# Assessing the Effectiveness of Paratransit Services

Ronald F. Kirby and Gerald K. Miller, Urban Institute, Washington, D.C.

**The information and procedures required for the assessment of the effectiveness of paratransit options as part of a comprehensive evaluation of public transportation alternatives are reviewed. Recent paratransit projects directed toward three major travel markets—high-density home-to-work travel, special-user-group travel, and general-purpose travel—are used to illustrate the discussion. Although these examples provide useful insight into the effectiveness of paratransit modes and their relationship to conventional transit, they also draw attention to some important information gaps and some major shortcomings in current evaluation procedures. Suggestions are made for filling these data gaps and improving overall evaluation procedures for paratransit and other public transportation modes.**

The involvement of the various levels of government in the regulation, financing, and administration of surface public transportation services has increased steadily in the United States over the last two decades. Where government agencies formerly regulated fares and service standards for private transportation companies, they now also finance public transportation programs at a level of several billions of dollars per year and play an increasing role in deciding the kinds of services that are to be provided to the traveling public. Sources of financial support for public transportation include the urban mass transportation program of the U.S. Department of Transportation (DOT), the human services programs of the U.S. Department of Health, Education, and Welfare (HEW), the urban development programs of the U.S. Department of Housing and Urban Development (HUD), and a variety of similar programs administered by agencies of state and local governments.

In addition to their earlier regulatory objective of maintaining a safe and reliable public transportation system, government agencies are now also pursuing broader social objectives. The programs they fund are usually aimed at accomplishing one or more of the following types of changes:

1. Improving the mobility of persons who do not have ready access to a private automobile;
2. Attracting private automobile users to higher-occupancy services such as carpools and buses to reduce the congestion, pollution, and energy consumption associated with their travel; and
3. Making selected locations in urban areas more accessible for shopping, business, and other activities.

Government funding for public transportation programs is currently spread among numerous federal, state, and local programs, each of which has its own set of objectives, eligibility requirements, and administrative procedures. Some programs have overlapping objectives, which leads to questions about which program should pay for the subsidy on a particular trip. (This problem may arise, for example, when a DOT program for the general public is introduced in an area in which certain elderly and handicapped residents are being served by an HEW human services program. The administrative staff for the HEW program may allow DOT funding to substitute for HEW funds previously spent on transportation, often to the consternation of the administrators for the DOT program.) Restrictive eligibility and administrative requirements sometimes result in inefficient duplication of facilities: vans bought for the client group of one agency often cannot be used to serve an equally needy but different client group of another agency. And procedures adopted by one program sometimes produce negative side effects for another program: earmarking subsidy funds for a costly new van service for elderly residents may deprive existing taxicab operators of much of their former business and reduce the service levels that can be provided to other agency client groups and to the general public.

Many of these problems and inefficiencies are due to poor planning and administration. (Some, however, are inherent in the structure of the programs and can only be removed by legislative action. In this paper, these are accepted as constraints that cannot be changed in the short run.) Proposed public transportation projects are rarely subjected to a careful accounting of benefits and costs followed by comparison with possible alternatives. And once implemented, projects become institutionalized and difficult to change.

Efforts are needed to make planners and administrators aware of the kinds of benefits and costs that should be taken into account in assessing public transportation proposals and of the kinds of alternatives that should be considered for achieving certain objectives. This information should be provided as part of a comprehensive, participatory planning process designed to involve all the interested parties in the decision-making process and to ensure that all the relevant benefits, costs, and alternatives are in fact considered (1).

Paratransit services constitute a promising set of alternatives for consideration in such a comprehensive planning process. Although these services were neglected in the past in favor of conventional bus and rail transit alternatives, over the last five years, paratransit options have received greatly increased attention. However, current knowledge of the demand response to paratransit services and the costs of providing these services does not provide planners and administrators with the information they need to evaluate paratransit alternatives adequately.

A great deal of attention is currently being devoted to the various institutional and operational conditions governing the supply of paratransit services in urban transportation systems. Regulation, labor-protection requirements, planning and programming procedures, administrative and subsidy arrangements, vehicle technology, and computerized operating systems are all subjects of intense study by the transportation community. Considerably less attention is being paid, however, to assessing the effectiveness with which paratransit options can contribute to overall urban transportation objectives by serving various kinds of travel demand. The available information on demand responses to paratransit services is limited and fragmented, and the current procedures for combining demand and cost information to evaluate alternatives are ill defined and inadequate in many respects.

This paper begins by outlining the demand and cost information needed for assessing the effectiveness of paratransit options as part of a comprehensive evaluation of public transportation alternatives. An attempt is then made to obtain and synthesize this type of information from a selection of data on some recent paratransit projects. The information presented is organized by three major travel markets: high-density home-to-work travel, special-user-group travel, and general-purpose travel. Significant gaps in the desired information base are noted, and approaches are suggested for filling these gaps in a systematic manner.

## THE PLANNING PROCESS

Ideally, the planning process for public transportation should involve a rigorous examination of the benefits and costs associated with the alternative proposals. This examination should be carried out within an institutional framework designed to permit all of the interested parties to express their views and suggestions. Unfortunately, the planning process currently used for public transportation projects falls far short of this ideal. The shortcomings of present procedures are especially severe in the case of short-range planning, which has not yet been subjected to even the broad alternatives analysis requirements imposed in recent years on long-range planning.

Improvements in the planning of public transportation services are needed in four major areas:

1. Estimation of the benefits to be generated by a proposed project,
2. Estimation of the costs associated with a proposed project,
3. Identification of worthy alternative projects, and
4. The institutional framework within which the planning process takes place.

Specific shortcomings and needed improvements can be identified for each of these four areas.

### Estimation of Benefits

The objectives of government regulation and financing of public transportation services are typically framed in very general terms. The Urban Mass Transportation Act of 1964, as amended through 1978, for example, states the following objectives for the mass transportation program:

> 1. To assist in the development of improved mass transportation facilities, equipment, techniques, and methods, with the cooperation of mass transportation companies both public and private;
> 2. To encourage the planning and establishment of areawide urban mass transportation systems needed for economical and desirable urban development, with the cooperation of mass transportation companies both public and private; and
> 3. To provide assistance to State and local governments and their instrumentalities in financing such systems, to be operated by public or private mass transportation companies as determined by local needs.

It is general directives of this kind (combined with a variety of requirements and restrictions on the use of the funding) that are placed before the civil servants whose responsibility it is to administer the program. Judging just how well a particular public transportation proposal contributes to the objectives of the program requires interpretation of the objectives by policymakers and administrators at several levels of government. Indeed, there is considerable room for different interpretations of a federal program such as the mass transportation program by different state or local governments: one local government may elect to devote considerable funding to keeping transit fares low, for example, while a nearby government might prefer to have higher fares and more extensive services.

Whatever the public transportation objectives of a given community, however, the benefits generated by a particular public transportation proposal will be determined primarily by its effect on travel. [Benefits independent of actual effects on travel (such as those due to increased options for travel, creation of new public transportation jobs, and enhancement of community image and pride) are difficult to quantify and are probably best left to be judged directly by community decision makers.] Thus, the first step in estimating these benefits is to determine the extent to which the proposal will influence travel behavior. This influence may be reflected in a change in any of several descriptors of trip making: (a) the number of trips made; (b) the service characteristics and price of the travel modes used; (c) the purposes for which trips are made; (d) the time of day, week, and month when trips are made; and (e) the origins and destinations of trips. A project does not necessarily have to change significantly the number of trips made to generate benefits: for some communities, a shift in the travel modes used or the time of day when trips are made may be the major effects sought by the project.

If the effects on travel of alternative public transportation proposals can be estimated with reasonable accuracy, community decision makers will be in a good position to judge the overall social benefits that should be attributed to the proposals. Effects on overall social welfare (such as improvements in the private travel benefits received by different population groups, reductions in gasoline consumption and air pollution, and likely changes in urban form) can all be estimated for decision makers once the initial travel responses to new proposals have been predicted.

There are a number of important methodological points that are sometimes overlooked in current practice but should be kept in mind in estimating the effects on travel of project proposals:

1. The definition of a trip must be clearly stated and unambiguous. A trip that involves a transfer is sometimes counted as two unlinked trips and sometimes as one linked trip. As some 10 to 20 percent of public transportation trips are likely to involve transfers, con-

fusion over this point sometimes produces misleading estimates. The distinctions between one-way trips and round trips, and between passenger trips and vehicle trips, also cause confusion at times.

2. Changes in travel behavior projected for alternative projects must be estimated with respect to the same base. Although it does not particularly matter which base is used, consistency must be maintained for all of the alternatives considered. Perhaps the most commonly used base is the hypothetical do-nothing situation: travel behavior as it would have been in the absence of all the alternatives being considered. (This is usually estimated by extrapolating the before situation: travel behavior as it is at the time the alternative proposals are being considered.) In some cases, however, it may be more convenient to use one of the alternatives as a base, perhaps the most popular one.

3. Care must be taken in the use of fare and service elasticities (2, 3). The distinctions between shrinkage ratios, growth ratios, and arc elasticities must be kept in mind. The application of a shrinkage ratio to the estimation of the effect of a fare reduction, for example, will result in underestimation of the effect. And it is essential that seasonal and secular (i.e., temporal) effects on travel be taken into account when elasticities are developed.

4. Account must be taken of the development of travel responses over time. A period of six months to a year may be needed before the travel response to even the simplest service change has fully developed, and the benefits of major projects may not be realized for several years. Travel responses and the associated benefits (and costs) should be estimated over reasonable project lifetimes and properly discounted to present values for comparison of alternatives.

5. Attempts should be made to assess the effects on urban form and future travel demand of projects that encourage travelers to change their trip origins or destinations. An effective vanpool or subscription bus service from a remote residential community to an employment center can influence more workers to move to the community, for example.

6. The incidence of benefits over different population groups and organizational entities must be explicitly identified. Community decision makers may place different values on trips made by different persons, for example. Similarly, trips that help promote downtown businesses may be valued more highly than those that encourage suburban business development.

7. Project effects that reduce overall benefits must also be taken into account. Many projects have negative effects that offset to some degree the positive benefits generated. For example, a dial-a-ride van service for the elderly may force a taxicab operator to reduce the level of service he or she can offer to the general public.

