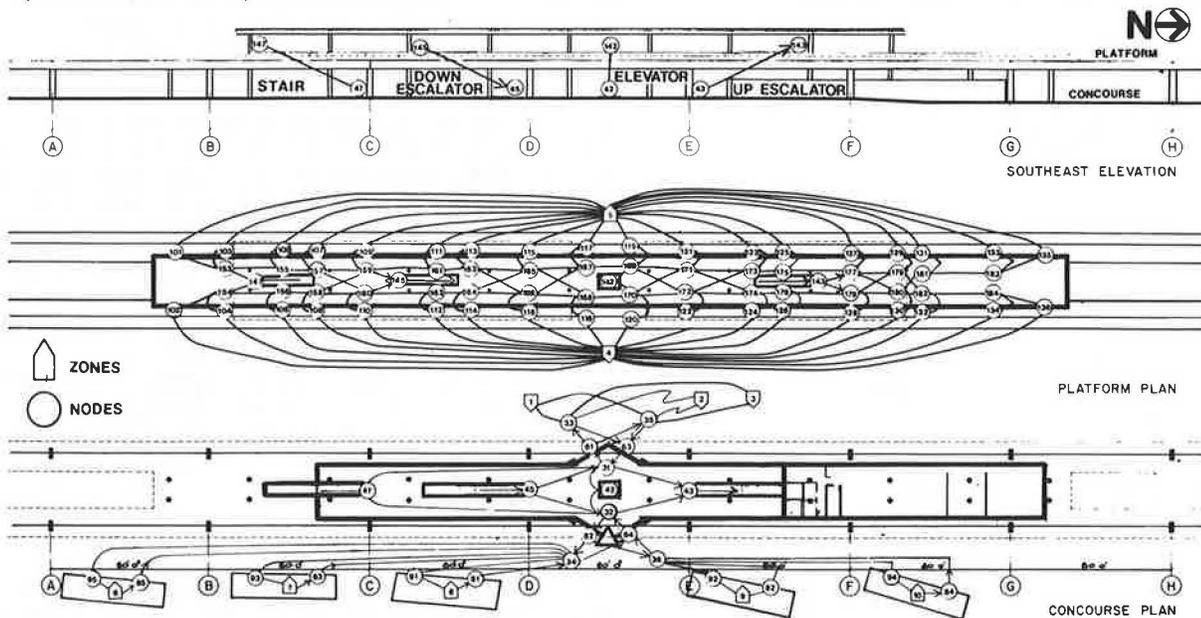
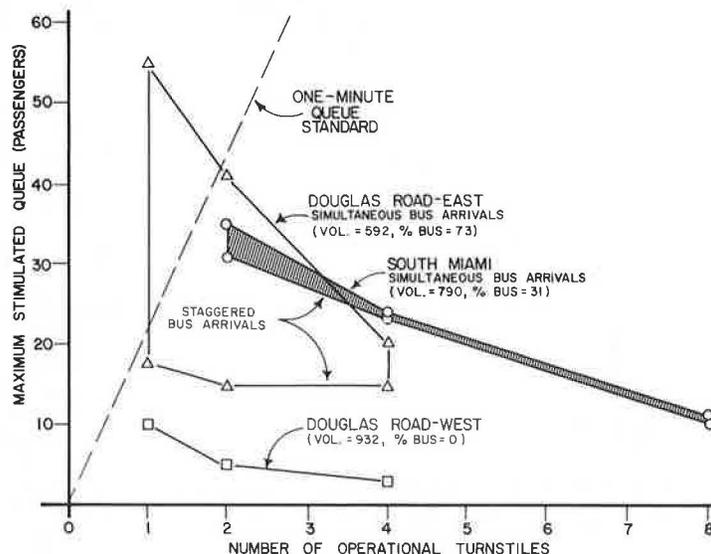


Figure 2. Maximum queues observed at access turnstiles.



63 and 64), move up to the platform level via stairs and escalators, wait for and enter a train by one of the several doors (such as node 122 for a northbound train or node 119 for a southbound train), and exit the model at the appropriate train zone (zones 4 and 5).

Passengers getting off trains follow reverse routes from train zones toward one of the other zones. Most links in the model permit flow in both directions. However, one-way links like the escalators are also considered appropriate and are identified in Figure 1 by arrows.

FARE-GATE REQUIREMENTS

KTG's use of USS has centered on a number of station-sizing issues (2). One such issue at the various rapid transit stations is the number of fare gates or turnstiles required to serve anticipated passenger volumes. The service level of a group of turnstiles is measured by the length of the queue that can develop. The guideline

KTG designers have used is that such a queue should never exceed the volume of patrons that can pass through the turnstiles in a minute.

Simulation analyses of fare-gate requirements were performed at all three stations tested. It was assumed that fare gates provide one-way service, that people can exit from them at a rate of 40/min, and that people can enter them at a rate of 24/min.

