Taxicab Feeder Service to Bus Transit

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The use of taxicabs as feeders to fixed-route transit is discussed. Reasons for involving privately operated taxicabs as feeders to publicly subsidized systems are presented and three existing systems are described to illustrate some of the benefits and problems associated with this innovative type of operation. The major questions about feeder service pertaining to economics, quality of service, and demand are reviewed, and the institutional issues that may inhibit using taxicabs as feeders are discussed. A proposal is outlined for an experimental demonstration for a large urban area.

In suburban areas and urban communities, there is often public and political pressure for broad public transportation coverage. In the United States, where many transit operations are supported by various forms of taxation on urban and suburban residents, this pressure has usually resulted in the conventional, radial-oriented, fixed-route bus service that extends far out into areas of low residential density. Because it is increasingly costly to operate transit systems at all, the high costs of operations in areas with low-density demand patterns (and low revenue) are difficult to justify. Thus, some transit authorities in large metropolitan areas are considering cutting back routes in suburban areas and reducing or dropping service during low-demand periods such as late at night and on weekends.

A novel way to provide broad coverage is to integrate dial-a-ride and subscription feeder service with fixed-route operation. Smaller vehicles would respond to telephone requests, pick up users at their homes, and take them to designated points for transfer to the scheduled transit service. On the return trip, these small vehicles would take transit users from the transit stop to their homes. In a well-integrated system, the transfers would be coordinated to minimize passenger wait time and the service would have convenient transfer mechanisms such as joint fares and sheltered transfer points. The problem is to provide high-quality collection and distribution service at a reasonable fare and at a low total cost to the transit authority or other public body that may be subsidizing the trip.

In the past few years, many demonstrations and examples of various types of dial-a-ride systems have been designed for the lower density demand patterns that are inefficiently served by conventional transit (1). Most of the implemented systems are in small and medium-size urban areas that either do not have fixed-route bus service or have paratransit services that are not integrated with the existing transit service. Although some examples of feeder service to line-haul bus transit exist, including the systems in the urban areas of Rochester, New York, and Toronto and the smaller cities of Ann Arbor, Michigan, and Regina, Saskatchewan, all are operated by transit authorities and use small bus- or van-size vehicles with seating capacities of 12 to 30 passengers.

This paper discusses using privately operated taxicabs as a cost-effective means of providing feeder service to line-haul bus transit. Three examples of currently operating taxicab feeder systems are described in detail. Questions about feeder service that require empirical investigation are discussed, and a proposal is presented for a demonstration of taxicab feeders in a large urban area.

WHY TAXICAB FEEDERS

The taxicab industry has a number of special characteristics that make it particularly well suited for serving the low-density demand patterns that cannot efficiently be served by fixed-route transit:

1. Taxis now operate in the majority of suburban communities and small towns and generally provide service 24 h/d, 7 d/week.
2. The taxicab industry is experienced in operating exclusive-ride taxi and dial-a-ride transportation systems and has managerial skills for dealing with dispatching, employee utilization, and vehicle maintenance.
3. Vehicle operating costs are usually substantially less for taxis than for conventional transit vehicles, primarily because of lower driver wage rates, flexibility of work rules, and the use of part-time workers (2).
4. Diversifying the types of services provided by taxicabs has potential for increasing overall driver, dispatching, and vehicle productivity so that costs for these additional services can be kept low while profits are increased.

Because scheduled transit service will tend to group feeder users, shared-ride taxi feeder service should allow higher vehicle productivity (average number of passengers per vehicle hour) and lower costs per passenger than the traditional, exclusive-ride taxi service. If taxi drivers were able to provide the feeder service "in between" their regular calls without disrupting this business, then the regular taxi revenue would be the primary source of income and the feeder revenue would be generated at low marginal costs. Establishing the proper balance between service levels and demand for the regular and feeder operations may present some operating problems for the taxi operator, of course. If such problems could be overcome, the feeder service could provide a convenient means of extending public transportation coverage at a relatively low cost per passenger.

Some special difficulties with taxi operations should be recognized. In a number of cities the financial condition of fleet operators is reportedly rather weak, taxicab vehicles are old and poorly maintained, driver turnover is very high, and illegal vehicles with inadequate insurance are on the street. Furthermore, some taxicab operators have been reluctant to work with city officials and transit authorities to develop new services. Improving the quality of taxicab services to these locations, which will require the efforts of both the operators and the regulators, is essential if the taxi operators are to be regarded as sufficiently reliable to provide feeder services to line-haul transit.

EXISTING TAXICAB FEEDER OPERATIONS

As of April 1977, three taxi feeder systems were operating in North America: one in Peterborough, Ontario, one in St. Bernard Parish, Louisiana, and another in Bremerton, Washington.

