tain less than 10 percent of a metropolitan area's employment. Even so, car-pool matching programs appear to have a wide potential market.

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Abridgment

Integrating Transit and Paratransit

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The declining fit of radially oriented transit to today's more dispersed travel, the recognition of the role of taxis, and the growth of paratransit have led to strong interest in integrating conventional transit and paratransit. This interest has been based on the expectation that, by and large, these services complement each other—particularly that paratransit can serve markets for which conventional service is either unequipped or overly expensive. Policy statements by the Urban Mass Transportation Administration (UMTA), the American Public Transit Association, and the International Taxicab Association support service integration.

However, the emergence of paratransit has raised more options and issues than can be dealt with by using current information. For example, there are a bewildering variety of service options—choices between public and private operators, labor questions, regulatory changes, insurance issues, high costs, and requirements for special services, to name just a few. Moreover, although UMTA activities for specific modes, primarily dial-a-ride and its variations, have been in progress for over 5 years, research and demonstrations addressing the integration of paratransit and transit only began within the past 3 years. The Rochester, New York, demonstration began in April 1975; the UMTA areawide demand-responsive transportation projects are just now being started.

Definitive results are not yet available, but the lessons from previous experience and research point toward several general conclusions. This paper highlights such tentative results.

PARATRANSIT IMPACTS

The major impacts of expanded paratransit services appear to be the following:

1. Improved mobility for people permanently or temporarily without access to private automobiles or high-quality transit service;
2. Reduced total cost of transportation for commuters, taxi users, and other individuals; and
3. Reduced congestion or parking requirements at individual employment or activity centers.

Improved mobility might well be the single largest impact of paratransit service. The low demand densities, scattered trip patterns, and special service needs that characterize the travel of people who are currently without adequate transportation are often more appropriate for demand-responsive or local minibus service than for conventional transit. Almost invariably, these people are unable to drive or they find the cost of private automobiles too high; the availability of a private automobile would remove the limitation on their mobility.

Notably missing from the list of impacts are the major national concerns of energy and environmental protection. Improvements in vehicle technology would probably have a larger impact on reducing energy use and pollutant emissions than would any foreseeable effect of paratransit. The percentage of trips by public transportation, about 5 percent nationwide, is so small that the impact of changes such as paratransit on total fuel consumption and emissions is small relative to the total problem. Paratransit by itself is not seen as a solution to energy and environmental problems, but paratransit as an element of the overall transportation system fills some roles—e.g., van pool, subscription bus, or line-haul feeder—better than any other mode.

In addition, the impacts of paratransit are likely to be more noticeable to individual people and at individual employment or activity centers than in national aggregate transportation statistics. As long as the private automobile is the overwhelmingly favored mode of travel, changes in one of the other modes will have only limited effect on the aggregate statistics for total transportation energy, total vehicle kilometers of travel, or total cost of transportation. However, paratransit can have significant impacts on the mobility of the nondriver and on the cost of transportation for commuters, for young families, for the elderly, and for others to whom the cost of one or more private automobiles is too large. Commuter paratransit can affect employer parking costs and the amount of space for parking, and it can affect highway construction by increasing the people-carrying capacity of existing roads.

PARATRANSIT COSTS

A major concern for localities considering paratransit is the cost of service; costs per ride of $1 to $3 have been common. Pooling and volunteer labor reduce costs, but these measures are often not available or not appropriate.

Not long ago, aggregate statistics for conventional bus transit showed average costs of about $0.40/ride. But costs have risen and fixed-route operating costs are approaching $1/ride. A recent UMTA report on the impacts of section 5 of the Urban Mass Transportation Act of 1964 showed that in 1975 one-quarter of the largest U.S. urban areas had bus operating costs of over $0.70/ride. Conventional, fixed-route buses are considerably less efficient for serving the low demand densities and dispersed travel patterns of paratransit markets than they are systemwide. For example, a low-density, suburban Washington, D.C., bus line showed an average operating cost of $2/ride on weekdays and over $12/ride on Sundays; the average cost on the Washington system was $0.78/ride.

In fact, costs of $1 to $3/ride appear to be realistic expectations for low-density service. Low densities limit the amount of possible trip aggregation and thus productivity. Common trip densities range from <2.5 to 12.5 passenger trips/$km^2 \cdot h$ (<1 to 5 passenger trips/$mile^2 \cdot h$). At these densities productivity will range from <2 to about 8 trips/vehicle·h. Even at the higher productivity of 8 trips/vehicle·h, the operating cost must be below $8/vehicle·h, among the lowest seen in practice, for the cost per ride to be held to $1. If productivity is lower or operating costs are higher, the cost per ride will exceed $1. When operating costs exceed $20/h, as in the case of the larger transit authorities, low-density productivities lead to costs of $3/ride or more.