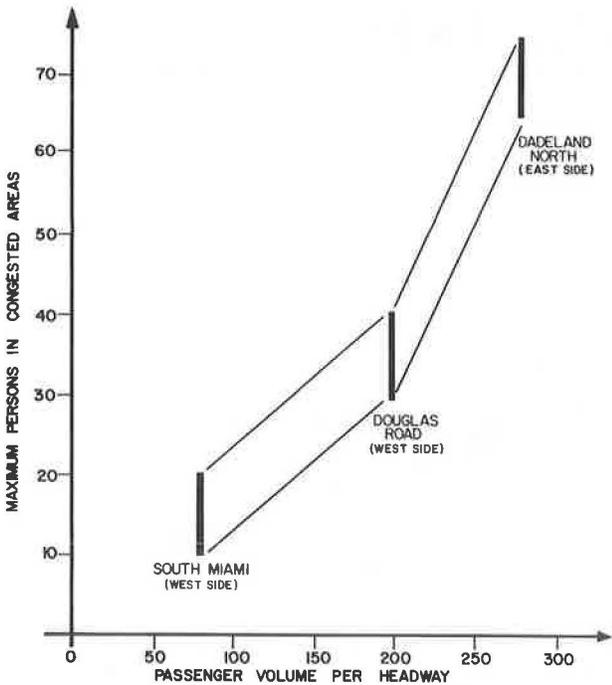
Figure 2 illustrates the results of queue simulation for turnstiles for the single bank of turnstiles planned at the South Miami station and for both the east (bus) and west (automobile) sides of the Douglas Road station. In each case, the hourly volume of passengers served and the percentage of patrons arriving on buses are indicated. The dashed line in Figure 2 shows the maximum allowable queue that can be cleared in a minute.

In general, the length of the queue observed for a given number of turnstiles increases as the volume of passengers does. However, the arrivals of buses com-

Table 1. Comparison of typical results for vertical-movement alternatives.

Category	Douglas Road	South Miami
Simulated morning peak-hour volume	3888	1578
Assumed service rate of stairway (min)	120	120
Maximum queue at top of stairway		
Case A	45	9
Case B	6	NA
Case C	6	1
Average passenger time in station (s)		
Case A	315	277
Case B	305	NA
Case C	300	272
Percentage of platform access by the south versus north vertical-movement devices		
Case A	27 versus 73	25 versus 75
Case B	100 versus 0	NA
Case C	7 versus 93	6 versus 94

Figure 3. Maximum simulated congestion in restricted areas beside vertical-movement devices.



plicate this matter, because bursts of passengers reach the turnstiles together and cause momentary overloading. This is accentuated when several buses arrive simultaneously. Staggering bus arrivals could minimize such bursts.

Figure 2 shows clearly how these factors will affect queues at access turnstiles at Dade County's transit stations. Although the west side of Douglas Road has the highest volume of those reported, it produces the smallest queues. Other areas have larger queues because substantial numbers of passengers arrive on buses. When this number becomes large, as in the case of the east side of Douglas Road, the difference between staggered and simultaneous bus arrivals becomes substantial. Actual experience should lie somewhere between these two limiting cases.

VERTICAL MOVEMENT

Another series of issues KTG has studied with USS centers on the number and orientation of vertical-

movement devices (escalators, stairs, and elevators) along the centerline of the station. For example, one sequence of alternatives consisted of a case A (one stair, one escalator, and one elevator for vertical movement) versus cases B and C (stair at the center of the platform replaced by a second escalator and a stairway added at the south end of the platform). The latter two cases are distinguished by the orientation of the escalators: In case B the up escalator is on the south, and in case C the up escalator is on the north.

Table 1 illustrates the USS results used to compare the three cases at the stations where they were considered. The effect of cases B and C is illustrated by the percentage distribution of access volumes as passengers enter the Douglas Road platform. Under case B, all access flow is to the same end of the platform (100 percent south versus 0 percent north). By separating the up escalator and the stair in case C, flows can be distributed slightly more evenly on the platform (7 percent south versus 93 percent north). Thus, case C is preferred and was the only two-escalator approach tested at South Miami.

In a comparison of cases A and C, the principal results of interest are the queue at the top of the case A stair and the average amount of time passengers spend in the station. If the queue at the stairway is too large or delays too lengthy, the escalator is necessary. However, stairway queues for case A, as shown in Table 1, are not great enough to justify the additional escalator. The largest value—45 at Douglas Road—is well within the number that can be cleared within a minute. There is a slight (5-10 s) reduction in the time passengers spend in the station when an extra escalator is added, but that savings is not enough to justify the extra escalator.

CONGESTION ON PLATFORMS

At all stations, the spaces alongside the vertical-movement devices are the platform areas most likely to produce congestion. Thus, the occupancy of such areas was monitored in all results of the USS simulation.