## Estimation of Costs

By comparison with the relatively complex task of quantifying the benefits of public transportation programs, the estimation of the costs associated with these programs often appears deceptively easy. The inadequacy of the computation and presentation of costs associated with recent programs serves to dispel any presumptions of this kind, however. Not only are the costs presented almost always incomplete, but, for some programs, costs are virtually impossible to obtain and are undoubtedly unknown even to the administrators and decision-makers responsible for the programs.

The following methodological points are probably the most commonly overlooked in costing public transportation alternatives.

1. All of the relevant administrative, capital, and operating costs must be identified and included. In some cases, it may be necessary to allocate costs among multiple activities (some of which may be unrelated to the public transportation project of interest). Special cost categories sometimes overlooked are start-up costs, supervisory and administrative costs, and costs associated with experimentation.

2. Cost comparisons between alternative projects should be made with respect to the same base as is used for estimating their benefits, and this same base should be used for all the alternatives under consideration.

3. The period of time over which costs are incurred must be taken into account through proper discounting to present values.

4. The public and private financing sources for different cost categories should be clearly identified. Public agencies often omit from their accounting costs that are financed by sources other than their own budgets. For comparison purposes, it is essential that all these costs be included and that their incidence on different financing sources be delineated.

## Identification of Worthy Alternatives

Public transportation projects have been repeatedly designed and implemented in U.S. cities without even the most cursory consideration of alternatives. In the absence of strict financial criteria, it is easy to justify a costly project by emphasizing some major benefit that is difficult to quantify in monetary terms. The discipline required to ensure that such a project is really worthwhile is an examination of alternative projects aimed at the same objective. Even where the benefits of a proposed project are judged to be well worth the costs, it is often possible to find alternative projects that provide essentially the same benefits at substantially lower costs.

When current alternatives analysis requirements are imposed on long-range project proposals (1), complaints are often heard that there are "too many alternatives to consider" and that this planning requirement causes unnecessary delays in project implementation. The response to this complaint should be to improve current procedures for identifying worthy alternatives: those relatively few alternatives that deserve serious consideration. If adequate procedures were developed to enable planners and decision makers to isolate the worthy options by which to achieve certain kinds of benefits, they would be able to conduct a rigorous examination of alternatives without elaborate and time-consuming technical studies.

Some important methodological points regarding the identification of worthy alternatives include the following:

1. The search should always be for alternatives that might be better than the one in hand. Projects should not be justified by comparing them with highly inferior alternatives but by demonstrating that they are superior to all of the worthy alternatives.

2. Alternatives identified for comparison should include not only the highly visible operating projects, but also the less-visible nonoperating projects (such as marketing and promotion programs, computerized management and control systems, and brokerage functions). These latter projects can involve substantial costs and should have to be justified in terms of the benefits they generate. In this sense, they should be considered as alternatives to expanded operating projects (addition of new service routes, for example).

3. Care must be taken to include all the benefits and costs of the alternatives considered. It is not uncommon

to see projects justified on the basis of the costs avoided by rejection of an alternative, while the benefits of the alternative go unmentioned.

### Institutional Framework for Planning

Although some of the impediments that limit the effectiveness of public transportation programs can be removed only through legislative changes, many of the problems can be dealt with through changes in planning and administrative practices. Procedures can be designed to ensure that proposed public transportation projects are subjected to careful study and review by appropriate technical staff and by all of the parties potentially affected by the projects. Proponents of such projects should be required as a condition for funding to demonstrate that the appropriate study and review processes have taken place. Further, persons who feel that their views have not been given proper consideration during these processes should be given the right to present their case directly to the technical and administrative staffs and, if necessary, to elected officials.

A major step toward the realization of such a comprehensive review process for public transportation projects was taken in 1975 when the Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration (FHWA) issued joint regulations that define the urban transportation planning process (1) required to justify applications for DOT funds. These regulations place the responsibility for "cooperatively carrying out transportation planning and programming" in the hands of the metropolitan planning organizations (MPOs) designated by the governors of the states, with one MPO for each urbanized area or group of contiguous urbanized areas. The MPO is intended to be "the forum for cooperative decision making by principal elected officials of general purpose local government".

The transportation planning process to be carried out by the MPO in cooperation with the state and the publicly owned operators of mass transportation services includes two major elements: a transportation system management element (4) designed to plan for short-range transportation needs that use existing facilities and a long-range element (5) that deals with long-range needs and in particular identifies desirable changes in transportation facilities. Experience in the implementation of these planning elements is still in the learning stage, and reviews of the early responses to the joint UMTA-FHWA regulations have identified a number of shortcomings (6, 7). One obvious limitation is that public transportation projects funded by agencies other than DOT, such as HEW and HUD, are not at present subject to the DOT planning requirements. Nevertheless, the regulations have established a basic framework within which transportation projects can be studied and reviewed by all interested parties, and it seems likely that, with experience, this framework will gradually become more workable and useful.

Specific shortcomings in the current institutional framework for planning that need attention in the near future include the following:

1. In many areas, the current arrangements for decision making on public transportation projects are either inappropriate or virtually nonexistent. Some MPOs have responsibility for very large areas and cannot serve all the needs of all their jurisdictions. Nonurbanized areas typically do not have local MPOs or any other framework for cooperative decision making. The establishment of an appropriate forum for decision making is an essential first step toward improving the planning process for public transportation.
2. Efforts are needed to upgrade the short-range planning capability of existing MPOs. For historical reasons, these organizations tend to be staffed mainly by long-range planners.
3. Agencies other than DOT that fund public transportation projects should establish regulations by which to include their projects within local and metropolitan transportation planning processes.

### Recent Experiences

Several of the paratransit projects planned and implemented during the last four or five years can be used to illustrate the points discussed above. Some results of these projects are presented in the sections below for each of three major travel markets: high-density home-to-work travel, special-user-group travel, and general-purpose travel. Some of the projects discussed are demonstration projects designed to test promising new paratransit concepts, and the special data bases collected for monitoring purposes provide some new insights into the shortcomings of current planning processes.

The basic objective of the discussion presented in these sections is to assist the short-range planner in his or her major task: the identification of worthy public transportation alternatives for particular travel markets. The intent is to identify project schemes that generate substantial benefits at reasonable costs and to eliminate inferior schemes that generate relatively few benefits at relatively high costs. Although the limited amount of knowledge that can be generalized and the variability in local conditions preclude the development of definitive planning formulas, some valuable insights and guidance can be obtained from the information currently available. Continuation of the current level of experimentation and data collection for paratransit modes should permit the development of greatly improved planning guidance over the next few years.

## HIGH-DENSITY HOME-TO-WORK TRAVEL

Public transportation programs directed at the high-density home-to-work travel market are usually seeking as primary benefits those that can be derived from shifting travelers to higher-occupancy modes. (The programs may also be seeking to improve the mobility of selected home-to-work travelers and to contribute to the development of certain land-use patterns.) The benefits associated with shifting travelers to higher-occupancy modes are determined by the reductions in congestion, pollution, and energy consumption that result from reductions in overall vehicle kilometers of travel. The actual benefits of reduced congestion, pollution, and energy consumption will vary greatly from one location to another, of course, depending on local levels of congestion, local air-pollution problems, and the severity of local and national energy shortages. Consequently, we will not attempt to quantify these benefits here. Instead, we will confine our attention to assessing the effectiveness of different methods of achieving reductions in vehicle travel.

Home-to-work trips can be made by any of several different modes: private automobile, conventional bus or rail transit, subscription bus, carpool, vanpool, bicycle, walking, and so on. To reduce the vehicle travel associated with these trips, public transportation programs must shift travelers from the low-occupancy vehicle mode—the private automobile—to the higher occupancy vehicle modes or the nonvehicular modes such as bicycles and walking. Several public transportation pro-

Table 1. Modal shifts at Aerospace-SAMSO.

| Date | No. of Employees | Mode (percentage of employees) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Drive Alone | Carpool | Transit | Express Bus | Vanpool | Walk, Bicycle, or Other |
| September 1973 | 5800 | 83 | 7 | 1 | 4 | - | 5 |
| November 1973 | 5800 | 67 | 23 | 1 | 4 | - | 5 |
| May 1974 | 5800 | 52 | 38 | 1 | 4 | - | 5 |
| 1975 | 6500 | 65 | 23 | 1 | 4 | 2 | 5 |
| 1978 | 6600 | 65 | 22 | 1 | 4 | 3 | 5 |

Table 2. Effects on vehicle travel at Aerospace-SAMSO.

| Mode | Average Vehicle Occupancy[a] | Average Vehicle Round Trip[a] (km) | No. of Commuters Shifted | Effect on Daily Vehicle Travel[b] (km) |
|---|---|---|---|---|
| Drive alone | 1.0 | 45 | -1188 | -53 222 |
| Carpool | 2.5 | 45 | 990 | 17 741 |
| Vanpool | 10.0 | 96 | 198 | 2 661 |
| Total | | | | -32 820 |

Note: 1 km = 0.6 mile.
[a] Estimate (data unavailable).
[b] A van is considered equivalent to 1.4 automobiles for vehicle travel calculations.

grams implemented during the last five or six years have achieved such shifts, although not without significant expenditure and effort.

## Aerospace Corporation-Air Force Space and Missile Organization Program

The Aerospace Corporation and the Air Force Space and Missile Organization (SAMSO) employ about 5800 persons in the El Segundo Employment Center, located near the Los Angeles International Airport. The site has good freeway access and free parking in widely dispersed parking lots. Since 1973, a group of transportation specialists at Aerospace has been developing and implementing a program designed to reduce the vehicle travel associated with work travel to and from the site.

The Aerospace-SAMSO program began with a subscription bus service implemented in November 1973, which was followed by a carpool matching program implemented in 1974 at the time of the gasoline shortage. The subscription bus service was abandoned early in 1974 after the bus company increased fares substantially, but many of the bus riders then formed carpools and, as shown in Table 1, carpool use increased dramatically: 38 percent of all employees were carpooling in May 1974 compared with 7 percent in September 1973. This increase was a result of a combination of three factors: the gasoline shortage, the carpool matching program, and the termination of the subscription bus program.