Whereas cost per ride is an important measure of efficiency, it is the annual subsidy that measures the impact on the local budget. Commuter paratransit (car pool, van pool, or subscription bus) operates with little or no subsidy. Moreover, any subsidy is visibly associated with an employment center and can be funded in part or in whole by the employers. Local community paratransit, in contrast, is often more highly subsidized by the community and there can be strong competition for tax funds and pressure to resist additional expenditures. The notable exceptions are private shared-ride taxis, such as those in Little Rock, Arkansas, which operate without subsidy.

Faced with competition for local funds, community transportation is being asked to justify its subsidy. The major justifications used are the provision of (a) equitable public transportation service and (b) mobility for people without access to private automobiles. Equity refers to providing public service opportunity in low-density areas in return for tax funds for regional bus or rail service. Providing mobility for the transportation disadvantaged is a well-known problem.

Several approaches to controlling cost and subsidy for community transportation are available. Briefly, these include limiting the coverage and headways of local fixed-route service, limiting those eligible to use demand-responsive service, providing service on limited days, requiring advanced reservations, and using taxis. Other promising approaches include user rather than service subsidies and marginal-cost fare policies to limit the subsidy without restricting the system to selected users.

CONTROLLING SUBSIDIES FOR DEMAND-RESPONSIVE SERVICES

One of the major problems of dial-a-ride has been controlling the total cost of the service. Attempts to hold down costs by deploying a small number of vehicles have failed because the generated demand has overwhelmed the capacity of the system; the resulting poor service has led to strong complaints and, in some cases (e.g., Santa Clara County), to the demise of the service. The conflict is that a dial-a-ride system large enough to satisfy the demand it generates can cost more than a locality can afford, and a system that can be afforded might not satisfy the demand. The limitation of service to special markets (e.g., the elderly and the handicapped), the development of computer scheduling, and the use of taxis address the conflict either by limiting demand, improving productivity, or reducing costs. Recent results suggest marginal-cost fare policies as a method of controlling subsidies.

Providing mobility for people who do not have private automobiles is a common objective of community-level transportation service. In fact, the near-term growth in public transportation is likely to be justified by the need for mobility of those market groups. But transportation services limited to such selected market segments are inherently inequitable; other people with limited mobility are faced with using conventional taxis, depending on relatives, or not traveling. People often not served by special transportation include young families and middle-income families for whom the cost of automobile ownership is becoming too great.

Demand-responsive services oriented toward special markets can be opened to others in the same service area, without increasing the subsidy and at reasonable fares, as long as operating costs are kept in line. The fares for additional passengers can be around $0.80 to $1.50/ride and operating costs about $8 to $15/h.

Table 1 gives a hypothetical example based on the El Cajon, California, shared-ride taxi system. The service in El Cajon is open to anyone in the service area, but 67 percent of the riders are elderly or handicapped. The average fare is $0.38, the subsidy $0.90/ride, and the operating cost $8.16/vehicle·h. The system subsidy is about $21 400/month.

Limiting service to the elderly and handicapped would reduce the operating subsidy to about $17 900/month; as productivity decreased the cost per ride would

Table 1. Estimated results of marginal-cost fare policy for El Cajon shared-ride taxi system.

		Marginal-Cost Fare Policy		
Item	Current System	Limited Service for Elderly and Handicapped	Service to Other Users	Result
Average fare, $	0.38	0.38	0.82	
Monthly passengers	23 700	15 800[a]	4500[b]	20 300
Productivity, passengers/vehicle·h[c]	6.4	5.4		6.0
Cost per ride, $	1.28	1.50	0.82	1.35
Subsidy per ride, $	0.90	1.15	—	0.90
Monthly cost, $	30 400	23 900	3700	27 600
Monthly revenue, $	9000	6000	3700	9700
Monthly subsidy, $	21 400	17 900	—	17 900

[a]Two-thirds of current system passengers.
[b]Estimated from fare-elasticity relations developed in the Haddonfield, New Jersey, demonstration project.
[c]Estimated from a supply model based on the Haddonfield and Rochester dial-a-ride systems.

increase to $1.50. The marginal cost of carrying additional passengers is about $0.82/ride; thus, with fares of $0.38 for the elderly and the handicapped and $0.82 for all others, the system could be open to everyone in the service area and also maintain the subsidy at the lower $17 900/month. Coupons sold at a discount could be used for the lower fare. Thus, a marginal-cost fare policy allows the subsidy to be held at the level of a service for the elderly and the handicapped while mobility is provided to other users. The marginal cost per passenger is lower for added passengers because productivity increases as demand density increases and thus the cost per ride decreases. The marginal cost illustrated here is applicable only if the size of the service area and the hours of service do not change. Different marginal costs would result if the increase in ridership came from such changes.