Peterborough TRANS-CAB

TRANS-CAB, which began in May 1974 as a demonstration project (3), has been operating in two suburban areas of Peterborough, Ontario, a city of 58 000 people. There was fixed-route bus service in one feeder area before the introduction of the taxi feeder service, but patronage was low and the estimated deficit per passenger was be-

tween $2.30 and $2.90. TRANS-CAB has proven to be a popular type of transit service that can be operated at a lower deficit per passenger ($0.88 in 1976) than conventional fixed-route service. After the demonstration ended in 1975, the city assumed the feeder service as part of the regular transit operations and now provides the municipal share of the operating subsidy. The taxi operator indicates that, in addition to stimulating bus use, the feeder-service project has helped the taxi business overall by providing advertising and exposure. Thus, the service appears to be successful from the viewpoints of both transit and taxi operators.

The two Peterborough feeder service areas (zones A and B) and the bus routes serving them are shown in Figure 1. The very low feeder use in zone B reflects the short walking distance to the route. Zone A contains a newly developed community of single-family homes (population 2000) that is separated from the main part of the city by a golf course and undeveloped land. The road network and the hilly terrain in this area make extensive bus service impracticable. Zone B on the edge of the city is an area of higher density development with duplexes and row houses (population 1400).

According to household surveys (4), the residents of these zones have substantially different characteristics. Zone A families are older than zone B residents: In zone A more than half of the residents are over 35 years of age and about half of the families have no children. Automobile ownership is quite different in the two zones: Only a quarter of zone B households but about half of zone A households own two or more automobiles.

The feeder service is provided by one of the two private taxicab operators under contract to the city-owned transit company. The taxicab company, which has a fleet of 20 taxis, charges the transit operator its regular meter rate for each feeder trip [$0.70 for the first 0.3 km (0.2 mile) plus $0.10 for each additional 0.3 km]. In 1976 the meter rate increased to $0.80 plus $0.10 for each 0.25 km (0.14 mile). No additional vehicles or drivers were required; the TRANS-CAB service is incorporated into the regular operation. (A new person was hired to answer the additional calls.) When the taxis are providing feeder service, a TRANS-CAB sign is placed on the dashboard at the passenger side.

Figure 1 shows the bus routes and the feeder transfer points. The buses are scheduled to depart at the transfer points for the central downtown terminal every half hour (hourly in the evenings). Bus service operates Monday through Saturday from 6:15 to 12:15 a.m. For inbound (home-to-bus) TRANS-CAB service, a user must call 1 h in advance of the bus departure time, giving address, destination, phone number, and number of passengers in the party. The taxi dispatcher tells the person the time of pickup (no more than 20 min before bus departure) and the bus route. On arrival, the taxi driver waits 30 s, sounds the horn, and leaves after another 30 s. If the person does not "show," the dispatcher will try to contact the passenger to advise him or her that the taxi was there and ask if another pickup is desired at another time.

The users on inbound trips pay the total TRANS-CAB fare to the taxi driver and receive a special transfer for the bus. On outbound (bus-to-home) trips, riders notify the bus driver when they board that they want TRANS-CAB service and pay the fare. The bus driver issues a special transfer for the taxi trips and radios the cab dispatcher the bus route number, the number of passengers, and the expected time the bus will be at the transfer point. Because only four passengers can board each taxi and additional vehicles may be required, the driver must call the dispatcher for every TRANS-CAB rider. Each passenger tells the taxi driver his or her destination in the feeder zone. Regular users are encouraged to reserve rides on a weekly (or longer) basis, which reduces the volume of calls and allows the dispatcher to increase taxi occupancy. The dispatcher also becomes familiar with the usual outbound passenger loads at the transfer points.

The TRANS-CAB fare structure is based on the bus fares with a $0.10 premium for the taxi feeder service. For adults and students the fare is $0.35 cash or $0.10 plus a ticket (5 tickets for $1); children pay $0.10 less. Senior citizens pay $0.25 or use a ticket (8 tickets for $1). Adults can also use a $12 monthly bus pass and pay $0.10 for TRANS-CAB. This fare structure produces an average revenue of about $0.30/user. Tipping drivers is not permitted. The system is audited and controlled: The dispatcher, the taxi driver, and the bus operator each keep complete logs for each day, recording several items including number of passengers and revenue.

Ridership and cost data for the demonstration period (May 6, 1974, to February 8, 1975) through 1976 are given below.