In April 1975, a commuter van program was initiated that has vans insured and maintained by Aerospace Corporation. The van drivers organize and maintain their own pools with assistance from the company and from Commuter Computer, a nonprofit regional corporation for commuter matching. Aerospace Corporation has also continued to maintain a transportation coordination office operated by a parttime staff member to promote carpools and vanpools. Although carpooling decreased from its 1974 peak of 38 percent of all employees to 22 percent in 1978, the overall use of high-occupancy modes by Aerospace employees is still substantially higher than it was in September 1973. The company is currently experimenting with a new subscription bus service for short trips that would permit the buses to make multiple trips in each rush hour (8).

### Benefits

The reductions in vehicle travel achieved by the Aerospace-SAMSO program appear to have been quite significant, although they can be estimated only approximately from data currently available. If the entire shift observed between September 1973 and 1978 is attributed to the program and, if this effect is applied to the current employment level of 6600, the overall daily reduction in vehicle travel achieved by the program is 32 800 km (20 500 miles) (see Table 2). This is almost certainly an overestimation, however, for the following reasons:

1. Many of the carpools formed during the gasoline shortage but before the Aerospace-SAMSO program would probably have continued even without the program,
2. The availability of carpool and vanpool matching programs encourages employees to locate further from the work place than they might in the absence of the program, and
3. Automobiles not used by commuters are probably used to some extent during the day by other members of the family.

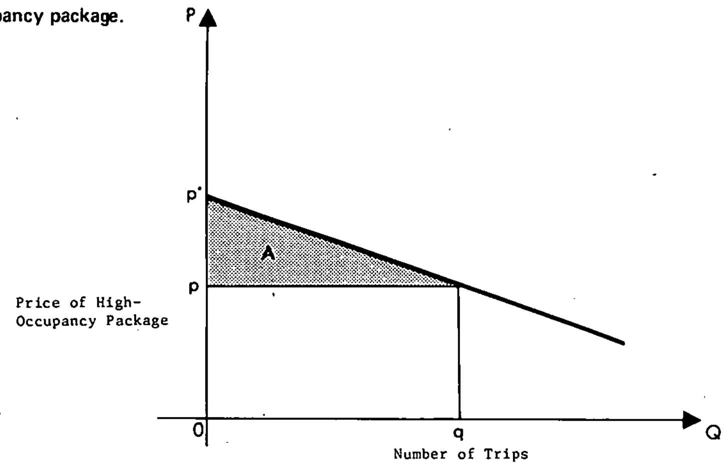
User benefits resulting from the program accrue to the individual employees who are able to find a preferable mode for home-to-work travel. An estimation of these user benefits can be obtained by halving the cost savings that would have resulted if all the program users had formerly driven to work alone in automobiles dedicated solely to that purpose.

The following rationale was used in developing the estimates of user benefits of the Aerospace-SAMSO project: Programs such as this, which effect travel modal shifts without withdrawing any existing travel opportunities, clearly generate travel benefits for those who switch modes—these travelers decide to choose a new mode although the opportunity to use their old mode is still present. The value of these benefits can be calculated by estimating the change in consumer surplus effected by the program.

Suppose that the demand for the carpooling and vanpooling package currently provided by the Aerospace-SAMSO program is represented by the straight-line demand schedule shown in Figure 1, where the amount actually consumed is represented by q, the price paid by the users is represented by p, and the price at which all users would refuse to participate is represented by p*. The increase in consumer surplus effected by the program is then the shaded area A, given by $(p^* - p)q/2$. The price p is the perceived user cost of participation, which we assume to be equal to the user's share of the full cost of operating the automobiles and vans involved in the program. We estimate p* by assuming that, if the perceived user cost for the program were gradually increased, the most enthusiastic of the current users would finally abandon it when the perceived user cost equaled the full cost of driving to work alone in an automobile used solely for that purpose. The increase in consumer surplus effected by the program is then one half of the cost savings that would have resulted if all the program users had formerly driven to work alone in automobiles dedicated solely to that purpose.

FHWA (9) estimated the cost of owning and operating a compact automobile, excluding parking, as 7.8 cents/kilometer (12.4 cents/mile) in 1976. Applying this figure to the vehicle travel reduction shown in Table 2 gives an estimation of user benefits from the program of $1272/day in 1976 dollars. At an inflation rate of 7

Figure 1. Demand for high-occupancy package.




percent/year, these benefits amount to $1558/day in 1979 dollars. In addition, some secondary benefits may accrue to family members or friends who are able to use an automobile left at home by a commuter or who are relieved of driving a commuter to work. Currently available data do not permit quantification of these benefits, however.

Costs and Cost-Effectiveness

Data currently available on the costs of the Aerospace-SAMSO program are very sketchy. The costs of the carpool matching activities in 1974 were estimated to be about $12 500 (10) ($17 530 in 1979 dollars). The planning and implementation of the vanpool programs involved a committee of about 12 professionals working about four hours a month for about three months, a cost of about $5000 in 1979. Ongoing maintenance of the program, including accounting and finding new riders, requires about eight hours a week of administrative time, costing about $120/week in 1979. The costs of vanpool insurance and leasing are currently covered by user fees, although they were initially underwritten by the company.

For a company or a public agency instituting a program similar to the Aerospace-SAMSO program in 1979, start-up costs would therefore be approximately $23 000 and ongoing operating costs would be about $120/week. If we calculate the present value of these costs for a 5-year program period (using a 10 percent discount rate and assuming 250 working days/year), we obtain a daily program cost of about $40. If such a program really generated benefits equivalent to those generated by the Aerospace-SAMSO program, i.e., a reduction in vehicle travel of 27 360 km/day (17 100 miles/day) and $1300 in user benefits/day (both quantities discounted at 10 percent over the 5-year period), it would presumably be considered highly cost-effective. For a public agency concerned solely with the reduction of vehicle travel, the cost-effectiveness of this program would be about 0.14 cents/kilometer (0.23 cents/mile). As discussed above, however, these estimates may exaggerate the benefit levels that could actually be achieved in the absence of a gasoline shortage.

Alternatives

For a private or public agency evaluating this program in 1979, the relevant alternatives might be dedication of all the program funding to conventional transit or changing the mix of the funding between carpooling and vanpooling. Suppose the agency wished to achieve a daily reduction in vehicle travel of 32 800 km by using conventional bus service having an average occupancy of 30 persons/bus. Based on the September 1973 modal shares and the assumption that a bus is the equivalent of three automobiles for vehicle travel purposes, it can be shown that 27 buses would be required to carry the 810 former private automobile drivers daily. To be as cost-effective as the current program, the service would have to operate at the rather unrealistic subsidy of about $0.03/one-way ride. The current program would therefore appear to be greatly superior to an all-transit program. Shifts of funding between carpooling and vanpooling would represent fairly minor modifications to the program and would have to be evaluated at a level of detail that is beyond the scope of the present paper.

## TVA Program

The Tennessee Valley Authority (TVA) has its headquarters in downtown Knoxville where, with a staff of more than 3400, it is the second largest employer in the city. Before 1974, TVA had been pressed to provide employee parking as a union benefit. When in the spring of 1974, TVA decided to construct new downtown office facilities, which would involve the elimination of about 1300 surface parking spaces, various transportation proposals were considered for providing substitute services. Negotiations between TVA administrators and employee union representatives resulted in the development of a mass transportation incentive plan that included parking discounts for carpools, discounted fares on bus services, and a subsidized vanpool program.

The TVA program was implemented in January 1975, initially as a demonstration program. The program is administered by a transportation coordinator who assists employees in forming carpools and vanpools and helps negotiate bus service levels with bus operators. The carpool parking discount was available to carpools of three or more riders (at least two of whom had to be TVA employees) and consisted of a $5/month ticket for parking spaces located some six blocks from the TVA offices. For bus users, a one-third fare discount was provided that could be used on regular and express services. TVA also provided a revenue guarantee to bus operators for certain routes serving TVA employees. The vanpool program actually began in June 1974 when the Knoxville Transit Corporation informed TVA that there was little prospect of additional bus service for TVA employees. In 1975, TVA began to subsidize vanpool user fees by $3-11/month depending on trip lengths and number of riders per van.

TVA employees have made substantial changes in their

Table 3. Modal shifts at Tennessee Valley Authority.

| | | Mode (percentage of employees) | | | | | |
|---|---|---|---|---|---|---|---|
| Date | No. of Employees | Drive Alone | Carpool | Transit | Express Bus | Vanpool | Walk, Bicycle, or Other |
| November 1973 | 2950 | 65 | 30 | 3.5 | - | 0.0 | 1.5 |
| December 1974 | 3000 | 42 | 40 | 3.0 | 11 | 2.3 | 1.7 |
| January 1975 | 3100 | 30 | 42 | 5.0 | 18 | 3.0 | 2.0 |
| January 1976 | 3200 | 19 | 42 | 3.0 | 28 | 5.0[a] | - |
| January 1977 | 3400 | 18 | 41 | 3.0 | 28 | 7.0 | 3.0 |

[a]Includes walking, bicycling, and other.

Table 4. Effects on vehicle travel at Tennessee Valley Authority.

| Mode | Average Vehicle Occupancy | Average Vehicle Round Trip (km) | No. of Commuters Shifted | Effect on Daily Vehicle Travel[a] (km) |
|---|---|---|---|---|
| Drive alone | 1.0 | 35 | -1598[b] | -56 250 |
| Carpool | 3.2 | 35 | 374 | 4 114 |
| Express bus | 41.4 | 35 | 952 | 2 429 |
| Vanpool | 13.2 | 74 | 238 | 1 858 |
| Total | | | | -47 844 |

Note: 1 km = 0.6 mile.
[a]A bus is considered equivalent to three automobiles and a van is considered equivalent to 1.4 automobiles for vehicle travel purposes.
[b]Includes commuters shifted to modes not accounted for here (e.g., bicycle).

home-to-work travel modes since November 1973 (see Table 3). The level of carpooling had previously been quite high (30 percent), and it increased to more than 40 percent after the gasoline shortage and the initiation of the TVA program. Perhaps the most dramatic impact of the program is that the level of express bus ridership has grown to 28 percent of all trips. Vanpooling has also had a significant effect and is apparently still increasing its share of the market.