Both overall subsidy and marginal-cost fare depend on operating cost per vehicle hour, which in turn depends on wage rates, overhead, and work rules. If the cost were $16.32/h, twice El Cajon's $8.16, the marginal-cost fare would double to $1.64 but would still be less than typical exclusive-ride taxi fares for the same trip length. At costs above $20/h, the marginal-cost fare for the shared-ride system becomes greater than the exclusive-ride taxi fare.

TAXI-RELATED IMPACTS

Paratransit offers taxi operators an opportunity to improve productivity, by means of ride sharing, and an opportunity to take part in publicly funded transportation programs. At the same time, paratransit, if publicly operated, threatens to reduce the market for taxi service—possibly, in some locations, to the point where taxis cannot survive.

The productivity of shared-ride services is often 50 to 100 percent higher than that of exclusive-ride taxis. Improved productivity can mean shorter waits for service, higher income for drivers and owners, and lower fares. The future well-being of the taxi industry depends on improving productivity; ride sharing and its associated computer and communications technology appear to provide a major opportunity comparable to the earlier advent of radio dispatching.

Restrictive regulations prohibiting shared-ride taxi services are a major barrier. However, lack of enthusiasm on the part of taxi operators can be a significant reason why the regulations are not changed. Taxi operators function in the restrictive environment of a tightly regulated industry with low profits; in any industry, such an environment is not conducive to risk taking and innovation. Many taxi operators have neither the resources nor the tradition of innovation to encourage substantial changes in methods of operation and the deployment of complex new technology.

Shared-ride operations are significantly more complex than exclusive-ride taxi operations. Shared-ride scheduling for effective aggregation of trips has little counterpart in exclusive-ride dispatching where drivers schedule themselves. An exclusive-ride taxi dispatcher can handle 100 or more vehicles; shared-ride schedulers lose their effectiveness with fleets of 10 to 15 vehicles.

Few taxi operators are experienced in the use and maintenance of computers and digital communications equipment. Such technology is sufficiently important that UMTA is sponsoring research and development to remove some of the uncertainty in its use.

Although participation in public transportation funding may be necessary for survival, it too is accompanied by problems and risks. Acceptance of public funding can be expected to be accompanied by strict accounting requirements, tighter controls on service quality, and public scrutiny of profits. Local and federal labor laws can be expected to be tied to public funding. The impact of these laws is uncertain, but there is no expectation that they will increase the operator's flexibility in dealing with employees nor that they will reduce costs. On the contrary, the concern is that costs will increase beyond what improvements in productivity justify.

FUTURE OUTLOOK

The integration of conventional transit and paratransit is a significant issue for UMTA, local urban areas, and transit and taxi operators. The market for public transportation (i.e., transportation other than by private automobile) is too small to support destructive competition among operators. Transit operators can benefit from the adoption of services that are more responsive to users, such as subscription commuter services, to improve routine efficiency and guarantee seats. On the other hand, there is little or no expectation of public operators taking on express package deliveries or special, doorstep, elderly-and-handicapped services, whereas taxi operators can integrate package delivery, shared-ride, and exclusive-ride services so as to better utilize personnel and equipment.

The most promising opportunities for the near future appear to be the following:

1. Expand services to the elderly and handicapped and coordinate social-service transportation. Transportation for the disadvantaged is a visible problem in many urban areas. Paratransit has the opportunity to show that it can be a solution to the problem, not just another competitor for scarce public funds. The inefficiency of multiple special-purpose transportation providers is beginning to be recognized. The paratransit operator has the opportunity to demonstrate a reduction in total cost by sharing personnel and equipment among services. The improved productivity resulting from aggregation of services can help to lower costs.
2. Expand transit by use of subscription commuter service. Subscription commuter services are the paratransit services most similar to conventional transit. These services appear to have potential productivities high enough to support conventional transit wages and might provide a better means than low-density dial-a-ride for familiarizing transit operators with paratransit. Techniques now being investigated for integrating subscription bus service with multiple working shifts offer promise of efficient 8-h/d utilization of drivers.
3. Expand taxi operations by use of ride sharing.

Taxis can get into ride sharing by contract with public agencies or on their own initiative. Public agencies and taxi operators need to learn much more about how to work together. UMTA is interested in learning more about the characteristics of shared-ride taxis, but there are too few such systems. UMTA intends to fund shared-ride taxi demonstrations, but such funds bring with them unresolved labor issues. Cautious expansion into ride sharing by private operators would add needed experience.

4. Formalize van pooling. More extensive commuter ride sharing can reduce the cost of commuting for both employees and employers if a sufficient number of people can be grouped together. Driver incentives often lacking in informal ride-sharing arrangements can encourage higher load factors. A transportation "broker" can provide supporting information services, such as locating existing pools for new riders, and can assist regular riders in finding needed alternative transportation. Insurance and other problems of formal pooling arrangements need to be addressed.

Other promising services are feeders to line-haul transit, the expansion of public transportation coverage to suburban areas, and the replacement of high-cost conventional transit line segments or very low-density service.