Item	Demonstration Period	1975	1976
Ridership			
Total passengers	35 049	65 754	79 988
Average passengers per week	880	1 260	1 539
Average passengers per weekday	158	215	—
Cost and revenue, $			
Total cost	31 437	61 264	94 970
Revenue	10 286	19 425	24 789
Deficit	21 150	41 839	70 181
Cost per passenger	0.90	0.94	1.19
Deficit per passenger	0.60	0.64	0.88
Taxi productivity			
Trips			
Number	16 445	38 702	44 130
Average per week	410	746	846
Average occupancy per taxi trip	2.13	1.70	1.80

These data show that the average occupancy per taxi trip has declined and the cost per passenger has increased since the initial demonstration period. Most of the higher cost in 1976 is attributable to the change in taxi meter rates. A reason for lower occupancy could be the development of more dispersed demand patterns that make it difficult to group inbound trips, especially with different transfer points for three bus routes. Passengers bound for the central business district are taken to the nearest transfer point, but travelers to other points are taken to the transfer point on the most direct bus route. Although this provides the best service to the user, it makes it more difficult to group passengers.

Perhaps a contributing factor is the manner in which the taxi-service contract is set up. Under the current procedure taxi operators have no direct incentive to increase shared-ride occupancy because they are paid by the distance traveled (through the meter charge). On outbound trips the passengers are grouped on the buses, which tends to keep the taxi occupancy higher. However, on inbound trips the taxi dispatcher and the drivers are not penalized if there are several single trips instead of one or two shared-ride ones. An alternative approach would be to pay the taxi operator on a per-passenger basis and thus encourage him or her to maximize the number of riders per trip. As use increased the operator would attempt to increase productivity to make more money and the transit company would not have to increase the user payment unless the taxi operator could justify it. It should also be less costly to administer payments to the operator based on transfer tickets than to record and audit the various meter fares.

Figure 1. TRANS-CAB service area in Peterborough, Ontario.