## Benefits

Perhaps the most important benefit of the TVA program is that it has satisfied the transportation obligations of TVA to its employees at a substantially lower cost to TVA than realistic alternatives such as provision of additional parking spaces. It is this benefit or objective that appears to have been the driving force behind the program. As shown below, TVA has been able to reduce its parking requirements by half while its employment has grown by more than 15 percent, a quite remarkable accomplishment (11).

| Item | November 1973 | December 1974 | January 1977 |
|---|---|---|---|
| Total employment | 2950 | 3000 | 3400 |
| Number of motor vehicles (automobiles and vans) | 2195 | 1641 | 1066 |

There have also been substantial reductions in vehicle travel as a result of the program, an effect that should be of considerable interest to public agencies trying to achieve such reductions. If the entire shift observed between November 1973 and January 1977 is attributed to the program, and if this impact is applied to the current employment level of 3400, the overall daily reduction in vehicle travel achieved by the program is approximately 48 000 km (30 000 miles) (see Table 4). (This is likely to be an overestimation for the same reasons as the Aerospace-SAMSO vehicle travel reductions calculated above.)

The net user benefits accruing to TVA commuters cannot be compared with those obtained under the Aerospace-SAMSO program because of the user benefits lost by the elimination of the 1300 parking spaces. If the TVA program had been implemented without the removal of the 1300 parking spaces, those employees who switched modes would certainly have benefited. It is interesting to speculate about how much of the TVA reduction in vehicle travel would have been achieved if the parking spaces had been retained: The user benefits accruing to those who would have switched modes even if the parking spaces had been retained are partly offset by the loss of the user benefits by those who were forced to switch modes by the removal of the spaces.

The following rationale was used in developing the estimates of user benefits of the TVA project: This program differs from the Aerospace-SAMSO program in that the opportunity to drive has been reduced by the elimination of 1300 parking spaces at the TVA office location. To investigate the effect of the TVA program on consumer surplus, we can consider the program in two hypothetical stages: in the first stage, only the incentive part of the program is implemented and, in the second stage, both the incentive part of the program and the reduction of the number of parking spaces are implemented. [To ensure that the impact on consumer surplus can be defined unambiguously, we must assume that the income elasticities of demand for the modal alternatives are equal. This condition and alternative procedures for estimating the change in consumer surplus are discussed in detail by Neuburger (12).] The first stage of the program would be analogous to the Aerospace-SAMSO program and can also be represented by Figure 1, where the change in consumer surplus is again equal to the shaded area A, i.e., $(p^* - p)q/2$.

When the second stage of the TVA program is introduced, the reduction in the availability of parking results in an increase in the total price of driving alone. This increase will cause additional automobile drivers to switch to one of the high-occupancy modes, which will result in a loss of consumer surplus relative to their situation under stage 1. Suppose that the demand for single-occupant automobile travel in the absence of the first stage of the TVA program is represented by demand schedule $D_0$ in Figure 2 and that the first stage of the program results in a decrease in this demand to $D_1$, where the price and quantity consumed during the first stage are given by $p_1$ and $q_1$. Then, when the second stage of the TVA program effectively increases the price of single-occupant automobile travel to $p_1^*$, there will be an accompanying decrease in quantity to $q_1^*$. The loss of consumer surplus effected by stage 2 is then the shaded area B (Figure 2), i.e., $(p_1^* - p_1)(q_1^* + q_1)/2$.

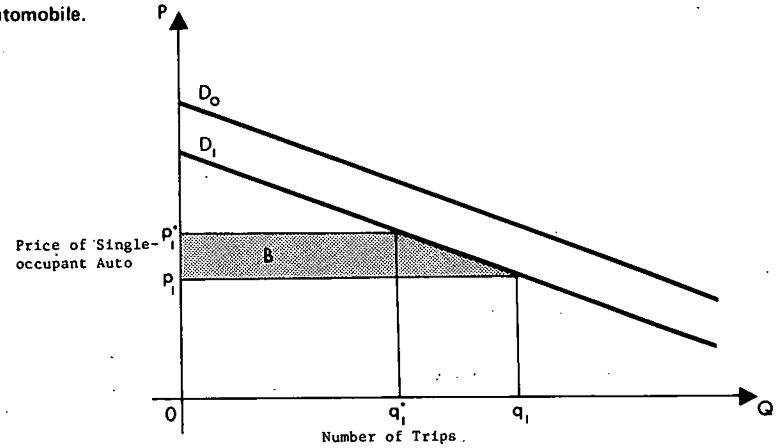
The net effect on consumer surplus of the TVA program is thus the difference between area A (the pluses) and area 3 (the minuses). Depending on the values of the various price and quantity variables, this net effect could be positive, zero, or even negative. In the case of TVA, the parking spaces that were eliminated had a daily parking charge in 1974 of about $1.00/day ($1.50 in 1979 dollars). As parking is currently available close to TVA at a daily charge of $1.50, the actual effect on the price of single-occupant automobile travel of eliminating the 1300 spaces appears to have been relatively small. Consequently, the effect on automobile use was probably also quite small and area B in Figure 2 probably represents a relatively small offset to the stage 1 benefits represented by area A. (If the 1300 parking spaces had been free, however, the effect of eliminating them would have been substantial and area B would probably have made a significant negative contribution to the net benefits of the program.)

(As for the Aerospace-SAMSO program, the TVA program also undoubtedly generates some secondary benefits that accrue to family members or friends who use an automobile left at home or who are relieved of driving a commuter to work.)

## Costs and Cost-Effectiveness

The only cost data readily available for the TVA program

Figure 2. Demand for single-occupant automobile.




are those shown below and do not appear to include start-up managerial costs or ongoing TVA administrative costs.

| Item | Cost ($ 1977) |
|---|---|
| Carpool parking subsidy | 1 900 |
| Express bus subsidy | 74 700 |
| Bus guarantees | 10 200 |
| Vanpool subsidy | 27 000 |
| Credit Union administrative charge | 11 200 |
| Total | 125 000 |

If we assume start-up costs of $10 000 and ongoing administrative costs of $15 000/year (both in 1979 dollars), an agency instituting a program similar to the TVA program in 1979 would incur start-up costs of $10 000 and ongoing subsidy and administrative costs of $158 000/year (inflating the $125 000 in 1977 by 7 percent/year). If we calculate the present value of these costs for a 5-year program period (using a 10 percent discount rate and assuming 250 working days/year), we obtain a daily program cost of about $535. If the program achieved the TVA level of reductions in vehicle travel of 25 020 per day (discounted over the program period), the cost effectiveness of the reduction in vehicle travel would be about 1.34 cents/kilometer (2.14 cents/mile). This is substantially higher than the 0.14 cents/km figure for the Aerospace-SAMSO project and perhaps reflects the fact that, once the most receptive converts to mass transportation have been obtained, the costs of shifting additional private automobile users increases dramatically, even where there are significant restrictions on parking.

### Alternatives

The relevant alternatives to the current TVA program are probably restricted to changes in the funding and levels of effort devoted to the different mass transportation modes. The alternative of building additional parking spaces at four times the annual cost of the current program is probably not a worthy option at this point. TVA reportedly discontinued the carpool parking subsidy early in 1978 because of low participation and is now concentrating its funding on express buses and vanpools. As noted for the Aerospace-SAMSO project, a detailed assessment of the effects of shifting TVA funds and effort between express bus, carpools, and vanpools is beyond the scope of the present paper.

## SPECIAL-USER-GROUP TRAVEL

Many different public transportation programs have as their objectives the improvement of mobility for specific user groups such as the elderly, the handicapped, the young, and the poor. These programs usually seek to change the travel behavior of the selected user group with respect to the number of trips made; the travel modes used; the fares paid; the purposes for which trips are made; the time of day, week, or month trips are made; or the origins and destinations of trips. The actual benefits generated by the programs are determined by the effects they have on travel, and these benefits may be interpreted in different ways depending on the program and the location. A program for the elderly in one location may place great emphasis on providing certain recreational trips at very low fares for all elderly persons, for example, while the same program in another location may be more concerned with providing medical trips for elderly persons who are handicapped. The programs may also generate secondary benefits that accrue to family members or friends who are relieved of driving a program user to his or her destination or who can use an automobile left at home. These benefits are usually difficult to quantify, and they will not be addressed explicitly here.

To assess the effects that alternative public transportation programs might have on the travel behavior of a special user group, we would ideally like to know the following characteristics for all the trips that would be made under each of the alternative programs of interest:

1. The identity and socioeconomic characteristics of the special-user-group traveler;
2. The service characteristics and price of the travel mode used and, for customer-surplus calculations, some indication of the shape of the demand curve for the mode;
3. The purpose of the trip;
4. The time of day, week, and month the trip is made; and
5. The origin and destination of the trip.

Unfortunately, current understanding of the travel behavior of special user groups does not permit the prediction of travel effects in this level of detail. Even the task of measuring these effects in a particular, well-defined demonstration or experiment is somewhat formidable because it involves the use of travel diaries by a sample of special-user-group travelers for periods of as much as a month at a time (13). (Such measurements are currently being taken in a user-side subsidy project for elderly and handicapped residents in Lawrence, Massachusetts, being conducted under the UMTA Service and Methods Demonstration Program.)

Some insight into the effects of public transportation programs for special user groups can be obtained from

Table 5. Participation in RTR program by eligible groups.

| Item | No. of Persons | Percentage of Total Eligible Persons | Percentage of Total RTR Trips (N = 8500/ month) |
|---|---|---|---|
| No. of trips per month | | | |
| >10 | 320 | 4 | 41 |
| 5-10 | 405 | 5 | 31 |
| 0-5 | 2010 | 27 | 28 |
| 0 | 640 | 9 | 0 |
| Subtotal | 3375 | 45 | |
| Group who did not register | | | |
| "No need" | 2805 | 37 | 0 |
| Service inaccessible | 124 | 2 | 0 |
| Other | 1196 | 16 | 0 |
| Subtotal | 4125 | 55 | — |
| Total | 7500 | 100 | 100 |

Table 6. Participation in RTR program by various socioeconomic groups.

| Group | Percentage of Total Eligible Persons | Percentage of Total Registrants | Percentage of Total RTR Trips |
|---|---|---|---|
| Age (years and conditions | | | |
| ≥65, handicapped | 18 | 19 | 17 |
| ≥65, nonhandicapped | 65 | 63 | 52 |
| <65, handicapped | 17 | 18 | 31 |
| Household income ($) | | | |
| <5000 | 52 | 73 | 89 |
| 5000-10 000 | 36 | 24 | 8 |
| >10 000 | 12 | 3 | 3 |

a common and relatively inexpensive source of information: on-board surveys or trip records for the trips made under the programs. For those public transportation trips surveyed, all of the desired information can be obtained with the exception of the highest price at which the trip would have been made. The problem of these surveys is that they do not provide information on the travel behavior of special user groups under alternative public transportation programs or under the do-nothing alternative. Attempts are usually made to obtain some information of this kind by asking the travelers hypothetical questions about their likely travel behavior under alternative circumstances. The alternative usually hypothesized is the do-nothing alternative: users of a public transportation program are asked what their travel behavior would have been in the absence of the program.