Figure 3 illustrates the results observed by showing the maximum number of persons observed in potentially congested areas during KTG's simulations of the three south corridor stations. Values varied somewhat according to the specific assumptions of particular simulation runs, so a range of values is shown for each station. Thus, for example, the Douglas Road station had a maximum of 30 to 40 persons in the potentially congested areas. These values translate to minimum areas per patron of 0.5 m² (4-5 ft²), which authorities such as Fruin (4) suggest is the minimum for patron convenience.

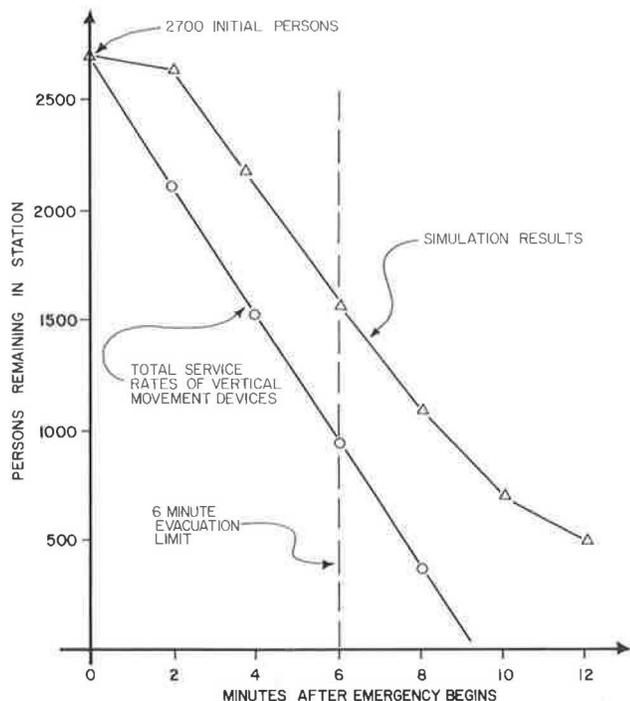
The values in Figure 3 may have been somewhat inflated by the internal logic of the USS program, but they showed clearly that congestion beside vertical-movement devices may be a concern in any of the stations at which volumes will be high.

EMERGENCY EXIT

KTG's main analysis of vertical-movement alternatives considered only the capacity required to serve patrons in the morning peak hour. However, the facilities for vertical movement must also allow evacuation of the platform in an emergency.

One series of KTG's simulation tests of the Douglas Road station addressed such requirements for emergency evacuation. The particular configuration tested has one stairway and two inoperative escalators that function as reduced-capacity stairs. The purpose of the test was to determine whether the 2700 people potentially on the platform and in two adjacent trains at the time of

Figure 4. Emergency exit routes for Douglas Road example.



an emergency could be cleared from the station in 6 min.

Figure 4 illustrates the observed results of the simulation. The number of people remaining in the station at each time interval simulated is compared to the number of people who could be cleared at the maximum capacities of the vertical-movement devices. Clearly, neither the observed simulation results nor the maximum vertical-movement capacities would permit all 2700 patrons to be cleared within 6 min. Additional vertical-movement capacity is required to meet the standard.

The parallel pattern of the two lines in Figure 4 indicates that vertical-movement capacity is the limiting consideration in emergency evacuation of all stations. Once an evacuation is under way, patrons are cleared from the station at about the capacity rate. However,

actual evacuations lag behind maximum capacities because some time is lost in starting patrons toward the vertical-movement devices.

COMMENTS

The USS program has not been widely released by UMTA because of many known deficiencies [see KTG's critique (3)]. In fact, UMTA has taken the first steps to produce a new version. Still, this paper demonstrates that pedestrian simulations can provide many useful analyses of station design. KTG's simulation results have been well received by the architects who must use them, and more analyses have been requested. It is rarely possible to determine exactly which analysis caused a given change in design, but simulation results have certainly influenced KTG's decisions on fare gates, capacity for vertical movement, and emergency exits.

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REFERENCES

1. J. E. Lutin and G. P. Benz. USS I Reference Manual. Transportation Program, Princeton Univ., NJ, UMTA Grant No. NJ-06-0010, March 1978.
2. Kaiser Transit Group. Patronage Flow Analysis: South (Dixie Corridor) Stations. Metropolitan Dade County (Florida) Transportation Improvement Program, Miami, June 1978.
3. Kaiser Transit Group. Opportunities for Improvements in the USS Station Simulation Evolved Through Its Use in the Metropolitan Dade County Transportation Improvement Program. Metropolitan Dade County (Florida) Transportation Improvement Program, Miami, March 1978.
4. J. J. Fruin. Pedestrian Planning and Design. Metropolitan Association of Urban Designers and Environmental Planners, Inc., Churchill, New York, 1971.

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