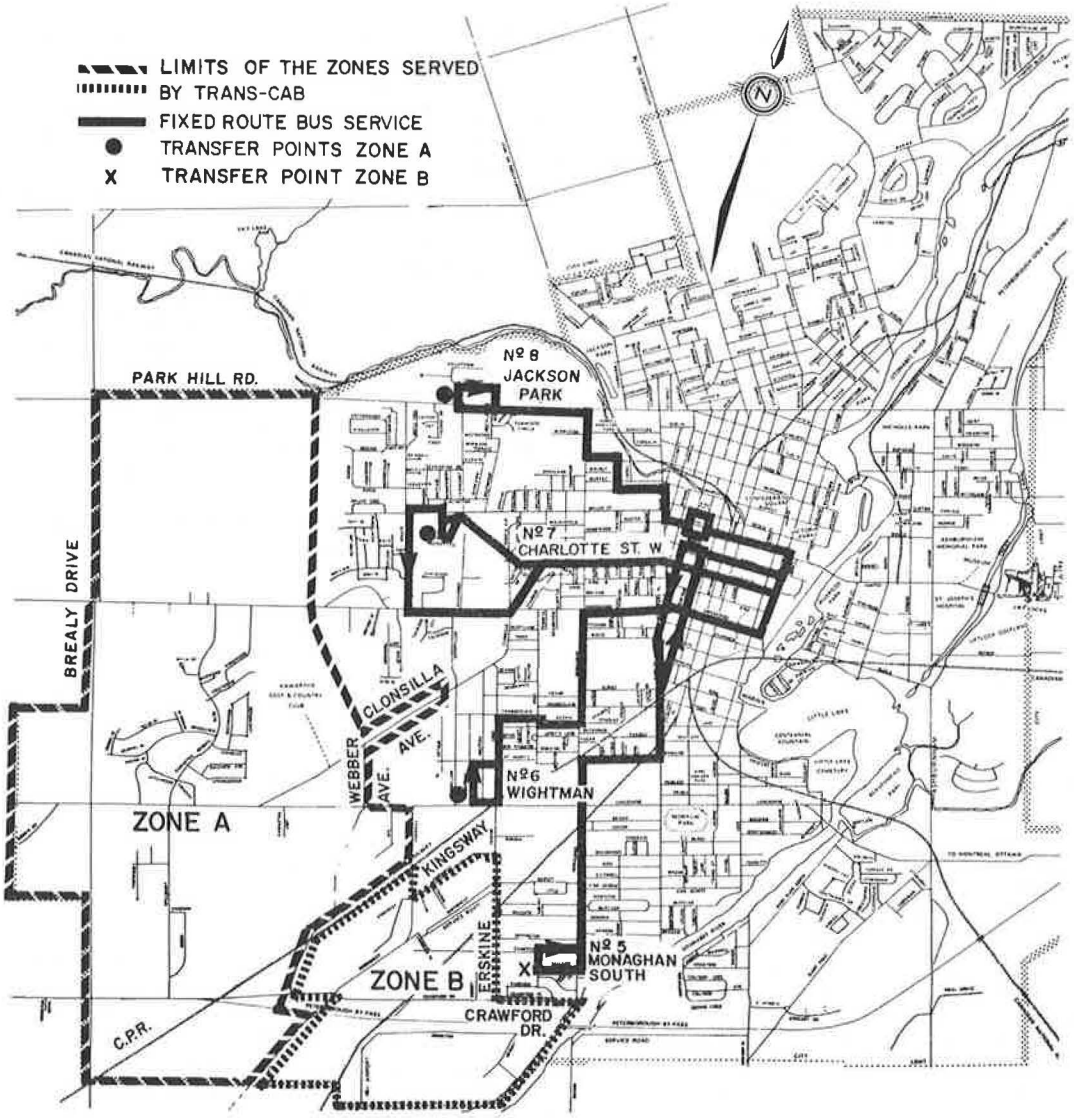
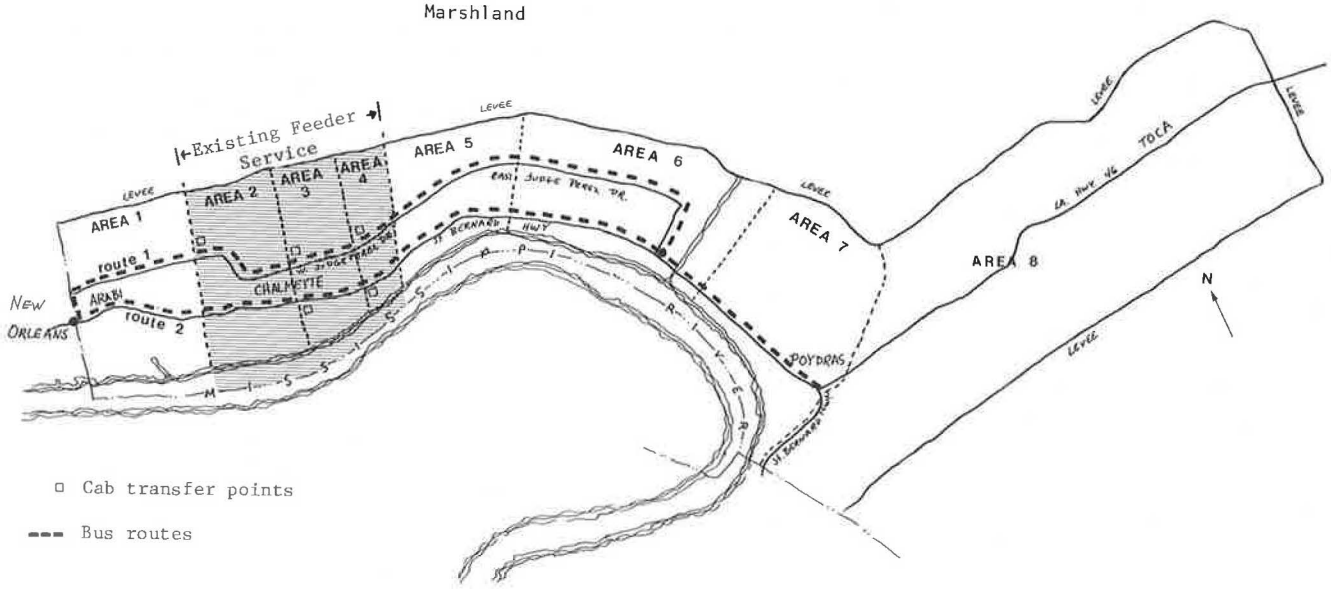


Figure 2. Bus-taxi transfer service area in St. Bernard Parish, Louisiana.



St. Bernard Bus-Taxicab Transfer

Since October 1974, a taxi company has been providing feeder service to two bus routes in St. Bernard Parish, Louisiana. This service is unlike the Peterborough system in that the feeder area was established along the routes and not at the ends. Located on the eastern boundary of New Orleans, St. Bernard Parish (population about 60 000) has developed in a relatively narrow strip, with the Mississippi River on one side and marshes on the other. As shown in Figure 2, the bus routes begin in the rather rural area and run 20 km (12 miles) along the river through suburban development into New Orleans. The feeder area covers 10 km^2 (4 $miles^2$) and contains an estimated 27 000 people, a density of over 2700 persons/km^2 (6700 persons/$mile^2$). Development in the area includes suburban homes, apartments in subdivisions, and scattered shopping and commercial areas.