Very few of the special-user-group programs implemented over the last five years have been monitored carefully enough to permit a good assessment of the effects the programs have had on travel. Even the demonstration projects have been concerned primarily with the issues surrounding the supply of improved public transportation services rather than with the responses on the demand side. Nevertheless, considerable insight has been obtained and interest in measuring travel effects appears to be growing. UMTA demonstration projects implemented over the last three years in Danville, Illinois, and Portland, Oregon, illustrate the kinds of information that are being obtained on the benefits and costs of special-user group programs.

Danville Reduced Taxi Rates Project

Danville is a small city that has a population of 43 000 and is located 6.4 km (4 miles) from the Illinois-Indiana boundary. Average family income is close to the national median income of about 13 000; the proportion of elderly persons (13 percent) is higher than the proportion nationally (9.9 percent). In March 1975, the city of Danville applied to UMTA for a demonstration grant to test the user-side subsidy concept as a means of improving the mobility of elderly and handicapped persons. The grant was awarded and, in December of 1975, a new reduced taxi rates (RTR) program began providing shared-ride taxi services to elderly and handicapped persons at 25 percent of the regular fare (up to a monthly limit of $20 in total full-fare value). In January 1977, the regular shared-ride taxi fares were increased by an average of 13 percent, and the program participant's share was increased to approximately 50 percent of the new rates. The RTR program continued at these fares and participant shares through July 1978. (In November 1977, a new fixed-route mass transportation service was introduced in Danville for the general public. This service will be described in the section below on general-purpose travel.) The benefits and costs discussed here for the RTR program apply to the period before January 1977.

The RTR program used a charge-slip scheme for disbursing subsidy funds. Eligible users obtained an identification card from city staff and then chose among the three companies offering shared-ride taxi services in the city. On completion of a trip, these users paid their share of the fare in cash and signed a charge slip specifying the total fare and the amount paid in cash. The taxicab companies submitted these signed charge slips to the city on a weekly basis and were reimbursed for the subsidized portion of the fares. The RTR project operated in Danville for two years and seven months; for the last six months, the project competed for ridership with the new fixed-route service.

Benefits

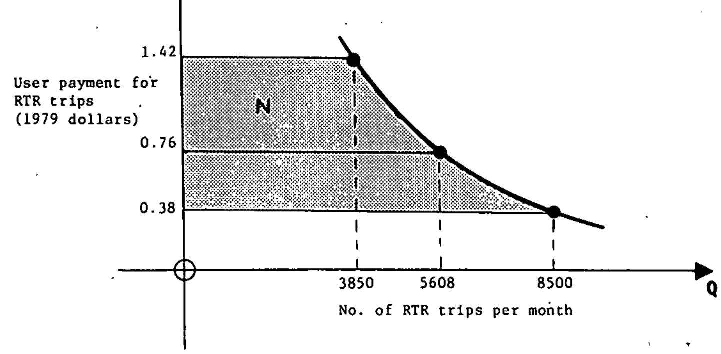
The effects of the RTR program on travel have been discussed in a report to UMTA (14). The charge-slip scheme used in the program identified the fare paid and the individual user for each RTR trip. Thus, it has been possible to compute the number of users making various numbers of trips per month (see Table 5) and the average numbers of trips made per month by several socioeconomic subgroups of the eligible population (see Table 6). The purposes of the RTR trips were determined by on-board surveys of RTR users.

| Trip Purpose | Total Trips (%) |
|---|---|
| Work | 7 |
| Shopping | 33 |
| Personal business | 21 |
| Medical | 15 |
| Recreation | 17 |
| Other | 7 |

An indication of likely travel behavior in the do-nothing base case was obtained by asking RTR users what they would have done in regard to the trip they were making in the absence of the RTR program.

| Alternative | Total Trips (%) |
|---|---|
| No trip | 15 |
| Automobile driver | 1 |
| Automobile passenger | 16 |
| Full-fare taxi | 50 |
| Walk | 15 |
| Other | 3 |

Figure 3. Demand for shared-ride-taxi trips by persons eligible to use RTR service.




These data suggest that the benefits of the RTR program were enjoyed by certain subgroups of the eligible population; the highest use groups were low-income and handicapped persons. The suggestion that 85 percent of the RTR trips would have been made in the absence of the program is perhaps a little surprising at first, although it can be reasoned that this is what should be expected when a program is aimed at facilitating trips that are valued highly by the travelers. It is worth noting that the table above implies that the RTR program increased vehicle travel in Danville as the vehicle travel generated per trip by the shared-taxi service probably equals or exceeds that generated by the alternatives listed.

The fare reduction for RTR users at the beginning of the program in December 1975 and the fare increases that took effect in January 1977 provided an opportunity for estimating fare elasticities for RTR users and for shared-ride taxi users in general. McGillivray (3) has shown that the arc fare elasticities for the initial RTR fare decrease, the RTR fare increase, and the general fare increase for shared-taxi riders are all approximately -0.6. If we assume that this arc fare elasticity is constant along the demand curve for RTR-eligible persons, the net consumer surplus accruing to RTR users as a result of the first phase of the RTR program (December 1975 through December 1976) can be estimated as $0.66/trip in 1979 dollars (4).

There were two changes in shared-ride taxi fares experienced by the elderly and handicapped residents of Danville who registered for the RTR program: The first was the fare reduction of approximately 75 percent in December 1975 when the program began, and the second was the increase of approximately 100 percent in January 1977 when the regular fares were increased 13 percent and the RTR user payments were increased to approximately 50 percent of the new fares. If we assume that the arc fare elasticity of -0.6 is constant along the demand curve for shared-ride taxi services for the elderly and handicapped, we can represent the demand as

$$Q = CP^{-0.6} \qquad (1)$$

where

- $Q$ = number of shared-ride taxi trips taken by RTR-eligible persons per month,
- $P$ = user payment for RTR eligible persons, and
- $C$ = constant.

By using the RTR ridership during the first phase of the program and expressing the fare payments in 1979 dollars, we can calculate C as follows:

$$C = QP^{0.6} = 8500(0.38)^{0.6} = 4757$$

That is, $Q = (4757)P^{-0.6}$

Hence, for $P = \$0.76$ (the average RTR payment after January 1977), $Q = 5608$ and, for $P = \$1.42$ (the average user payment in the absence of the RTR program), $Q = 3850$, as shown in Figure 3.

The net consumer surplus (N) generated by reducing the user payments for RTR registrants from $1.42 to $0.38 is shown by the shaded area in Figure 3. This can be calculated as

$$N = 3850(1.42 - 0.38) + \int_{3850}^{8500} P\,dQ - 0.38(8500 - 3850)$$

$$= 4004 + \int_{3850}^{8500} (4757/Q)^{1.67} dQ - 1767$$

$$= 4004 + \left[(4757)^{1.67} \times Q^{-0.67}/-0.67\right]_{3850}^{8500} - 1767$$

$$= 4004 + [-4812 + 8181] - 1767$$

$$= 5606$$

Hence, if we assume a constant new level of ridership of 8500/month, the increase in consumer surplus generated by the 75 percent fare reduction is $5606/month. Of this total, $4004 or $1.04/trip corresponds to the old trips that continue to be made at lower fares and $1602 or $0.34/trip corresponds to the new trips generated by the program. The overall average increase in consumer surplus is then $0.66/trip in 1979 dollars.

It should be noted that the fare-elasticity and consumer-surplus calculations given above assume that the $20/month limit on the total full-fare value of RTR trips has a negligible effect on ridership. Crain and Associates (14) have reported that this limit has not been rigidly enforced in practice and that overuse accounts for about 5 percent of the RTR trips. Although some 90 percent of the RTR riders use less than two-thirds of the monthly limit, there may be some dampening of ridership for the 10 percent who are relatively heavy users.

## Costs and Cost-Effectiveness

The total cost per one-way passenger trip for the RTR system (including fares and administrative costs) was $1.41 in 1976 dollars. This total included a user payment of $0.31, a fare subsidy of $0.85, a start-up cost of $0.07, and an ongoing administrative cost of $0.18 (14). The total public subsidy per passenger trip was therefore $1.10. (As only 50 percent of the RTR trips served were actually new mass transportation trips, the subsidy per new mass transportation trip was $2.20. And if effectiveness is to be measured in terms of the 15 percent of trips that were actually new trips, the relevant measure is $7.33/new trip.)

For a public agency instituting a program similar to the RTR service in 1979, the start-up costs would be approximately $17 150 (inflating the $14 000 reported for 1976). By using a 5-year program period with a 10 percent discount rate and assuming an average ridership of 7000/month for the first year and 8500/month for subsequent years, we can calculate that the average cost per trip would be $1.64 in 1979 dollars: a $0.38 user payment, a $1.04 fare subsidy, and a $0.22 administrative cost. The total public subsidy per passenger trip therefore would be $1.26. If the average trip length of 3.2 km (2 miles) reported for 1976 were maintained, the overall cost would be $0.51/passenger trip-km (a user payment of $0.12 and a public subsidy of $0.39) [$0.82/passenger trip mile (a user payment of $0.19 and a public subsidy of $0.63)].

Alternatives

Perhaps the most obvious alternative to the RTR program is a publicly operated dial-a-ride system. Although the cost of $1.64/RTR trip is substantially lower than most public dial-a-ride costs, it is possible that a public dial-a-ride system might have attracted a different segment of the eligible population. Comparison of market penetration by the RTR service with that achieved by public dial-a-ride systems would shed some light on this question.

## Portland Specialized Dial-a-Ride Service

Since 1977, elderly and handicapped persons who cannot use the fixed-route service in Portland have had the option of taking "The LIFT", a door-to-door service provided by the public transit authority, which uses 15 medium-sized buses equipped with retractable lower steps and wheelchair lifts. Service that cannot be supplied conveniently by the bus system is provided by two taxi operators under contract to the transit authority. Under an UMTA demonstration grant, service is available weekdays from 7 a.m. to 7 p.m. and users must request service 48 h in advance. The fare is $0.50 for eligible users not affiliated with a social service agency; for agency and agency-affiliated users, the agencies are billed at rates of $2.00 to $3.00/trip and the users pay nothing. There is no limit on individual use of the system.