Before the feeder service was introduced, one of the bus routes wound through the residential streets in the feeder area. Because of low residential density and slow bus speed, the patronage was too low to cover costs and the private bus operator dropped the bus route and substituted taxi transfers to the two direct bus routes. The coordination between the two modes was relatively easy because the private company that operates the three-vehicle bus system (at 40 passengers/vehicle) is controlled by the owners of the 21-vehicle taxi company.

A traveler in the transfer area calls and requests taxi service to one of five bus stops. Bus service on the main route is provided by two buses that shuttle back and forth every half hour from 6 a.m. to 7 p.m. on weekdays and hourly on Saturdays. The other route has only 1 bus/h on weekdays. The dispatcher sends a taxi and also notifies the bus driver that a passenger should be expected at a specified stop. (Passenger wait time is minimized by coordinating the pickup time at the home with the arrival of the bus at the bus stop.) If a bus rider wants to take a taxi home, he or she tells the bus driver, who in turn radios the dispatcher when and where the rider will be discharged. A taxi picks up the passenger, often moments after he or she is discharged by the bus.

Each user pays a joint fare of $0.50 on the first mode used and is given a transfer slip to be shown to the driver of the connecting mode as evidence of payment. Within the area served by the taxi feeder, the regular bus fare ranges from $0.35 to $0.50; the regular taxi fare to the bus stop would be over $1. Thus, for a payment of a $0.50 joint fare, the user receives a $0.35 to $0.50 bus ride and a $1 taxi ride. [The transfer service is not available for trips less than 0.4 km (0.25 mile) from the bus stop.]

The feeder system began with about 75 users/month and by August 1976 had grown to over 1000/month or about 10 percent of the bus ridership. The operation of this small-scale system was sufficiently encouraging to interest the Urban Mass Transportation Administration (UMTA) in the establishment of a demonstration project designed to expand the bus and taxi fleets and extend the feeder service throughout the parish. Bus-taxi transfer service will be started in area 1 and areas 5 to 8 (Figure 2). Taxi feeder service to commuter subscription buses will also be introduced. The proposed transfer fare structure is based on the existing distance-related bus fares (ranging from $0.25 to $1.30); there is a $0.25 premium for the off-peak and $0.35 for the peak taxi ride. The taxi drivers currently receive $0.50/user, and the bus company does not receive any revenue from the feeder trips. Under the proposed fare structure, a portion of the user charges will go to the bus company.

Bremerton Taxicab Feeder

In November 1976, bus service on a low-ridership route in Bremerton, Washington, was stopped and replaced with taxicab feeder service. Located across the Puget Sound from Seattle, Bremerton (population about 35 000) has a city-owned bus system with five routes serving the downtown area and the naval shipyards. Because only a few persons per day were riding buses on the 4-km (2.5-mile) route segment that served a peninsula of low-density residential development, the city contracted with the major taxi operator to provide feeder service to the nearest bus route. The company was paid $1.50/feeder user. Taxi feeder use was also very low, about 30 trips/month; the city thus achieved a substantial savings by not operating one bus.

Within the city the joint fare for a taxi-and-bus trip was $0.50 for all users, which was higher than the regular $0.35 bus fare. Taxi pickup times inbound were coordinated with the bus schedule; however, because the buses did not have radios, homebound users had to use the taxi phones in the downtown area to notify the taxi company that they wanted a taxi transfer.

In April 1977, a citywide taxi feeder service was started. For a $0.50 joint fare, any resident can take a taxicab to or from the nearest bus stop along all five routes. For a trial period, the taxi company will receive $1.50 for each user. Although the service will be convenient for the elderly and people who have difficulty walking to bus stops, the city does not expect many users. At the end of the trial period, the city and the taxi operator will evaluate costs and public acceptance and determine if changes should be made.

UNCERTAINTIES ABOUT FEEDER SERVICE

The two general areas of uncertainty for any new transportation service are supply and demand. On the supply side the major concern is the relation between the cost and the level of service provided. These are influenced by (a) operational and technological requirements, such as speed and capacity of vehicles, nature of the service area, management and control, and labor utilization; and (b) institutional aspects, such as organizational, financial, and regulatory constraints. On the demand side, the major concern is the relation between use and the level and the price of service in different socioeconomic environments.

Before feeder service can be considered for widespread implementation and before its applicability for a particular area can be evaluated, planners, policy makers, and transportation operators need to have a sound understanding of the supply and demand aspects and their interaction. Three sets of general questions regarding feeder service are discussed below. Although some of the questions are specific to taxicab feeder service, most refer to feeder service provided by any operator.

Costs of Providing Feeder Service

The key concerns in implementing this type of service are as follows: How efficiently can coverage be provided by feeders? What are the costs per feeder rider? How do the feeder-to-bus and bus-to-feeder vehicle productivities and average feeder occupancies vary? What are the practical costs per kilometer and costs per vehicle hour for feeder operations? What major factors determine these costs? Can taxi feeder service be provided at a low marginal cost by a taxi company because the regular taxi business covers the fixed costs? What are the

costs if the feeder ridership increases beyond the point where it can be handled as a marginal taxi service? How does the size of the service area affect costs? Are costs lower if several taxi companies participate? Are taxi insurance costs affected by the integrated service? Empirical data on the total costs as well as the detailed elements (e.g., wages, vehicle operation, dispatching) for different sizes of operations in various parts of the country would be useful in assessing the costs of implementing this type of system.

Cost savings that result from shortening routes (or not extending them) are a major concern. How are the costs of fixed-route bus service affected by feeders? What are the actual avoidable costs per route? Are there significant new costs associated with the administration of transfer tickets or with the procedures for coordinating buses and feeder vehicles?

Quality of Service

What are the operational and technological procedures for providing high-quality service? If this type of innovation is to be implemented, proven operating techniques will be necessary. Because a key to minimum travel and wait times as well as lower costs per passenger is the dispatcher's ability to develop efficient shared-ride tours, the manual dispatching capacity and any requirements for users to place their call within some set time before the scheduled bus arrival should be determined. What factors improve vehicle utilization and quality of service? How should the boundaries for a feeder area be determined? Are special procedures necessary to ensure that commissioned taxi drivers respond reliably to feeder calls? Is the quality of service affected if several taxi companies are providing the feeder service?

An important question for taxi operators and regulators when they consider feeder service is, Does the shared-ride taxi feeder service affect the level of service provided to regular taxi customers? Regulators would not want the feeder service to adversely affect the dispatching or the availability of taxis for regular service, and taxi drivers would not want to reduce their normal revenue.

Transportation Demand

A basic implementation question for any new service is, What is the ridership response to feeder service? To determine the benefits and costs of a proposed feeder system, planners will need to estimate how many people will use it. Ideally, demand models can be developed that will be useful for forecasting ridership in different socioeconomic areas and for predicting the demand under various fares and service levels. Eventually, as more examples are implemented in different environments, it may be possible to develop planning models. Some of the questions that should be answered as part of the effort to understand travel behavior and to develop useful forecasting models include the following:

1. What are the characteristics of the users? Are they transit dependent or former automobile users? Are they in high- or low-income groups, young or old?
2. How do the characteristics of the service areas (population density, automobile ownership) influence ridership? How does the demand develop over time?
3. Were the trips formerly made by walk-on bus or regular taxi or are they new trips?
4. What is the fare demand elasticity and how do other level-of-service variables (wait time, bus headways) affect ridership?

Does providing feeder service affect regular taxi ridership? Taxi operators will be concerned about the effects on their business. Extensive feeder service might reduce the demand for taxis in the feeder areas; however, if the taxis provide this different type of service the exposure could also stimulate greater use. Taxicab regulatory bodies will be interested if the taxi feeder service increases total revenue and profits because the need for higher regular taxi fares would be reduced. If fares could be kept from rising, this would also influence regular ridership.

Institutional Issues

In addition to an improved understanding of the economic, level-of-service, and demand impacts of feeder services, major legal and institutional issues have to be resolved before private taxi operators can provide the service. A full discussion of these issues, which were addressed at the 1975 Conference on Paratransit (5), is beyond the scope of this paper, but the major areas of concern are as follows:

1. Because local taxicab regulations in most areas prohibit shared-ride services and require the fare to be computed by a meter, ordinances may have to be changed.
2. Bus labor unions may oppose the substitution of taxi service for bus service.
3. Taxi operators may be reluctant to participate with regional transit authorities if too much control and regulation of their companies are required.
4. The additional feeder-service profits could create a competitive advantage for some taxi operators. If this created a monopoly situation, then taxi service in general could be affected.

NEXT STEP IN INVESTIGATING FEEDER SERVICES

Although some useful information is available about costs, level of service, and demand for feeder service in several locations, almost all of the knowledge is based on feeder systems operated by transit authorities. A great amount of information was obtained during the UMTA demonstration project in Haddonfield, New Jersey, and the ongoing UMTA demonstration project in Rochester, New York, is testing the use of a computer-dispatched feeder service in three areas. In addition, there are data on the systems in Toronto; Ann Arbor, Michigan; and Regina, Saskatchewan. Some information is also available about demand response at certain fare and service levels in several environments.