Benefits

Of the total population of Portland of about 380 000, about 21 000 (5.5 percent) are estimated to be eligible to participate in the LIFT program. As for the Danville RTR program, it was possible to identify the individual user for each LIFT trip. The number of users making various numbers of trips per month are summarized below.

| Item | No. of Persons | Percentage of Total Eligible Persons | Percentage of Total LIFT Trips (N = 7300/month) |
|---|---|---|---|
| No. of trips per month | | | |
| >8 | 420 | ~2 | 74 |
| 0-8 | 630 | 3 | 26 |
| 0 | 3 150 | 15 | 0 |
| No. of persons who did not register | 16 800 | 80 | 0 |
| Total | 21 000 | 100 | 100 |

However, information about the number of trips per month made by various socioeconomic subgroups is not yet available; the table below provides only the age and income distributions for the registrants and the total eligible population.

| Group | Percentage of Total Eligible Persons | Percentage of Total Registrants |
|---|---|---|
| Age (years) | | |
| >65 | 69 | 77 |
| <65 | 31 | 23 |
| Household income ($) | | |
| <5000 | 51 | 66 |
| 5000-10 000 | 23 | 16 |
| >10 000 | 26 | 18 |

The LIFT program has attracted an even smaller proportion of the eligible population than has the RTR program: almost all of the trips are made by just 5 percent of the eligible persons. As shown below, a much higher proportion of LIFT trips are for medical purposes than was found for the RTR program, which tended to serve a broader range of trip purposes.

| Trip Purpose | Percentage of Total Trips |
|---|---|
| Work | 14 |
| Shopping | 5 |
| Personal business | 15 |
| Medical or dental | 56 |
| Recreation | 8 |
| Other | 2 |

And, as shown below, like the RTR program, the LIFT program has served primarily trips that would have been made in the absence of the program (although the proportion of new trips is significantly higher for the LIFT program than for the RTR program).

| Alternative | Percentage of Total Trips |
|---|---|
| No trip | 36 |
| Don't know | 16 |
| Automobile driver | 3 |
| Automobile passenger | 7 |
| Full-fare taxi | 15 |
| Regular bus | 11 |
| Social service agency | 12 |

During the first year of the service, more than 80 percent of the trips were served by LIFT buses and 20 percent were served by taxicabs, even though more than 50 percent of the registrants reported that they had no difficulty using a taxi. Some 15 to 20 percent of the users are wheelchair bound, however. As for the RTR program, the LIFT program has probably resulted in a slight (but negligible) increase in vehicle travel in Portland.

Costs and Cost-Effectiveness

Data are available on the full costs for the first year of service (15). These costs include estimates of the transit authority administrative expenses, the direct operating costs, and depreciation and finance charges for the 15 special buses. The total cost of an average passenger trip on the LIFT service was $8.92, and that for the taxi service was $6.77. As the average taxi trip length is about 9.3 km (5.8 miles) and the average bus trip length is about 6.9 km (4.3 miles), the costs are $0.73/passenger trip-km ($1.17/passenger trip mile) by taxi and $1.28/passenger trip-km ($2.07/passenger trip mile) by bus. In 1979 dollars, these costs would be $0.83/passenger trip-km ($1.34/passenger trip mile) by taxi and $1.47/passenger trip-km ($2.37/passenger trip mile) by bus. User payments average about $0.06/passenger trip-km ($0.10/passenger trip mile); thus the total public subsidy costs are $0.77/passenger trip-km ($1.24/passenger trip mile) for the taxi service and $1.41/passenger trip-km ($2.27/passenger trip mile) for the bus service.

Alternatives

The wide disparity between the LIFT and taxi service costs suggests that a more effective approach would be to have the taxi operators provide more of the service. During the second year, the amount budgeted for taxi service was doubled to $110 000 and more riders are being served by taxis. Two major taxi operators currently provide the service under contract to the transit authority, and each provides the service every other month. An alternative would be a user-side subsidy approach that would involve all qualified private and public transportation providers. The users could then select the provider they wished to patronize, and the operators could provide different services and compete for riders. This approach could include different subsidy levels for various types of users: wheelchair-bound riders, for example, could be subsidized at much higher levels.

GENERAL-PURPOSE TRAVEL

Public transportation programs directed at general-purpose travel rather than specifically at the high-density home-to-work or special-user-group markets are usually seeking the benefits that can be derived from improving the mobility of the general population of an area (although a reduction in vehicle travel is often a secondary objective). As for programs directed at special user groups, the benefits of general-purpose programs are determined primarily by the effects they have on travel and the interpretation of these benefits may vary, depending on the program and the location. A general-purpose program in one location may place great value on increasing shopping trips to the downtown area, for example, while a program in another location may be more concerned with serving social and recreational travel by local residents.

General-purpose programs typically have a more complex set of objectives than the other two types of programs, and assessing the benefits of these programs often involves trading-off or weighing several different kinds of effects. The basic input required for this process is a quantitative description of the changes effected in the travel behavior of different socioeconomic groups in the general population. As described in the section above on special user groups, current knowledge provides only limited information on these effects. A review of the general-purpose programs funded by UMTA in Westport, Connecticut, and Danville, Illinois, illustrates the types of information that are currently available to policymakers.

Westport: Fixed-Route and Dial-a-Ride Services

Westport, a small suburban town that has a population of about 28 000, is located in the southwestern part of Connecticut, about a one-hour drive from New York. Residential density is about 500 persons/km$^2$ (1300 persons/mile$^2$), and residents are relatively affluent: average annual household incomes for 1976 were in excess of $26 000. In 1974, a newly formed Westport Transit District (WTD) began operating a Minnybus service oriented to the downtown during the day and to the rail stations during the commuter hours. The daytime service has seven loop routes, and all vehicles are scheduled to arrive at the center of town every 35 minutes to permit convenient transfers. Almost all riders use annual passes, which range in price from $15 to $40. The commuter service operates along 11 routes and meets selected trains at two stations. An annual pass for this service costs $65.

In 1976, efforts were made to integrate private taxi operations into the WTD system to better serve the elderly and handicapped and to improve the door-to-door service available to the general public (17). With an UMTA demonstration grant, 12-passenger vans were purchased and a central dispatching center was established. A private company was formed by a bus operator and a taxi operator and awarded a contract to provide a Maxytaxy dial-a-ride service using these vehicles. The cost plus fixed-fee contract negotiated with the company contained productivity incentives to encourage service efficiency.

Several attempts were made to involve the two private taxi operators in Westport directly in the Maxytaxy system, but agreements could not be reached and one company went to federal court in an unsuccessful attempt to stop the project. (About a year after the dial-a-ride service began, both private firms had ceased operating their taxi services.) Fares for the Maxytaxy service are based on a zone system and produce an average revenue per person trip of about $1.40. Elderly users receive a 25 percent fare discount, and specialized advance-request service for the elderly and handicapped is available for only $0.25. Package delivery services are also provided.

Benefits

Average monthly passenger boardings on the fixed-route system were about 50 000 during 1978; there were about 39 000 daytime boardings and approximately 11 000 commuter trips. More than 20 percent of the daytime boardings are transfers made during a trip. After 20 months, the dial-a-ride ridership had grown to an average of 13 000 passenger trips/month. About 10 percent of the trips were made by elderly persons, and 5 percent were made by handicapped individuals. In addition, more than 1000 package deliveries were made. Before they ceased operations, the two private taxi companies were serving between 5000 and 6000 trips/month. Late in 1978, a new private operator began to offer exclusive-ride service with two limousines.

On-board surveys for a single day in November 1977 (a time eight months after the Maxytaxy had started operations when the regular private taxis were still operating) provide our best current estimates of the travel impacts of the WTD services. The response rates for these surveys were 28 percent for the daytime Maxytaxy, 20 percent for the daytime Minnybus, and 76 percent for the Minnybus commuters. The numbers of trips made per month by various socioeconomic groups are summarized in Table 7 and the purposes of the trips are given below.

| | Percentage of Trips on Mode | | |
|---|---|---|---|
| Trip Purpose | Daytime Minnybus | Commuter Minnybus | Maxytaxy |
| Work | 22 | 100 | 42 |
| Shopping | 25 | | 10 |
| School | 15 | | 5 |
| Medical | 8 | | 10 |
| Recreation | 30 | | 19 |
| Other | | | 14 |

Perhaps the most striking feature of these results is the market differentiation between the three services listed: the daytime Minnybus, the commuter Minnybus, and the

Table 7. Participation in WTD program various socioeconomic groups.

| Group | Percentage of Total Population | Percentage of Trips: Daytime Minnybus (N = 31 000/ month) | Commuter Minnybus (N = 11 000/ month) | Maxytaxy (N = 13 000/ month) |
|---|---|---|---|---|
| Age (years) | | | | |
| <20 | 25 | 72 | 0 | 21 |
| 20-64 | 67 | 23 | 95 | 67 |
| ≥65 | 8 | 5 | 5 | 12 |
| Handicapped | 3 | - | - | 5 |

Maxytaxy. The daytime Minnybus service, which accounts for some 56 percent of the WTD ridership, is heavily patronized by teenagers and serves social and recreational trips more than any other purpose. The commuter Minnybus serves residents more than 20 years old making work trips. And the Maxytaxy carries a large number of work trips (serving the train stations after Minnybus hours), as well as recreational and other trips by adult residents.

As shown below, the daytime Minnybus appears to be serving a substantial number of trips that would not have been made in the absence of the service.

| Alternative | Percentage of Trips on Mode: Daytime Minnybus | Commuter Minnybus | Maxytaxy |
|---|---|---|---|
| No trip | 45 | | 20 |
| Automobile driver | 9 | 60 | 11 |
| Automobile passenger | 27 | 33 | 25 |
| Regular taxi | 2 | 1 | 22 |
| Walk or other | 11 | 6 | 8 |
| Minnybus | | | 14 |
| Maxytaxy | 6 | | |

These trips appear to be mainly teenage recreational travel. The commuter trips would all have been made in the absence of the service, almost exclusively as automobile-driver or automobile-passenger trips. The Maxytaxy has also tapped some previously unserved travel demand, although the majority of those trips also would have been made in any case. A substantial proportion of the trips for all three services would have been automobile-passenger trips, so that many family members and friends have probably been relieved of providing serve-passenger trips. And 60 percent of the commuters have left an automobile at home for possible use by other family members. The table above also suggests that there is a not insignificant degree of competition between the different WTD services and regular taxi services: 14 percent of Maxytaxy riders would have taken the Minnybus in the absence of the Maxytaxy service, and 22 percent would have taken a regular taxi.