On the other hand, relatively little is known about the supply and demand aspects of taxicab feeders. Although the three existing taxi feeder operations described in this paper demonstrate that it is technically feasible to provide high-quality transfers between buses and taxis, they are small-scale systems with somewhat unique institutional aspects. The next step is to experiment with taxi feeder services in situations with more typical institutional arrangements and with a broader range of demand conditions.

All large urban areas in the United States have publicly subsidized and operated bus systems as well as several private taxi operators; therefore, what are the best institutional arrangements for involving taxi companies with a typical public transit authority? Should the transit agency or another transportation organization plan and manage the service? What should the role of the local taxi regulatory body be regarding the new shared-ride feeder service? Operating arrangements should be developed that allow taxis to receive a subsidy

for the feeder operations and to continue to make an overall profit. These arrangements should be perceived as equitable by the taxi operators and must motivate them to continue to provide reliable feeder service at the lowest possible cost. Because a monopolistic situation can be encouraged by exclusive contracts or franchises, efforts should be made to involve more than one taxi company.

Because of the complexities of bus systems in metropolitan areas, many transit authorities may find that it is difficult to estimate how much cost saving is possible when routes are cut back and feeders are introduced. If fewer bus kilometers are operated, some direct costs, such as those for fuel and maintenance, are avoidable. However, labor-related cost savings are not directly related to kilometers of operation. Shortening even one route can affect several other routes because of the ways in which drivers and vehicles are used in large systems. Although it should be possible to make some estimate of the potential cost savings attributable to shorter routes, the actual reductions will depend on how driver and vehicle assignments for the new routes and schedules are made. In some cases, it may be difficult to realize potential labor-related cost savings because under protective labor union agreements the number of drivers cannot be reduced. Actual cost savings under different circumstances need to be demonstrated for typical bus systems in metropolitan areas.

For large bus systems and several taxi operations, the control and coordination procedures for feeder operation may be more complex than those for the three small-scale examples cited here. How can high-quality, reliable service be provided by taxis at low cost in typical urban areas? The usefulness of existing taxi and bus communications equipment and dispatching capabilities should be determined before new technology and expensive computer systems are tried. New technology can be implemented, if necessary, as more is learned about problems with manual decision-making and control procedures for operating integrated service.

Bus service is provided to different types of suburban communities and city neighborhoods in a typical metropolitan area. What will the feeder ridership be in areas with different socioeconomic characteristics? What are the relations between fare or level of service and ridership in different areas? Can the fare surcharge for this new service reflect the actual additional costs and still be considered an acceptable public transit fare? Feeder service in some suburban areas could stimulate increased commuter bus ridership and may be very convenient for the elderly and for persons who find walking difficult. However, in some situations, the same transit dependents who walked to the bus may have to pay more to take the feeder. Information on ridership at different fare and service levels should be developed for taxi feeder service in large urban areas.

The taxi feeder experiments should be part of a broad program of investigation designed to provide comprehensive cost, level-of-service, and demand information for different demand environments and various types of institutional arrangements. Because it is not possible to learn everything in one experiment, each example should focus on specific supply and demand questions. As more results are obtained from various operations, planners will be able to determine more easily the applicability of specific types of feeder services for their particular area.

PROPOSED DEMONSTRATION PROJECT

The hypothetical project discussed here is an initial demonstration project to examine how taxi feeder systems should be set up in a typical metropolitan area. It presents one set of institutional arrangements and operational procedures for involving several taxi operators and would provide ridership information for different types of feeder areas at reasonably high fare levels. Although this is a project for a hypothetical area, it is based on conditions in an actual urban area that is currently under consideration as a demonstration site. It is hoped that this initial demonstration would show conventional transit managers as well as taxi operators that they can work together to provide a new type of low-cost, high-quality service. Other projects should examine bus-system cost savings, level of service, and costs under different institutional arrangements as well as determine the effectiveness of more sophisticated control and coordination procedures. Understanding of ridership response would also be improved with more experience from feeder areas in different environments at higher and lower fares and other service levels.

The demonstration would be conducted by the local government's planning body, which would be responsible for the management of the service. Management skills, labor requirements, and cost-saving motives for conventional transit and taxi service are very different; a third party would thus be required who would be impartial and view each operator as a provider of transportation services that should be effectively integrated. The project would involve all interested taxi operators so as not to encourage a monopoly by one taxi company. This can be accomplished by working out with the taxi operators an acceptable per-person transfer fee for each of the proposed areas. Because the taxi companies receive more revenue per passenger, they should be motivated to provide good service at the lowest cost. It should also be less costly to administer payments to taxi companies based on ridership than to pay them on the basis of kilometers of service or some other performance measure.