These results provide the initial data needed for examining the probable impacts of the WTD services on vehicle travel in Westport. They indicate that, if all of the WTD services were terminated, there would be an extra 10 820 automobile-driver trips, an extra 15 250 automobile-passenger trips, and an extra 3590 taxi trips each month. If we assume that, (a) for automobile-driver trips, vehicle kilometers generated are equal to passenger kilometers traveled, (b) for automobile-passenger and taxi trips, vehicle kilometers generated are equal to twice passenger kilometers traveled (i.e., all automobile-passenger trips are serve-passenger trips), and (c) one WTD vehicle is equivalent to 1.4 automobiles for vehicle travel purposes, it can be shown that the WTD services are effecting a reduction of vehicle travel only if the number of trips served per vehicle kilometer exceeds 1.59 divided by the average person-trip length. For person-trip lengths averaging 3.2 km, the number of WTD trips per kilometer would have to exceed 0.50. If we assume 20 trips/h for the Minnybus and 4.5 trips/h for the Maxytaxy and average vehicle speeds of 24 km/h (15 mph), the number of WTD trips/km would be 0.68 (1.09 trips/mile), which implies a vehicle travel reduction of about 41 600 km/month (26 000 miles/month) or about 1600 km/day (1000 miles/day). (These calculations are provided only for illustrative purposes; with reasonable data estimates they suggest that there is some reduction in vehicle travel due to the WTD services, but they should be carried through with actual data from the WTD system.)

As almost all of the Minnybus commuters would have driven or traveled as automobile passengers, the WTD services have reduced vehicle trips to the rail stations by about 250. However, there are still about 1800 commuters each day boarding trains, and congestion and parking are continuing problems at the stations. Efforts to attract central business district workers to the WTD services have not been very successful. Data available on the elderly and handicapped are not sufficient to determine whether many of the potential users are riding or whether a relatively few users are taking most of the trips.

### Costs and Cost-Effectiveness

A detailed analysis of the individual service costs is not yet available, but we can present some preliminary cost data supplied by the system director and supplement these data with some of our estimates.

The operating costs in 1979 dollars for the dial-a-ride service average about $36 000/month and those of the Minnybus system are about $32 000/month; the addition of the estimated vehicle capital costs gives total costs of $39 000 and $35 000/month, respectively. We have not attempted to estimate the administrative costs (which include the staff, office space, and materials), because we do not have detailed information and some of the costs are associated only with the demonstration. Start-up costs and some marketing costs are also excluded. With these exclusions, the cost per passenger trip for the Maxytaxy service is about $3.00 (an average user payment of $1.20 and a subsidy of $1.80) and, for the Minnybus service, the cost per passenger trip is about $0.85 (an average user payment of $0.27 and a subsidy of $0.58). Thus, the average cost per trip for all the WTD services is about $1.39 (an average user payment of $0.50 and a subsidy of $0.89). A more useful cost-effectiveness measure might be cost per passenger trip kilometer, but unfortunately no information on trip lengths is currently available.

### Alternatives

The alternative to the WTD services that is most often mentioned is the construction of additional parking spaces at a cost of $1 million. (The costs avoided by not building these parking spaces are sometimes cited as a benefit of the WTD system while the benefits foregone go unmentioned.) Other alternatives that might have been considered include an aggressive carpooling and vanpooling program for commuters, a discount-taxi-ticket program for the elderly and handicapped, and alternative pricing schemes on the Minnybus system designed to reduce the overcrowding that sometimes occurs. Detailed route and schedule changes are also alternatives that deserve consideration on a continuing basis in a system of this type.

## Danville: Scheduled and On-Call Fixed-Route Service

In Danville, two versions of the user-side subsidy concept have been implemented under UMTA demonstration grants: The first is designed to provide shared-ride taxi services for the elderly and handicapped as described above, and the second is designed to provide scheduled and on-call fixed-route service for the general public. A privately operated fixed-route transit service existed until 1970, and the new fixed-route system—the Runaround—began operations in November 1977. The Runaround system uses a special set of administrative procedures for involving private operators and reimbursing them on a user-side subsidy basis. Riders prepurchase Runaround tickets from some 32 ticket outlets in the city and use them to pay for Runaround service: Full-fare tickets cost $0.40 each and are available in books of 5 and 20 tickets; $0.20 half-fare tickets are available to the elderly, the handicapped, and children less than 16 years old in books of 10 tickets; and in addition, an unsubsidized cash fare of $1.00 has been established. Runaround providers then submit the used tickets to the city on a weekly basis and are reimbursed at prearranged rates. Every four months existing and potential new providers are invited to propose service and fare levels at which they could operate profitably on the basis of the reimbursement guidelines announced by the city. Any conflicts among the providers over routes and fare structures are resolved through discussions between the providers and city planning staff, and contracts are negotiated specifying service levels and reimbursement rates for each provider over the next 4-month period (18).

During the fourth service period, which began on November 27, 1978, Runaround services were provided over 11 routes between 6 a.m. and 6 p.m. Monday through Saturday by two private transportation companies. One company operates five 45-passenger buses over 7 routes on 30-min and 60-min headways and the other operates a 21-passenger minibus over 2 routes on 60-min headways and regular taxicabs over 2 other routes on an on-call basis. Free transfers are available between all routes. The first company's contract provides for a payment of $1.85/ticket collected, and the second company's contract specifies $1.50/ticket. Both contracts include maximum total payments for the 4-month period. Unsubsidized shared-ride taxi service continues to be provided by the second company and one other small operator and carries about 15 000 passengers/month at an average fare of $1.50.

### Benefits

In the first 12 months of service development, Runaround ridership levels experienced some variations but, at the end of the period, appeared to be growing steadily; the fourth period ridership was about 22 000 persons/month (these are complete trips based on ticket counts and do not include transfers between routes). The effects of the Runaround on travel are suggested by the results of an early on-board survey. (This survey was made only four months after the Runaround began service, when reduced-rate taxi service was still available for elderly and handicapped users; it appears that young, elderly, and handicapped riders may be underrepresented in the returns.) The number of trips made by various socioeconomic groups is summarized below.

| Group | Percentage of Population | Percentage of Total Trips (N = 22 000/month) |
|---|---|---|
| Age (years) | | |
| <20 | 27 | 20 |
| 20-64 | 60 | 63 |
| >65 | 13 | 17 |
| Handicapped | 4.5 | 8 |

It appears that the Runaround is serving largely work, school, and medical trips and has generated relatively few new trips. About one-third of all Runaround trips appear to have been diverted from the Danville shared-ride-taxi system, and 12 percent appear to be diverted automobile-passenger trips (which probably relieved some residents of providing serve-passenger trips).

| Trip Purpose | Percentage of Trips |
|---|---|
| Work | 39 |
| Shopping | 7 |
| School | 21 |
| Medical | 14 |
| Recreation | 6 |
| Other | 13 |

| Alternative | Percentage of Trips |
|---|---|
| No trip | 8 |
| Automobile driver | 24 |
| Automobile passenger | 12 |
| Shared-ride taxi | 30 |
| Walk | 22 |
| Other | 4 |

With regard to the effects of the Runaround on vehicle travel in Danville, the results suggest that, if the Runaround services were terminated, an extra 5280 automobile-driver trips, an extra 2640 automobile-passenger trips, and an extra 6600 shared-ride-taxi trips would be taken in Danville each month. If we assume that (as for Westport), (a) for automobile-driver trips, vehicle kilometers equal passenger kilometers and (b) for automobile-passenger and shared-ride-taxi trips, vehicle kilometers equal twice passenger kilometers and further assume that one Runaround bus is equivalent to 2.5 automobiles for vehicle travel purposes, it can be shown that the Runaround system is effecting a reduction in vehicle travel only if the number of trips served per vehicle kilometer exceeds 2.31 divided by the average person-trip length. As the average person-trip length is probably close to the RTR value of 3.2 km, the minimum number of trips per vehicle kilometer if the service is to effect a reduction in vehicle travel is 0.72, which slightly exceeds the current value for the Runaround system of 0.59. Thus, the effect of the Runaround on vehicle travel appears to be slightly negative. As for the Westport example, however, these calculations should be carried through again when better Runaround system data become available.

### Costs and Cost-Effectiveness

A detailed analysis of the service costs is not yet available, but we can present some preliminary cost data supplied by the project administrator. The total operating costs during the fourth service period for both companies were estimated to be $146 000, which includes vehicle depreciation for the privately owned buses and taxis. The city administrative costs for the 4-month period were about $18 500, which includes the staff, office space, and printing costs for the tickets and service schedules.

Table 8. Demographic and public system characteristics in Westport and Danville.

| Characteristic | Westport | Danville |
|---|---|---|
| Demographic | | |
| Population | 29 300 | 42 800 |
| Area (km$^2$) | 58.0 | 33.4 |
| Median annual household income[a] ($) | 26 000 | 13 000 |
| Age (percent of population) | | |
| <19 | 25 | 27 |
| >65 | 8 | 13 |
| Handicapped (percent of population) | 3 | 4.5 |
| System | | |
| Fixed-route trips per month | 41 000 | 22 000 |
| Dial-a-ride and shared-ride taxi trips per month | 13 000 | 15 000 |
| Total passenger trips per month | 54 000 | 37 000 |
| Fixed-route costs per month ($) | 35 000 | 42 000 |
| Dial-a-ride costs per month ($) | 39 000 | 22 500 |
| Total costs per month ($) | 75 000 | 64 500 |
| Fixed-route revenue per passenger trip ($) | 0.27 | 0.30 |
| Dial-a-ride revenue per passenger trip ($) | 1.20 | 1.50 |
| Average revenue per passenger trip ($) | 0.50 | 0.79 |
| Fixed-route cost per passenger trip ($) | 0.85 | 1.90 |
| Dial-a-ride cost per passenger trip ($) | 3.00 | 1.50 |
| Average cost per passenger trip ($) | 1.39 | 1.74 |
| Average subsidy per passenger trip ($) | 0.89 | 0.96 |
| Total subsidy per month ($) | 48 000[b] | 35 400[c] |

Notes: 1 km$^2$ = 0.386 mile$^2$.
Costs in 1979 dollars.
[a]1976 estimate. [b]Excludes start-up, administrative, and some marketing costs.
[c]Excludes start-up costs.