Four or five feeder areas might be established throughout the urban area. Factors to be considered in the selection of the proposed areas include (a) cost, ridership, and level of service of the existing bus routes and potential cost savings; (b) the amount of taxi activity in each area; and (c) the availability of convenient transfer points and public concern for personal safety during the walk to and the wait for a bus. The socioeconomic characteristics (such as residential density, automobile ownership, and number of elderly) should be as different as possible in each area. The feeder areas will be opened sequentially during the project so that operational and ridership experience from each area can provide guidance for other areas.

After the operators consider the size and the boundaries of each area and estimate average trip length and occupancy, they propose per-person charges of, say, $1 for a trial period. These transfer fees could be adjusted periodically based on the actual demand patterns, the level of service provided, and the available subsidy funds. If there are few feeder trips, taxi drivers will receive little revenue and will have an incentive to provide good service and encourage more trips. As the number of riders in an area increases, it should be possible to provide more shared-ride trips with two, three, or four passengers per cab. This increased productivity should keep the total subsidy costs down and could justify a decrease in the transfer fee per rider. On the other hand, if there are so few feeder users in an area that the taxi companies find the service unprofitable, then the transfer fee might be increased to make the feeder trips worthwhile to the drivers.

Although the operators would be free to provide feeder service in any of the transfer areas at the established price per rider, it might be more efficient for

them to concentrate on one or two areas. In areas where more than one taxi company provides feeder service, the users select the one that best meets their needs.

Users pay one joint fare when they begin their trip. A premium charge is added to the basic bus fare in each feeder area. The premium would be determined by considering the expected transfer ridership and bus cost savings, the taxi transfer fee, and the available subsidy. In this project the premium charges would be high—say, between $0.25 and $0.50.

A user who pays a joint fare is given a two-part transfer ticket. One part is retained by the operator of the first mode as a record of payment; the user presents the other part when he or she transfers. The tickets are color coded to indicate which operator collects the fare, and codes are punched to show which feeder area or bus route is served. Because the fare is collected by the first driver, the tickets are required in order to ensure proper accounting of the revenue for each company. For example, if a taxi driver collects $0.65 for a transfer, he or she submits the ticket to the transit operator for the remaining $0.35 of the fee. When a user gives the bus driver $0.65 for a transfer, the taxi driver submits the second part of the transfer ticket for the $1 transfer fee. There would be a check on the payments to each company in that every taxi transfer has a corresponding bus ticket.

To coordinate the taxi-bus transfers, all vehicles have radios and the taxi dispatchers are linked directly by radio or telephone to the bus dispatcher. For inbound trips, the taxi dispatcher receives a telephone call and assigns the appropriate vehicle by considering the bus schedule and the location of available taxis. Some users, particularly commuters, would be picked up on a regular basis. On outbound trips, the bus drivers radio the location, the expected time of arrival, the number of transfers, and the requested taxi company to the bus dispatcher who contacts the appropriate taxi dispatcher. The bus dispatcher also informs the appropriate taxi dispatcher if certain buses are not on schedule. As ridership develops for the outbound trips, the taxi dispatchers should be able to anticipate the taxis required for most of the buses. For users, an alternative to calling the taxi companies on inbound trips would be calling the bus dispatcher, who would then contact the different companies under some equitable procedure (e.g., a different company every week).

At reasonably high fare levels, the transfer ridership in each of the areas should be relatively small and manageable by the taxi and bus dispatchers. If ridership in an area increases to the point where the subsidy costs are becoming too great or the level of service is deteriorating, then the premium fare could be raised to discourage use and reduce the costs. If ridership develops so that a good level of bus service could be justified, another option would be to discontinue the feeder service and introduce buses.

A comprehensive data collection and monitoring effort would be undertaken so that the demonstration would be a learning process. Information on economics and level of service would be obtained on a regular basis for each feeder area. Ridership would be monitored and the users and nonusers surveyed to provide information on the demand relations in each area.

CONCLUSIONS AND RECOMMENDATIONS

The description of the three existing taxi feeder operations shows that it is possible to save some operating costs and still provide broad public transportation coverage by substituting feeder service for bus routes. Providing coordinated transfers between buses and taxicabs at low cost per passenger seems to be technically feasible. However, questions remain concerning economics, quality of service, and ridership response to this innovative service. There are also legal and institutional barriers to implementing it.

It is recommended that a set of experiments be developed to address these questions and overcome the institutional obstacles. A proposal for a first demonstration for a typical large urban area is outlined in this paper. As more is learned about the benefits and problems experienced with this type of service in a variety of places, taxicab feeders may become an important element in public transportation.

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