Advertising costs were about $2700. Because this is a demonstration project, there are some administrative costs (such as managing data-collection activities and preparing reports) that should be excluded if the costs are to be compared with those for other systems. The total operating cost for the fourth service period was about $167 800 or $41 950/month, about 11 percent of which is for city administrative expenses. This does not include about $46 000 of start-up costs incurred at the beginning of the project.

For a public agency instituting a program similar to the Runaround in 1979, the start-up costs would be approximately $49 200 (inflating the $46 000 incurred in 1978). By using a 5-year program period with a 10 percent discount rate and assuming an average ridership of 17 000/month for the first year and 24 000/month for succeeding years, the average cost per Runaround trip would be $1.92 in 1979 dollars: a $0.30 user payment, a $1.34 fare subsidy, and a $0.28 administrative cost. For an average trip length of 3.2 km, the overall cost per passenger trip kilometer would be $0.58 ($0.96/passenger trip mile).

### Alternatives

Given that the city of Danville wishes to support subsidized mass transportation services for the general public, there are several alternatives to the current Runaround system that might be considered. First, the user-side subsidy approach, which involves a rather costly prepaid ticket system, might be abandoned in favor of a provider-side approach such as contracting with providers on the basis of a cost plus fee payment per in-service kilometer. Second, the restriction on service to fixed-route operation could be lifted and area-wide shared-ride-taxi services considered. Careful consideration is expected to be given to these alternatives as city staff prepare applications for state and federal funding to continue mass transportation services in Danville.

### Some Comparisons Between Westport and Danville Systems

The Westport and Danville systems have somewhat different local objectives and illustrate two innovative techniques for providing public transportation services to the general public. In both systems, UMTA funds have been used to involve private taxi operators, but they have been used in different ways and at different costs.

The demographic characteristics of the two cities and the system characteristics of the two services are compared in Table 8. After about one year, the total number of passengers using the public bus and taxi services in Danville is considerably lower than that in Westport, and the users and trip purposes of the two systems are quite different. The revenues and costs per passenger for the services are also different and reflect local policies about user charges and the status of private taxi services in the towns.

To assess the effect of the subsidized mass transportation services in Westport and Danville, we must estimate how many new mass transportation trips are being made and the average subsidy required to generate each new trip. This can be done by subtracting the level of taxi travel estimated by assuming that no new services had been introduced and that the private taxi ridership had continued at about previous levels from the current ridership.

| Item | Westport | Danville |
|---|---|---|
| Assumed taxi ridership per month in absence of current program | 6 000 | 25 000 |
| Total passenger trips per month with current program | 54 000 | 37 000 |
| New mass transportation passenger trips per month | 48 000 | 12 000 |
| Subsidy per new mass transportation trip ($) | 1.00 | 2.95 |

The new system in Westport has generated about four times as many new trips as that in Danville, and the Danville subsidy cost per new passenger trip is about three times that of Westport. The Westport program has been more successful in generating new mass transportation trips than the Danville program, but this is due in part to the fact that the level of mass transportation activity prior to the programs was much lower in Westport than in Danville. Major socioeconomic and travel market differences also exist between the two communities.

## CONCLUSIONS

The individual paratransit projects described in this paper illustrate the difficulties encountered in quantifying the benefits, costs, and cost-effectiveness of alternative public transportation proposals. The evaluation measures developed often had to be based on questionable or hypothetical data and, in some cases, the data gaps were such that even reasonable hypothetical data could not be constructed. Some of the specific problem areas raised by the examples are discussed below.

### Estimation of Benefits

Perhaps the major difficulty in estimating benefits is the delineation of a base case and the estimation of travel behavior for this case. In each of the examples, a hypothetical do-nothing situation was used as the base and the benefits and costs of the programs were quantified relative to this base. For the home-to-work examples, travel behavior for the base case was estimated by extrapolating behavior observed before the programs were initiated and, for the special-user-group and general-purpose examples, users were asked hypothetical questions about their probable travel behavior in the absence of the program. Neither of these techniques is very satisfactory, and it is clearly desirable that our ability to predict travel behavior under different circumstances be improved. (A current project that is using travel diaries to monitor the travel behavior of elderly and handicapped residents in Lawrence, Massachusetts, should provide a useful contribution in this regard.)

The effects on travel of the special-user-group programs suggest that the benefits of these programs are being enjoyed by a relatively small proportion of the eligible population. And, for both special-user-group and general-purpose programs, the primary effect is to facilitate existing trip making rather than to generate new trips (with the possible exception of the Westport daytime Minnybus service). Whether or not these are the desired outcomes of the programs is a subject for debate by policymakers. If greater emphasis is to be placed on generating new trips, it will be necessary to focus the programs more sharply on those who are likely to increase their trip making. If, on the other hand, permitting urban residents to make their existing trips more conveniently is considered worthwhile, extensive targeting may be inappropriate. (The secondary benefit of diverting trips from private automobile-driver or automobile-passenger modes that often accrue to family members or friends who make use of an automobile left at home or who are relieved of providing serve-passenger trips should also be considered.) An important side issue is the effect the modal shifts occasioned by these programs might have on other transportation services: systems such as the Danville Runaround and the Westport Maxytaxy, which have diverted significant ridership from taxi services, may reduce the general level of taxi service available in these towns.

Programs aimed at high-density home-to-work travel frequently consider all of the user-cost savings that result from switches to higher-occupancy modes as user benefits of the programs. As the examples for the Aerospace-SAMSO and TVA programs point out, this practice overstates these benefits. There are also indications that some of the reductions in vehicle travel effected by these programs may be offset by increased use of vehicles left at home and by decisions to locate further away from the work place and so make longer trips, and these indications should be explored.

## Estimation of Costs

The major problem encountered in dealing with costs and cost-effectiveness in the examples was the identification of the start-up and ongoing administrative costs. In some cases, these costs could not be obtained explicitly, which required that they be either estimated or omitted entirely. In the future, special efforts should be made to identify the costs associated with these and other nonoperating activities. Capital costs are also difficult to identify and treat properly, particularly where UMTA capital grants are involved.

A second problem in treating costs is the determination of the period of time over which they should be considered. Start-up costs should be considered over a reasonable project life along with other costs, for example. Both benefits and costs should be considered (and properly discounted) over suitable project lifetimes so that the usual high first-year deficits are put in the proper perspective. In several of the examples discussed, the start-up costs appeared quite high but were actually small proportions of the total project costs when considered over a 5-year project period. The examples also illustrate the importance of identifying the year to which dollar amounts apply.

A problem that arose in computing cost-effectiveness measures was the paucity of information about trip lengths. The common cost-effectiveness measure of cost per passenger trip can be very misleading if trip lengths vary considerably. Comparison of the Danville RTR and Portland LIFT projects illustrates this point: the average trip length for the former project was about 3.2 km and that for the latter was around 8 km (5 miles). (Where it was possible in the examples, program cost per passenger trip kilometer or per vehicle kilometer of travel were computed.)

## Consideration of Alternatives

An attempt was made in each of the examples to suggest worthy alternative projects: projects that might be more cost-effective than the present scheme. The merits of a particular project should rest not on its superiority over a highly-inferior alternative but on its superiority over alternatives that have comparable performances. Paratransit projects have sometimes been justified in part on the basis of the costs avoided by rejecting an alternative while ignoring the benefits of the alternative. In addition, the alternatives considered have often been unrealistic or inferior ones. Presentation of the benefits and costs for realistic and worthy alternatives to current projects would avoid this pitfall and provide other cities with a better understanding of why the project was implemented in its present form.

As illustrated by the Aerospace-SAMSO and TVA programs, the evaluation of worthy alternatives involves predicting the effects on modal choice of relatively minor changes in the incentives provided for high-occupancy modes. Assessing alternatives for special-user-group and general-purpose programs involves predicting the number of new trips generated as well as the modal shifts among a variety of modes. Further progress must be made in understanding travel demand if we are to be able to analyze these kinds of alternatives adequately.

## Institutional Framework for Planning

Unfortunately, the examples described in this paper cannot serve to illustrate the points raised in the sections about planning procedures. The home-to-work examples were entirely within the private sector, and the other examples were primarily demonstration projects that were not developed through normal planning processes. The fact that paratransit projects are still largely experimental limits the number of examples that can be used to illustrate planning issues, although as time goes on, more paratransit projects will presumably be developed as part of mainstream public transportation programs. (The procedures for dealing with these mainstream projects are currently the subject of much of the discussion surrounding the UMTA proposed paratransit policy statement.)

## Relationship Between Paratransit and Conventional Transit Modes

The question of whether paratransit and conventional transit modes are or should be competitive is often raised but is rarely pursued in any depth. Some paratransit projects are designed to avoid any competition with transit services; the TVA vanpools are designed to operate in areas not served by transit, for example.

On the other hand, there is ample evidence that transit and paratransit modes can appeal to the same market. The fixed-route Runaround system in Danville apparently draws a third of its ridership from the shared-ride taxi service, for example, and 14 percent of the Westport Maxytaxy riders said that they would have used the Minnybus service if the Maxytaxy had not been available. There is also evidence of considerable overlap in the markets for carpooling and fixed-route transit (19-21).

The overriding concern of public transportation planners is presumably the identification of the most cost-effective public transportation program, and the examples discussed in this paper suggest that such a program might well include a combination of paratransit and transit modes. In some areas, these modes might well be actively competing for ridership and, in others, they might each have essentially their own turf.

In the absence of any strong supporting evidence, it is difficult to justify broad policies that would restrict paratransit and transit to different market areas. What if, for example, carpools were not permitted to compete with conventional transit along the Shirley Highway express lanes in Washington, D.C.? Such a policy would result in a dramatic increase in traffic congestion or transit subsidies and probably in both. The planner's task is to incorporate paratransit modes into the public transportation system in a way that maximizes overall net public benefit. Such an approach will require careful tailoring of paratransit and transit services to market areas and should not be constrained by a priori decisions on the roles of different services.

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